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(54) **CONDENSED CYCLIC COMPOUND AND ORGANIC LIGHT-EMITTING DEVICE INCLUDING THE SAME**

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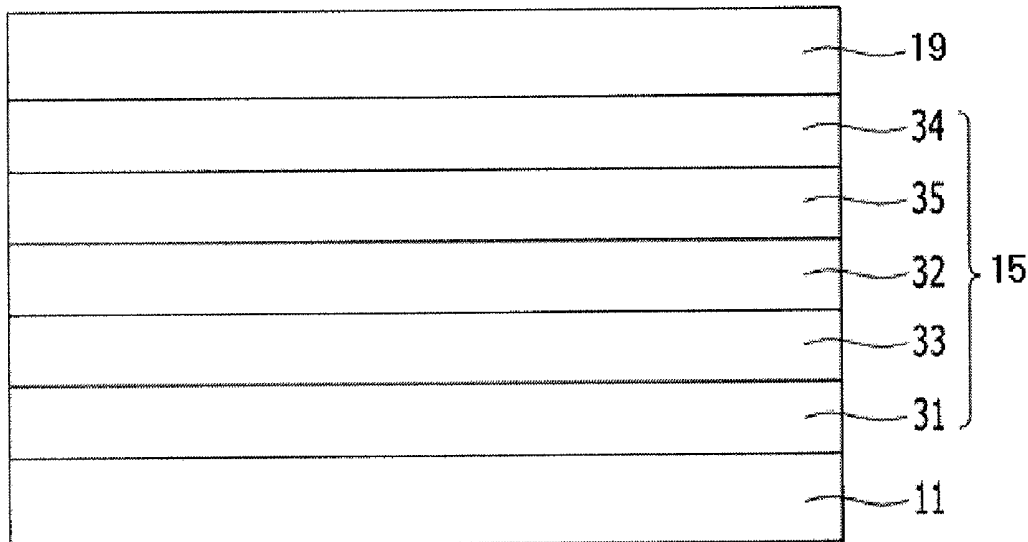
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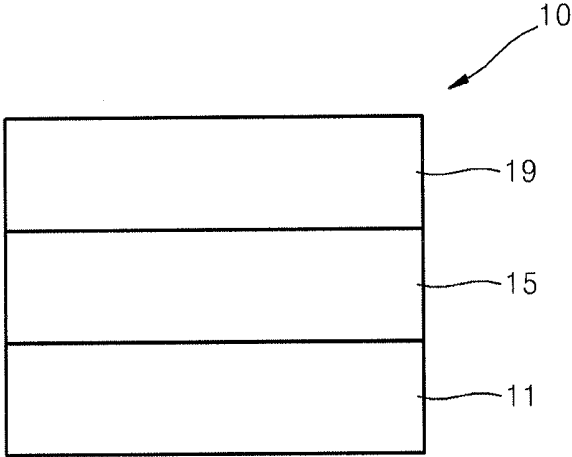
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(57) **ABSTRACT**

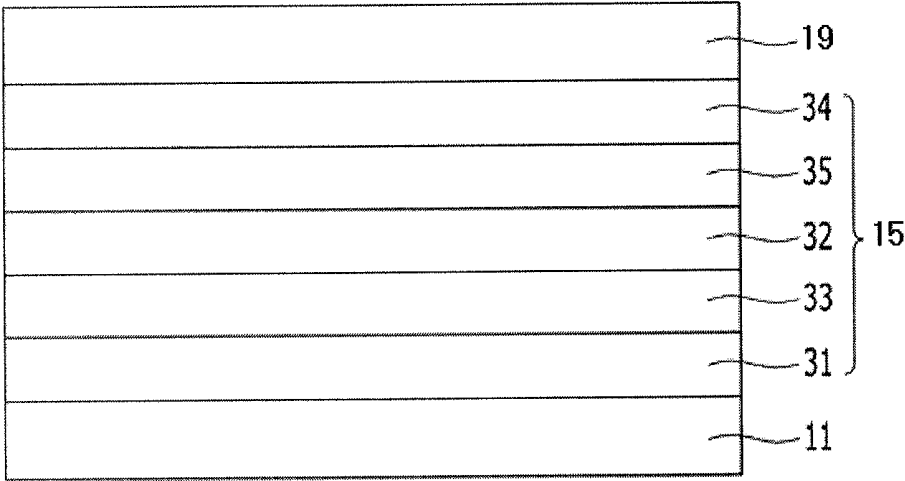
A condensed cyclic compound and an organic light-emitting device including the condensed cyclic compound are provided.



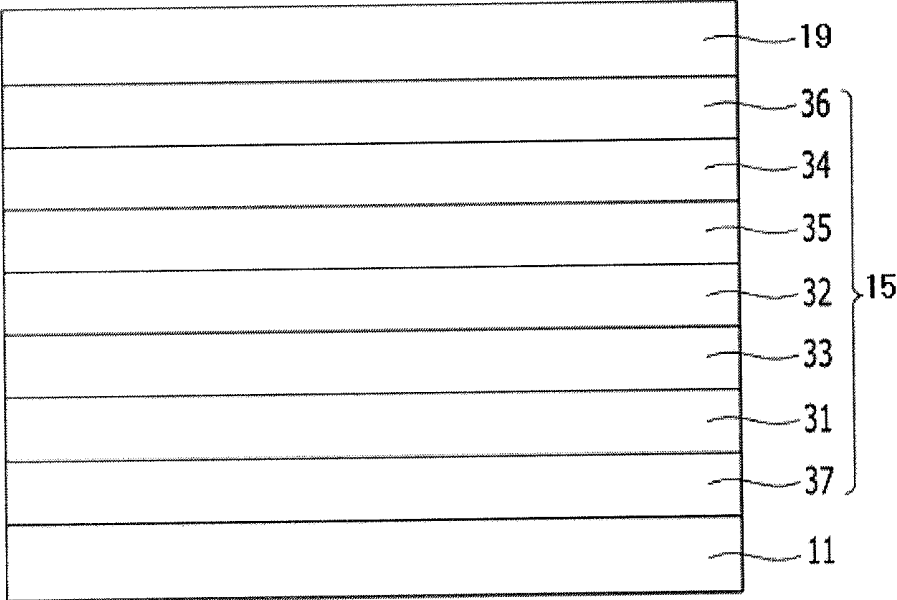
[Fig. 1]



[Fig. 2]



[Fig. 3]



**CONDENSED CYCLIC COMPOUND AND  
ORGANIC LIGHT-EMITTING DEVICE  
INCLUDING THE SAME**

TECHNICAL FIELD

**[0001]** One or more embodiments of the present disclosure relate to a condensed cyclic compound, and an organic light-emitting device including the same.

BACKGROUND ART

**[0002]** Organic light-emitting devices (OLEDs), which are self-emitting devices, have advantages such as wide viewing angles, excellent contrast, quick response, high brightness, excellent driving voltage characteristics, and can provide multicolored images.

**[0003]** An organic light-emitting device may include an anode, a cathode, and an organic layer including an emission layer and disposed between the anode and the cathode. The organic light-emitting device may include a hole transport region between the anode and the emission layer, and an electron transport region between the emission layer and the cathode. Holes injected from the anode move to the emission layer via the hole transport region, while electrons injected from the cathode move to the emission layer via the electron transport region. Carriers such as the holes and electrons recombine in the emission layer to generate excitons. When the excitons drop from an excited state to a ground state, light is emitted.

DISCLOSURE

Technical Problem

**[0004]** One or more embodiments of the present disclosure include a novel condensed cyclic compound, and an organic light-emitting device including the same.

**[0005]** The light-emitting device includes compounds different from each other, for example as hosts, and thus has a lower driving voltage, high efficiency, high luminance and long life-span characteristics.

**[0006]** The compound is used in an electron transport auxiliary layer to provide a light-emitting device having a lower driving voltage, high efficiency, high luminance and long life-span characteristics.

**[0007]** The light-emitting device includes different compounds from each other, for example as hosts, and thus has a lower driving voltage, high efficiency, high luminance and long life-span characteristics.

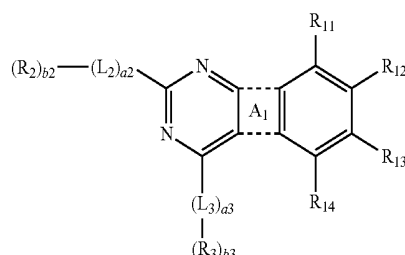
**[0008]** The compound is used in an electron transport auxiliary layer to provide a light-emitting device having a lower driving voltage, high efficiency, high luminance and long life-span characteristics.

**[0009]** Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

Technical Solution

**[0010]** According to one or more embodiments of the present disclosure, there is provided a condensed cyclic compound represented by Formula 1:

<Formula 1>



**[0011]** wherein, in Formula 1, ring A<sub>1</sub> is represented by Formula 1A, where X<sub>1</sub> is N-[(L<sub>1</sub>)<sub>a1</sub>-(R<sub>1</sub>)<sub>b1</sub>], S, O, or Si(R<sub>4</sub>)(R<sub>5</sub>);



<Formula 1A>

**[0012]** L<sub>1</sub> to L<sub>3</sub> are each independently selected from a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylene group, and a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, wherein L<sub>2</sub> and L<sub>3</sub> are not a substituted or unsubstituted carbazoylene group,

**[0013]** a<sub>1</sub> to a<sub>3</sub> are each independently an integer selected from 0 to 5,

**[0014]** R<sub>1</sub> to R<sub>5</sub> are each independently selected from a hydrogen, a deuterium, a fluoro group (—F), a chloro group (—Cl), a bromo group (—Br), an iodo group (—I), a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylthio group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>1</sub>)(Q<sub>2</sub>), —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), and —B(Q<sub>6</sub>)(Q<sub>7</sub>), wherein at least one of R<sub>2</sub> and R<sub>3</sub> is a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

**[0015]** R<sub>11</sub> to R<sub>14</sub> are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), and

**[0016]** wherein R<sub>3</sub> is not a substituted or unsubstituted morpholinyl group;

**[0017]** b<sub>1</sub> to b<sub>3</sub> are each independently an integer selected from 1 to 3,

**[0018]** at least one of substituents of the substituted C<sub>6</sub>-C<sub>60</sub> arylene group, the substituted C<sub>2</sub>-C<sub>60</sub> heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted C<sub>1</sub>-C<sub>60</sub> alkyl group, the

substituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, the substituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, the substituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, the substituted C<sub>6</sub>-C<sub>60</sub> aryl group, the substituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, the substituted C<sub>6</sub>-C<sub>60</sub> arylthio group, the substituted C<sub>2</sub>-C<sub>60</sub> heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from

**[0019]** a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group,

**[0020]** a C<sub>1</sub>-C<sub>60</sub> alkyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>11</sub>)(Q<sub>12</sub>), —Si(Q<sub>13</sub>)(Q<sub>14</sub>)(Q<sub>15</sub>), and —B(Q<sub>16</sub>)(Q<sub>17</sub>),

**[0021]** a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group,

**[0022]** a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>21</sub>)(Q<sub>22</sub>), —Si(Q<sub>23</sub>)(Q<sub>24</sub>)(Q<sub>25</sub>), and —B(Q<sub>26</sub>)(Q<sub>27</sub>), and

**[0023]** —N(Q<sub>31</sub>)(Q<sub>32</sub>), —Si(Q<sub>33</sub>)(Q<sub>34</sub>)(Q<sub>35</sub>), and —B(Q<sub>36</sub>)(Q<sub>37</sub>);

**[0024]** Q<sub>1</sub> to Q<sub>7</sub>, Q<sub>11</sub> to Q<sub>17</sub>, Q<sub>21</sub> to Q<sub>27</sub>, and Q<sub>31</sub> to Q<sub>37</sub> are each independently selected from a hydrogen, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

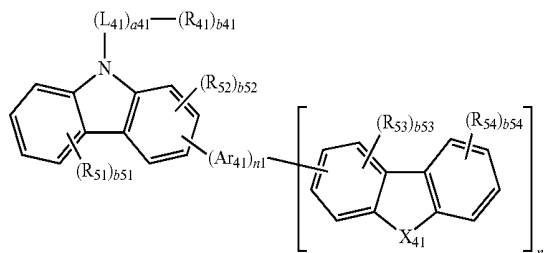
**[0025]** According to one or more embodiments of the present disclosure, an organic light-emitting device includes a first electrode, a second electrode, and an organic layer disposed between the first electrode and the second electrode and the organic layer including the condensed cyclic compounds of Formula 1 defined above.

**[0026]** The condensed cyclic compounds of Formula 1 may be included in the emission layer or electron transport

auxiliary layer of the organic layer, and the emission layer may further include a dopant. The condensed cyclic compounds of Formula 1 in the emission layer may serve as a host.

**[0027]** According to one or more embodiments of the present disclosure, an organic light-emitting device includes an organic layer including i) a condensed cyclic compound represented by the following Formula 1 and at least one of ii) a first compound represented by Formula 41 and a second compound represented by the following Formula 61.

<Formula 41>



**[0028]** In Formula 41, X<sub>41</sub> is N—[(L<sub>42</sub>)<sub>a42</sub>—(R<sub>42</sub>)<sub>b42</sub>], S, O, S(=O), S(=O)<sub>2</sub>, C(=O), C(R<sub>43</sub>)(R<sub>44</sub>), Si(R<sub>43</sub>)(R<sub>44</sub>), P(R<sub>43</sub>), P(=O)(R<sub>43</sub>) or C=N(R<sub>43</sub>);

**[0029]** In Formula 61, the ring A<sub>61</sub> is represented by Formula 61A;

**[0030]** In Formula 61, the ring A<sub>62</sub> is represented by Formula 61B;

**[0031]** X<sub>61</sub> is N—[(L<sub>62</sub>)<sub>a62</sub>—(R<sub>62</sub>)<sub>b62</sub>], S, O, S(=O), S(=O)<sub>2</sub>, C(=O), C(R<sub>63</sub>)(R<sub>64</sub>), Si(R<sub>63</sub>)(R<sub>64</sub>), P(R<sub>63</sub>), P(=O)(R<sub>63</sub>) or C=N(R<sub>63</sub>);

**[0032]** X<sub>71</sub> is C(R<sub>71</sub>) or N, X<sub>72</sub> is C(R<sub>72</sub>) or N, X<sub>73</sub> is C(R<sub>73</sub>) or N, X<sub>74</sub> is C(R<sub>74</sub>) or N, X<sub>75</sub> is C(R<sub>75</sub>) or N, X<sub>76</sub> is C(R<sub>76</sub>) or N, X<sub>77</sub> is C(R<sub>77</sub>) or N, and X<sub>78</sub> is C(R<sub>78</sub>) or N;

**[0033]** Ar<sub>41</sub>, L<sub>41</sub>, L<sub>42</sub>, L<sub>61</sub> and L<sub>62</sub> are each independently a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkylene group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkenylene group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group or a substituted or unsubstituted divalent non-aromatic heterocondensed polycyclic group;

**[0034]** n<sub>1</sub> and n<sub>2</sub> are each independently an integer selected from 0 to 3;

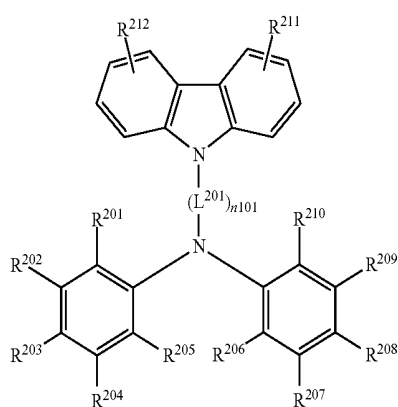
**[0035]** a<sub>41</sub>, a<sub>42</sub>, a<sub>61</sub> and a<sub>62</sub> are each independently an integer selected from 0 to 5;

**[0036]** R<sub>41</sub> to R<sub>44</sub>, R<sub>51</sub> to R<sub>54</sub>, R<sub>61</sub> to R<sub>64</sub> and R<sub>71</sub> to R<sub>79</sub> are each independently hydrogen, deuterium, —F (a fluoro group), —Cl (a chloro group), —Br (a bromo group), —I (an iodo group), a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> alkenyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> alkynyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl

group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylthio group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic heterocondensed polycyclic group, —N(Q<sub>1</sub>)(Q<sub>2</sub>), —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>) or —B(Q<sub>6</sub>)(Q<sub>7</sub>);

[0037] b41, b42, b51 to b54, b61, b62 and b79 are each independently an integer selected from 1 to 3.

[0038] According to another aspect, an organic light-emitting device that includes the condensed cyclic compound in an electron transport auxiliary layer of an organic layer, and further includes a hole transport auxiliary layer including a compound represented by the following Formula 2.



&lt;Formula 2&gt;

[0039] In Formula 2, L<sup>201</sup> is a substituted or unsubstituted C<sub>6</sub> to C<sub>30</sub> arylene group, or a substituted or unsubstituted C<sub>2</sub> to C<sub>30</sub> heteroarylene group, n<sub>101</sub> is an integer selected from 1 to 5, R<sup>201</sup> to R<sup>212</sup> are each independently hydrogen, a deuterium, a substituted or unsubstituted C<sub>1</sub> to C<sub>20</sub> alkyl group, a substituted or unsubstituted C<sub>6</sub> to C<sub>50</sub> aryl group, a substituted or unsubstituted C<sub>2</sub> to C<sub>50</sub> heteroaryl group or a combination thereof, and R<sup>201</sup> to R<sup>212</sup> are each independently present or are fused to each other to form a ring.

#### Advantageous Effects

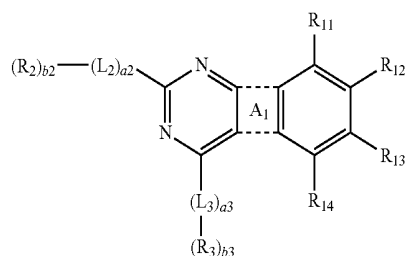
[0040] The condensed cyclic compound has improved electrical characteristics and thermal stability, and thus the organic light-emitting device including the condensed cyclic compound has a lower driving voltage, high efficiency, high luminance and long life-span characteristics.

#### DESCRIPTION OF THE DRAWINGS

[0041] FIGS. 1 to 3 are schematic views of an organic light-emitting device according to an embodiment of the present disclosure.

#### MODE FOR INVENTION

[0042] According to an embodiment of the present disclosure, there is provided a condensed cyclic compound represented by Formula 1 below:



&lt;Formula 1&gt;

[0043] In Formula 1, ring A<sub>1</sub> may be represented by Formula 1A:



&lt;Formula 1A&gt;

[0044] In Formula 1A, X<sub>1</sub> may be N-[(L<sub>1</sub>)<sub>a1</sub>-(R<sub>1</sub>)<sub>b1</sub>], S, O, or Si(R<sub>4</sub>)(R<sub>5</sub>),

[0045] L<sub>1</sub> to L<sub>3</sub> are each independently selected from a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroarylene group, and a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, wherein L<sub>2</sub> and L<sub>3</sub> are not a substituted or unsubstituted carbazoylene group,

[0046] a<sub>1</sub> to a<sub>3</sub> are each independently an integer selected from 0 to 5,

[0047] R<sub>1</sub> to R<sub>5</sub> are each independently selected from a hydrogen, a deuterium, a fluoro group (—F), a chloro group (—Cl), a bromo group (—Br), an iodo group (—I), a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylthio group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>1</sub>)(Q<sub>2</sub>), —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), and —B(Q<sub>6</sub>)(Q<sub>7</sub>), wherein at least one of R<sub>2</sub> and R<sub>3</sub> is selected from a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

[0048] R<sub>11</sub> to R<sub>14</sub> are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), and

[0049] wherein R<sub>3</sub> is not a substituted or unsubstituted morpholinyl group;

[0050] b<sub>1</sub> to b<sub>3</sub> are each independently an integer selected from 1 to 3,

[0051] at least one of substituents of the substituted C<sub>6</sub>-C<sub>60</sub> arylene group, the substituted C<sub>2</sub>-C<sub>60</sub> heteroarylene

group, the substituted divalent non-aromatic condensed polycyclic group, the substituted  $C_1$ - $C_{60}$  alkyl group, the substituted  $C_1$ - $C_{60}$  alkoxy group, the substituted  $C_3$ - $C_{10}$  cycloalkyl group, the substituted  $C_2$ - $C_{10}$  heterocycloalkyl group, the substituted  $C_6$ - $C_{60}$  aryl group, the substituted  $C_6$ - $C_{60}$  aryloxy group, the substituted  $C_6$ - $C_{60}$  arylthio group, the substituted  $C_2$ - $C_{60}$  heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from

**[0052]** a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{60}$  alkyl group, a  $C_2$ - $C_{60}$  alkenyl group, a  $C_2$ - $C_{60}$  alkynyl group, and a  $C_1$ - $C_{60}$  alkoxy group,

**[0053]** a  $C_1$ - $C_{60}$  alkyl group, and a  $C_1$ - $C_{60}$  alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_2$ - $C_{10}$  heterocycloalkyl group, a  $C_3$ - $C_{10}$  cycloalkenyl group, a  $C_2$ - $C_{10}$  heterocycloalkenyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>11</sub>)(Q<sub>12</sub>), —Si(Q<sub>13</sub>)(Q<sub>14</sub>)(Q<sub>15</sub>), and —B(Q<sub>16</sub>)(Q<sub>17</sub>),

**[0054]** a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_2$ - $C_{10}$  heterocycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group,

**[0055]** a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_2$ - $C_{10}$  heterocycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{60}$  alkyl group, a  $C_2$ - $C_{60}$  alkenyl group, a  $C_2$ - $C_{60}$  alkynyl group, a  $C_1$ - $C_{60}$  alkoxy group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_2$ - $C_{10}$  heterocycloalkyl group, a  $C_3$ - $C_{10}$  cycloalkenyl group, a  $C_2$ - $C_{10}$  heterocycloalkenyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>21</sub>)(Q<sub>22</sub>), —Si(Q<sub>23</sub>)(Q<sub>24</sub>)(Q<sub>25</sub>), and —B(Q<sub>26</sub>)(Q<sub>27</sub>), and

**[0056]** —N(Q<sub>31</sub>)(Q<sub>32</sub>), —Si(Q<sub>33</sub>)(Q<sub>34</sub>)(Q<sub>35</sub>), and —B(Q<sub>36</sub>)(Q<sub>37</sub>);

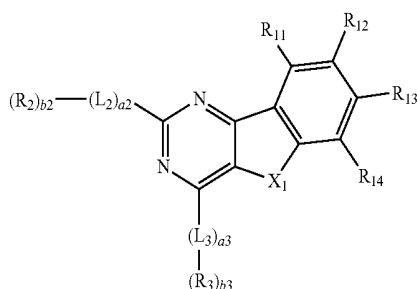
**[0057]** Q<sub>1</sub> to Q<sub>7</sub>, Q<sub>11</sub> to Q<sub>17</sub>, Q<sub>21</sub> to Q<sub>27</sub>, and Q<sub>31</sub> to Q<sub>37</sub> are each independently selected from a hydrogen, a  $C_1$ - $C_{60}$  alkyl group, a  $C_2$ - $C_{60}$  alkenyl group, a  $C_2$ - $C_{60}$  alkynyl group, a  $C_1$ - $C_{60}$  alkoxy group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_2$ - $C_{10}$  heterocycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

**[0058]** In Formula 1, L<sub>1</sub>, a1, R<sub>1</sub>, b1, R<sub>4</sub>, and R<sub>5</sub> will be defined below.

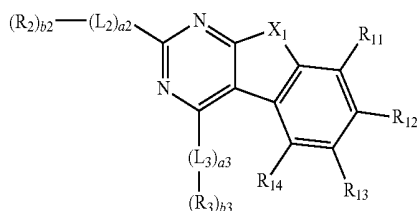
**[0059]** In some embodiments, X<sub>1</sub> may be S, O, or Si(R<sub>4</sub>)(R<sub>5</sub>), but is not limited thereto. In some other embodiments, X<sub>1</sub> may be S or O, but is not limited thereto.

**[0060]** The ring A<sub>1</sub> may be fused to adjacent two 6-membered rings with shared carbon atoms. Accordingly, the condensed cyclic compound of Formula 1 above may be represented by one of Formulae 1-1 and 1-2:

<Formula 1-1>



<Formula 1-2>



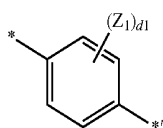
**[0061]** In Formulae 1-1 to 1-2, X<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub>, a2, a3, R<sub>2</sub>, R<sub>3</sub>, R<sub>11</sub> to R<sub>14</sub>, b2, and b3 may be the same as those of Formula 1 defined below.

**[0062]** In Formulae 1, 1-1, and 1-2, L<sub>1</sub> to L<sub>3</sub> may be each independently selected from a substituted or unsubstituted  $C_6$ - $C_{60}$  arylene group, and a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, wherein L<sub>2</sub> and L<sub>3</sub> may be not a substituted or unsubstituted carbazoylene group.

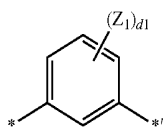
**[0063]** For example, L<sub>1</sub> to L<sub>3</sub> may be each independently selected from a phenylene group, biphenylene, terphenylene, quaterphenylene, a pentalenyne group, an indenylene group, a naphthylene group, an azulenyne group, a heptalenyne group, an indacenyne group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a phenalenyne group, a phenanthrylene group, an anthracenyne group, a fluoranthrylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenyne group, a picenylene group, a perylenylene group, a pentaphenyne group, a hexacenyne group, pyrrolylene, imidazolyene, pyrazolyene, pyridinyne, pyrazinyne, pyrimidinyne, pyridazinyne, isoindolyne, indolyne, indazolyne, purinyne, quinolinyne, isoquinolinyne, benzoquinolinyne, phthalazinyne, naphthyridinyne, quinoxalinyne, quinazolinyne, benzoquinolynyl group, benzoisoquinolynyl group, benzoquinazolynyl group, benzoquinoxalynyl group, cinnolinyne, phenanthridinyne, acridinyne, phenanthrolienyne, phenazinyne, benzoxazolyne, benzimidazolyne, furanylene, benzofuranylene, thiophenyne, benzothiophenyne, thiazolyne, isothiazolyne, benzothiazolyne, isoxazolyne, oxazolyne, triazolyne group, tetrazolyne group, oxadiazolyne, triazinyne, dibenzofuranylene, dibenzothiophenyne, benzocarbazolyne group, dibenzocarbazolyne group, imidazopyrimidinyne and imidazopyridinyne; and

**[0064]** a phenylene group, a biphenylene group, a terphenylene group, a quaterphenylene group, a pentalenylene group, an indenylene group, a naphthalenylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a pice-nylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, pyrrolylene, imidazolylene, pyrazolylene, pyridinylene, pyrazinylene, pyrimidinylene, pyridazinylene, isoindolylene, indolylene, indazolylene, purinylene, quinolinylene, isoquinolinylene, benzoquinolinylene, phthalazinylene, naphthyridinylene, quinoxalinylene, quinazolinylene, benzoquinolynyl group, benzoisoquinolynyl group, benzoquinazolynyl group, benzoquinoxalinyl group, cinnolinylene, phenanthridinylene, acridinylene, phenanthrolinylene, phenazinylene, benzoxazolylene, benzimidazolylene, furanylene, benzofuranylene, thiophenylene, benzothiophenylene, thiazolylene, isothiazolylene, benzothiazolylene, isoxazolylene, oxazolylene, triazolylene group, tetrazolylene group, oxadiazolylene, triazinylene, dibenzofuranylene, dibenzothiophenylene, benzocarbazolylene group, dibenzocarbazolylene group, imidazopyrimidinylene and imidazopyridinylene, and each substituted with at least one of a deuterium atom, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a C<sub>6</sub>-C<sub>20</sub> aryl group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent nonaromatic condensed polycyclic group, a monovalent nonaromatic condensed heteropolycyclic group, and —Si(Q<sub>33</sub>)(Q<sub>34</sub>)(Q<sub>35</sub>), wherein Q<sub>33</sub> to Q<sub>35</sub> are each independently a hydrogen, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a phthalazinyl group, a quinoxalinyl group, a cinnolinyl group, a quinazoliny group, benzoquinolinyl group, benzoisoquinolinyl group, benzoquinazoliny group, and a benaoquinoxalinyl group, wherein L<sub>2</sub> and L<sub>3</sub> are not a substituted or unsubstituted carbazolylene group.

**[0065]** In some other embodiments, in above Formulae, L<sub>1</sub> to L<sub>3</sub> may be each independently represented by one of Formulae 2-1 to 2-11:

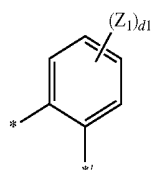


Formula 2-1

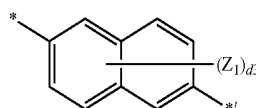


Formula 2-2

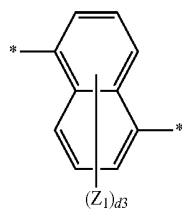
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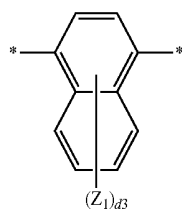
Formula 2-3



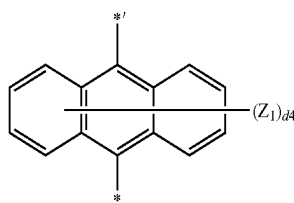
Formula 2-4



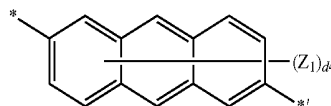
Formula 2-5



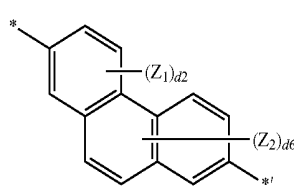
Formula 2-6



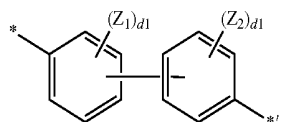
Formula 2-7



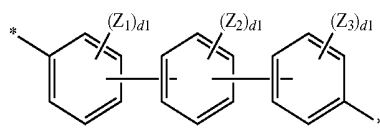
Formula 2-8



Formula 2-9



Formula 2-10



Formula 2-11

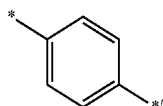
**[0066]** In Formulae 2-1 to 2-11,

**[0067]** Z<sub>1</sub> to Z<sub>3</sub> may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino groups,

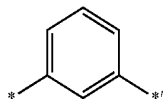
a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a naphthyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazoliny group, a quinoxaliny group, a benzoquinolinyl group, a benzoisoquinolinyl group, a benzoquinazoliny group, a benzoquinoxaliny group, a biphenyl group, and —Si(Q<sub>33</sub>)(Q<sub>34</sub>)(Q<sub>35</sub>), wherein Q<sub>33</sub> to Q<sub>35</sub> may be each independently selected from a hydrogen, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazoliny group, a quinoxaliny group, a benzoquinolinyl group, a benzoisoquinolinyl group, a benzoquinazoliny group, and a benzoquinoxaliny group;

**[0068]** d1 may be an integer selected from 1 to 4; d2 may be an integer selected from 1 to 3; d3 may be an integer selected from 1 to 6; d4 may be an integer selected from 1 to 8; d6 may be an integer selected from 1 to 5; and \* and \*' may be each independently a binding site with an adjacent atom.

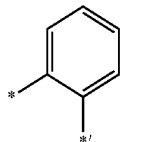
**[0069]** In some other embodiments, in above Formulae, L<sub>1</sub> to L<sub>3</sub> may be each independently represented by one of Formulae 3-1 to 3-32, but are not limited thereto:



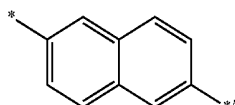
Formula 3-1



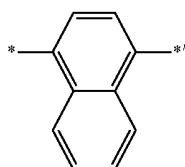
Formula 3-2



Formula 3-3

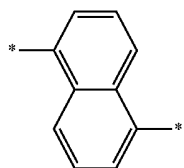


Formula 3-4

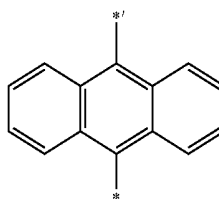


Formula 3-5

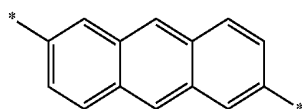
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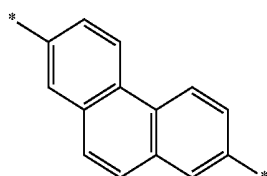
Formula 3-6



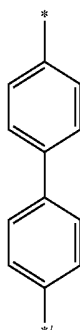
Formula 3-7



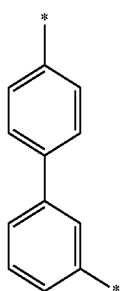
Formula 3-8



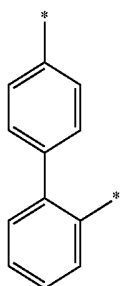
Formula 3-9



Formula 3-10

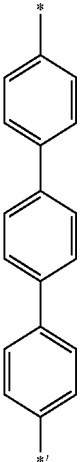
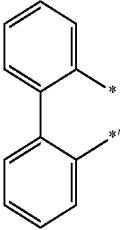
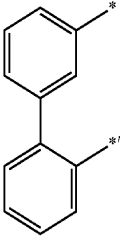
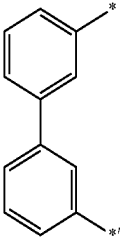
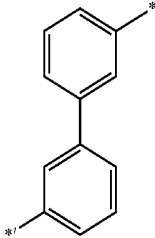


Formula 3-11

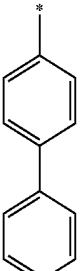


Formula 3-12

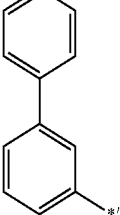
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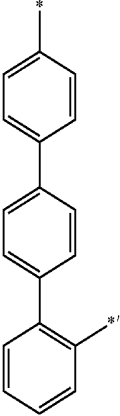
Formula 3-13



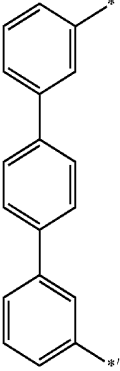
Formula 3-14



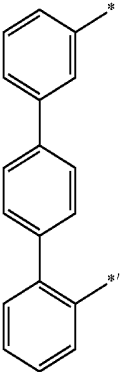
Formula 3-15



Formula 3-16



Formula 3-17



-continued

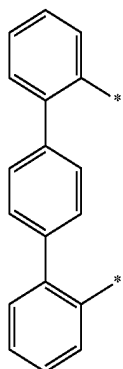
Formula 3-18

Formula 3-19

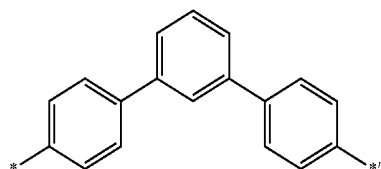
Formula 3-20

Formula 3-21

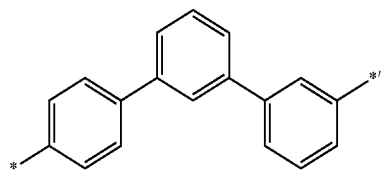
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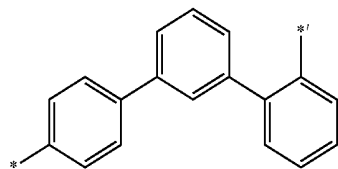
Formula 3-22



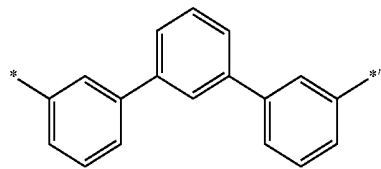
Formula 3-23



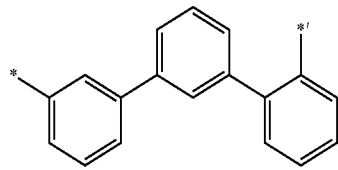
Formula 3-24



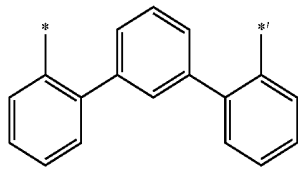
Formula 3-25



Formula 3-26

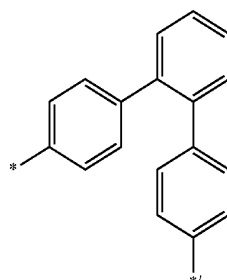


Formula 3-27

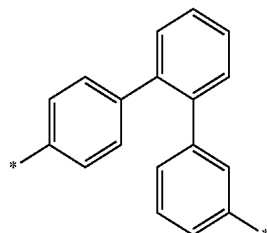


Formula 3-28

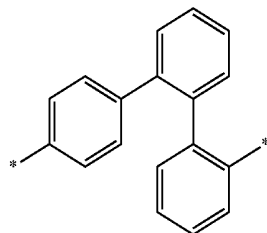
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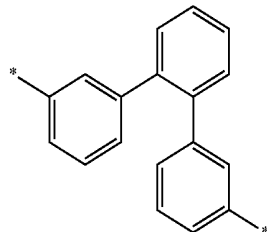
Formula 3-29



Formula 3-30



Formula 3-31



Formula 3-32

**[0070]** In Formula 1 above, a<sub>1</sub>, which indicates the number of L<sub>1</sub>s, may be 0, 1, 2, 3, 4, or 5, and in some embodiments, 0, 1, or 2, and in some other embodiments, 0 or 1. When a<sub>1</sub> is 0, \*(L<sub>1</sub>)<sub>a1</sub>-\*<sup>1</sup> may be a single bond. When a<sub>1</sub> is 2 or greater, the at least two L<sub>1</sub>s may be identical to or different from each other. a<sub>2</sub> and a<sub>3</sub> in Formula 1 may be understood based on the description of a<sub>1</sub> and the structure of Formula 1.

**[0071]** In some embodiments, a<sub>1</sub>, a<sub>2</sub>, and a<sub>3</sub> may be each independently 0, 1, or 2.

**[0072]** In above Formulae, R<sub>1</sub> to R<sub>5</sub> may be each independently selected from a hydrogen, a deuterium, a fluoro group (—F), a chloro group (—Cl), a bromo group (—Br), an iodo group (—I), a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylthio group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aro-

matic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,  $-\text{N}(\text{Q}_1)(\text{Q}_2)$ ,  $-\text{Si}(\text{Q}_3)(\text{Q}_4)(\text{Q}_5)$ , and  $-\text{B}(\text{Q}_6)(\text{Q}_7)$ , wherein at least one of  $\text{R}_2$  and  $\text{R}_3$  is selected from a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

**[0073]** In some embodiments, in above Formulae,  $\text{R}_1$  to  $\text{R}_5$  may be each independently selected from

**[0074]** a hydrogen, a deuterium,  $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ , a hydroxyl group, a cyano group, an amino group, an amidino group, a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, and a  $\text{C}_1$ - $\text{C}_{20}$  alkoxy group,

**[0075]** a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group and a  $\text{C}_1$ - $\text{C}_{20}$  alkoxy group, each substituted with at least one of a deuterium atom,  $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ , a hydroxyl group, a cyano group, an amino group, and an amidino group,

**[0076]** a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacacenyl group, a pentacacenyl group, a rubicenyl group, a coronenyl group, a ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, a oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group,

**[0077]** a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacacenyl group, a pentacacenyl group, a rubicenyl group, a coronenyl group, a ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, a oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a

benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from a deuterium,  $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ , a hydroxyl group, a cyano group, an amino group, an amidino group, a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a  $\text{C}_1$ - $\text{C}_{20}$  alkoxy group,  $-\text{Si}(\text{Q}_{33})(\text{Q}_{34})(\text{Q}_{35})$ , a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacacenyl group, a pentacacenyl group, a rubicenyl group, a coronenyl group, a ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, a oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and a biphenyl group, and

**[0078]**  $-\text{Si}(\text{Q}_3)(\text{Q}_4)(\text{Q}_5)$ ,

**[0079]** wherein  $\text{R}_4$  and  $\text{R}_5$  may be not  $-\text{Si}(\text{Q}_3)(\text{Q}_4)(\text{Q}_5)$ ;

**[0080]**  $\text{Q}_3$  to  $\text{Q}_5$ , and  $\text{Q}_{33}$  to  $\text{Q}_{35}$  may be each independently selected from a hydrogen, a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a  $\text{C}_1$ - $\text{C}_{20}$  alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a benzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazolinyl group, and a quinoxalinyl group; and

**[0081]** at least one of  $\text{R}_2$  and  $\text{R}_3$  may be each independently selected from

**[0082]** a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group,

**[0083]** a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, each substituted with at least one selected from a deuterium,  $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ , a hydroxyl group, a cyano group, an amino group, an amidino group, a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a  $\text{C}_1$ - $\text{C}_{20}$  alkoxy group,  $-\text{Si}(\text{Q}_{33})(\text{Q}_{34})(\text{Q}_{35})$ , a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a

spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluorantenylyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacenylyl group, a pentacenylyl group, a rubicenylyl group, a coronenyl group, a ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranlyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and a biphenyl group;

**[0084]** In some other embodiments, in Formula 1, 1-1, and 1-2,  $R_1$  to  $R_5$  may be each independently selected from

**[0085]** a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group,

**[0086]** a  $C_1$ - $C_{20}$  alkyl group and a  $C_1$ - $C_{20}$  alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, and an amidino group,

**[0087]** a phenyl group, a naphthyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group;

**[0088]** a phenyl group, a naphthyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluorantenylyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, a benzoquinolinyl group, benzoisoquinolinyl group, benzoquinazolinyl group, and a benzoquinoxalinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, —Si( $Q_3$ )( $Q_4$ )( $Q_5$ ), a phenyl group, a naphthyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluorantenylyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a

carbazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, and

**[0089]** —Si( $Q_3$ )( $Q_4$ )( $Q_5$ ),

**[0090]** wherein  $R_4$  and  $R_5$  may be not —Si( $Q_3$ )( $Q_4$ )( $Q_5$ );

**[0091]**  $Q_3$  to  $Q_5$ , and  $Q_{33}$  to  $Q_{35}$  may be each independently selected from a hydrogen, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazolinyl group, a quinoxalinyl group, a benzoquinolinyl group, benzoisoquinolinyl group, benzoquinazolinyl group, and a benzoquinoxalinyl group; and

**[0092]** at least one of  $R_2$  and  $R_3$  may be each independently selected from

**[0093]** a carbazolyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group; or

**[0094]** a carbazolyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, —Si( $Q_3$ )( $Q_4$ )( $Q_5$ ), a phenyl group, a naphthyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluorantenylyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a dibenzofuranlyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group.

**[0095]** In some other embodiments, in Formulae 1, 1-1, and 1-2,  $R_1$  to  $R_5$  may be each independently selected from

**[0096]** a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a hydrazine, a hydrazone, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group,

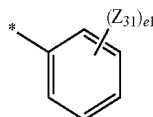
**[0097]** a  $C_1$ - $C_{20}$  alkyl group and a  $C_1$ - $C_{20}$  alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, and an amidino group,

**[0098]** a group represented by one of Formulae 4-1 to 4-34, and

**[0099]** —Si( $Q_3$ )( $Q_4$ )( $Q_5$ ),

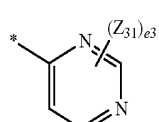
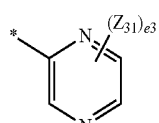
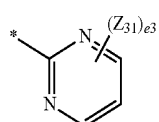
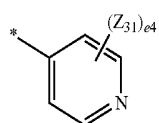
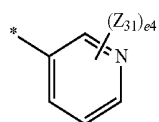
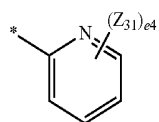
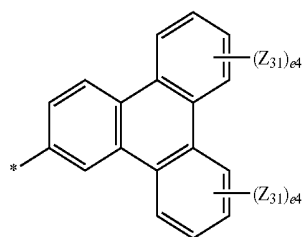
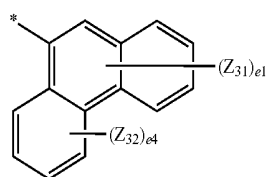
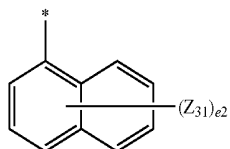
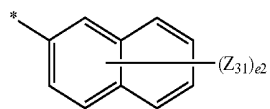
**[0100]** wherein  $R_4$  and  $R_5$  may be not —Si( $Q_3$ )( $Q_4$ )( $Q_5$ ); and

**[0101]** at least one of  $R_2$  and  $R_3$  may be each independently a group represented by one of Formulae 4-26 to 4-33:



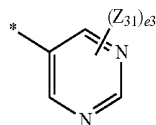
Formula 4-1

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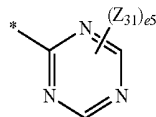


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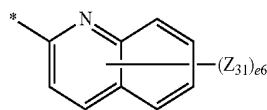
Formula 4-2



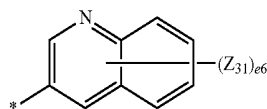
Formula 4-3



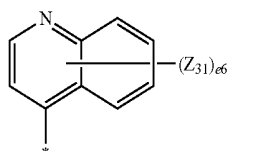
Formula 4-4



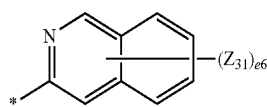
Formula 4-5



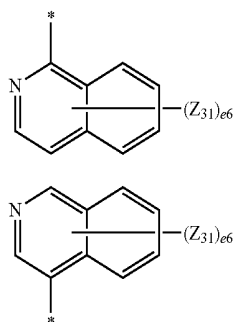
Formula 4-6



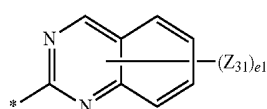
Formula 4-7



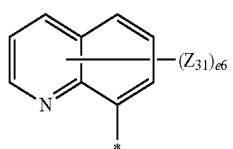
Formula 4-8



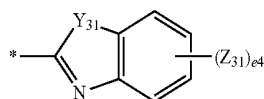
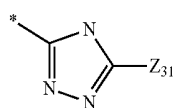
Formula 4-9



Formula 4-10



Formula 4-11



Formula 4-12

Formula 4-13

Formula 4-14

Formula 4-15

Formula 4-16

Formula 4-17

Formula 4-18

Formula 4-19

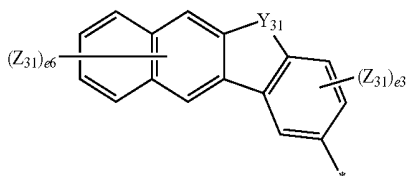
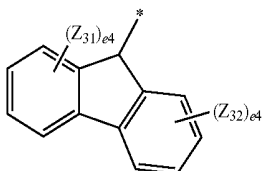
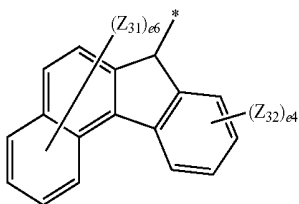
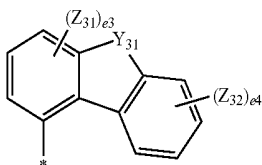
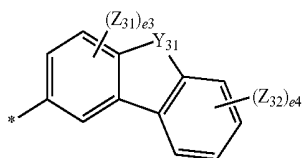
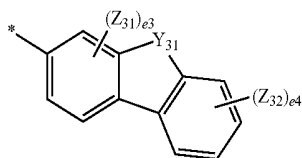
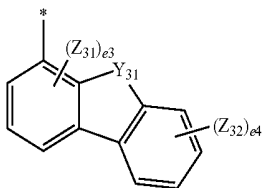
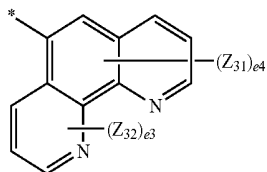
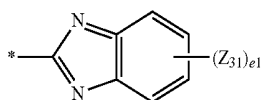
Formula 4-20

Formula 4-21

Formula 4-22

Formula 4-23

-continued



Formula 4-24

Formula 4-25

Formula 4-26

Formula 4-27

Formula 4-28

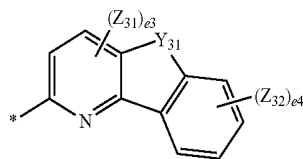
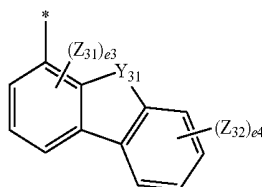
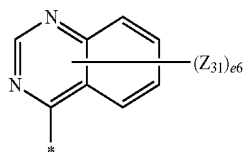
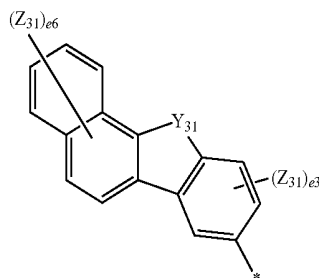
Formula 4-29

Formula 4-30

Formula 4-31

Formula 4-32

-continued



Formula 4-33

Formula 4-34

Formula 4-35

Formula 4-36

[0102] In Formulae 4-1 to 4-36,

[0103]  $Y_{31}$  may be O, S, or N( $Z_{35}$ ), where  $Y_{31}$  in Formula 4-23 may be not NH,

[0104]  $Z_{31}$ ,  $Z_{32}$ , and  $Z_{35}$  may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, naphthyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a carbazolyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazolinyl group, a quinoxalinyl group, a benzoquinolinyl group, benzoisoquinolinyl group, benzoquinazolinyl group, benzoquinoxalinyl group, and —Si( $Q_{33}$ )( $Q_{34}$ )( $Q_{35}$ ), wherein  $Q_{33}$  to  $Q_{35}$  may be each independently selected from a hydrogen, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazolinyl group, a quinoxalinyl group, a benzoquinolinyl group, benzoisoquinolinyl group, benzoquinazolinyl group, and benzoquinoxalinyl group

[0105]  $e_1$  may be an integer selected from 1 to 5,  $e_2$  may be an integer selected from 1 to 7,  $e_3$  may be an integer

selected from 1 to 3, e4 may be an integer selected from 1 to 4, e5 may be 1 or 2, e6 may be an integer selected from 1 to 6, and \* may be a binding site with an adjacent atom.

**[0106]** In some embodiments,  $Z_{31}$  may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a benzocarbazolyl group.

**[0107]** In some other embodiments, in Formulae 1, 1-1, and 1-2,  $R_1$  may be selected from

**[0108]** a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a naphthyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a fluorenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, and a perylenyl group, and

**[0109]** a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a naphthyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, and a perylenyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a naphthyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a fluorenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, and a perylenyl group.

**[0110]**  $R_4$  and  $R_5$  in above Formulae may be each independently selected from a  $C_1$ - $C_{20}$  alkyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, and an amidino group. For example,  $R_4$  and  $R_5$  may be each independently selected from a methyl group, an ethyl group, a propyl group, an isopropyl group, but are not limited thereto.

**[0111]** In some other embodiments, at least one of  $R_2$  and  $R_3$  in above Formulae may be selected from

**[0112]** a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a benzocarbazolyl group, and

**[0113]** a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a benzocarbazolyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, —Si( $Q_{33}$ )( $Q_{34}$ )( $Q_{35}$ ), a phenyl group, a naphthyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, benzoisoquinolinyl group, benzoquinazolinyl group, benzoquinoxalinyl group, a carbazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group.

**[0114]** In above Formulae,  $R_{11}$  to  $R_{14}$  may be each independently selected from a hydrogen, a deuterium, —F, —Cl,

—Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted  $C_1$ - $C_{60}$  alkyl group, a substituted or unsubstituted  $C_1$ - $C_{60}$  alkoxy group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a monovalent non-aromatic condensed polycyclic group, and —Si( $Q_3$ )( $Q_4$ )( $Q_5$ ).

**[0115]** In some embodiments,  $R_{11}$  to  $R_{14}$  in above Formulae may be each independently selected from

**[0116]** a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group,

**[0117]** a  $C_1$ - $C_{20}$  alkyl group and a  $C_1$ - $C_{20}$  alkoxy group, each substituted with at least one of a deuterium atom, —F, —Cl, —Br, —I, a hydroxyl group, and a cyano group,

**[0118]** a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, and a pentacenyl group.

**[0119]** In some other embodiments,  $R_{11}$  to  $R_{14}$  in above Formulae may be each independently selected from

**[0120]** a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group,

**[0121]** a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a thiophenyl group, a furanyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, and

**[0122]** —Si( $Q_3$ )( $Q_4$ )( $Q_5$ ), wherein  $Q_3$  to  $Q_5$  may be each independently selected from a hydrogen, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazolinyl group, and a quinoxalinyl group.

**[0123]** In some other embodiments, in above Formulae,  $R_{11}$  to  $R_{14}$  may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group, but are not limited thereto.

**[0124]** In some other embodiments,  $R_{11}$  to  $R_{14}$  in above Formulae may be all hydrogens.

**[0125]** In some other embodiments,  $R_1$  to  $R_5$  in above Formulae may be each independently selected from

[0126] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group,

[0127] a  $C_1$ - $C_{20}$  alkyl group and a  $C_1$ - $C_{20}$  alkoxy group, each substituted with at least one of a deuterium atom, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, and an amidino group,

[0128] a group represented by one of Formulae 5-1 to 5-141, and

[0129] —Si( $Q_3$ )( $Q_4$ )( $Q_5$ ),

[0130] wherein  $R_4$  and  $R_5$  may be not —Si( $Q_3$ )( $Q_4$ )( $Q_5$ );

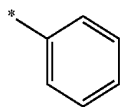
[0131] at least one of  $R_2$  and  $R_3$  are each independently selected from a group represented by one of Formulae 5-10 to 5-17, 5-22 to 5-26, and 5-56 to 5-141; and

[0132]  $R_{11}$  to  $R_{14}$  may be each independently selected from

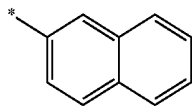
[0133] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group,

[0134] a group represented by one of Formulae 5-1 to 5-9, and

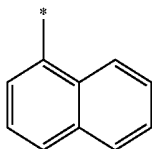
[0135] —Si( $Q_3$ )( $Q_4$ )( $Q_5$ ), wherein  $Q_3$  to  $Q_5$  may be each independently selected from a hydrogen, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazolinyl group, a quinoxalinyl group, benzoquinolinyl group, benzoisoquinolinyl group, benzoquinazolinyl group and a benzoquinoxalinyl group, but are not limited thereto:



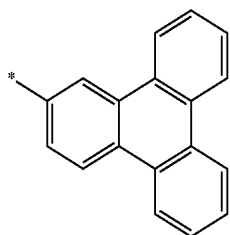
Formula 5-1



Formula 5-2

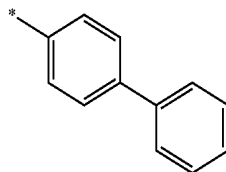


Formula 5-3

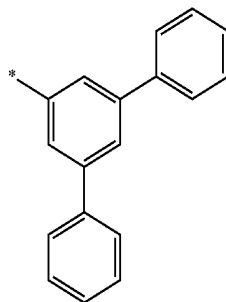


Formula 5-4

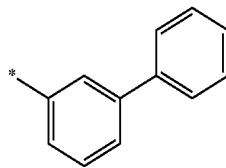
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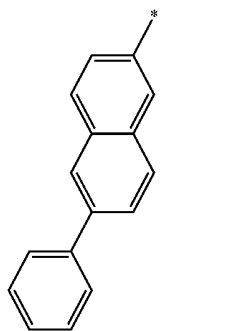
Formula 5-5



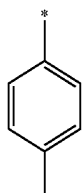
Formula 5-6



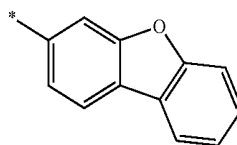
Formula 5-7



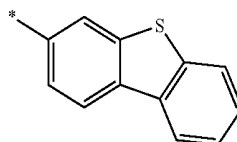
Formula 5-8



Formula 5-9

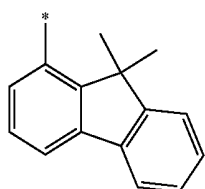
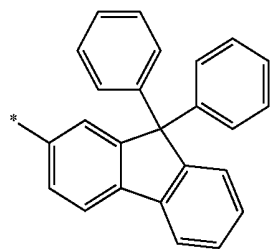
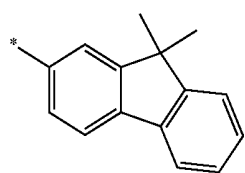
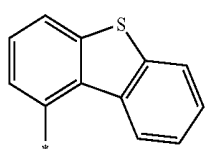
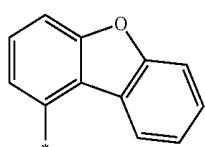
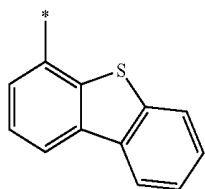
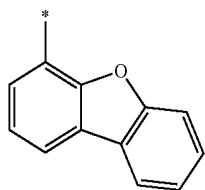
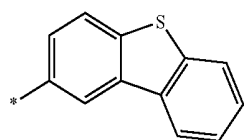
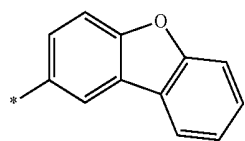


Formula 5-10



Formula 5-11

-continued



Formula 5-12

Formula 5-13

Formula 5-14

Formula 5-15

Formula 5-16

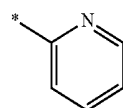
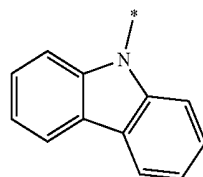
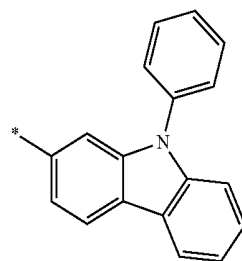
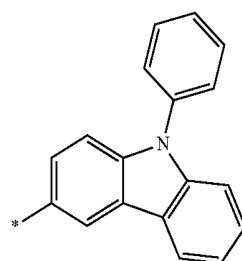
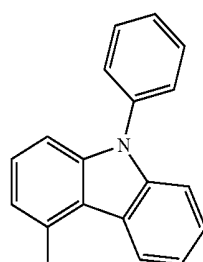
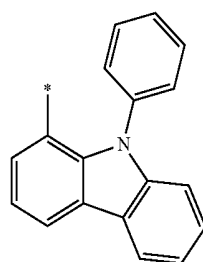
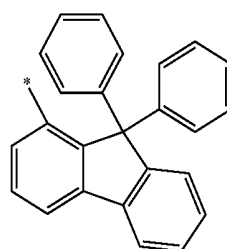
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Formula 5-18

Formula 5-19

Formula 5-20

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Formula 5-21

Formula 5-22

Formula 5-23

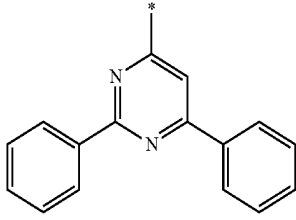
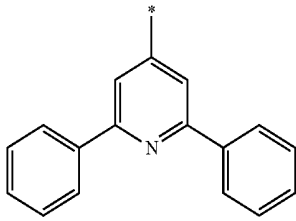
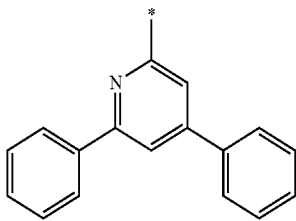
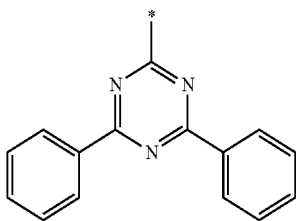
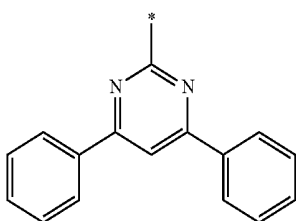
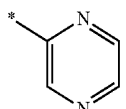
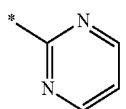
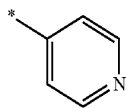
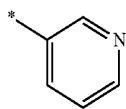
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Formula 5-25

Formula 5-26

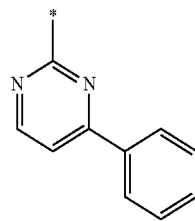
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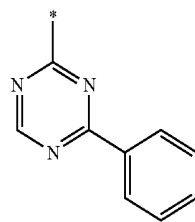
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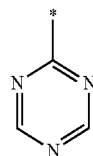
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Formula 5-30

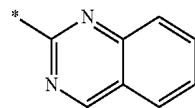


Formula 5-31

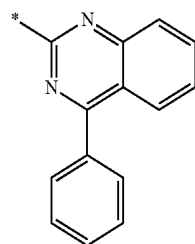
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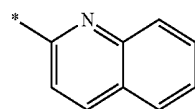
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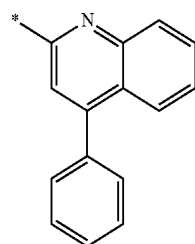
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Formula 5-35



Formula 5-36



Formula 5-37

Formula 5-38

Formula 5-39

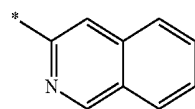
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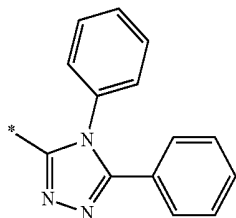
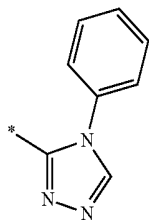
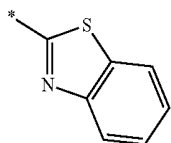
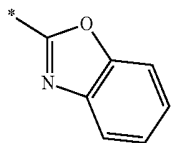
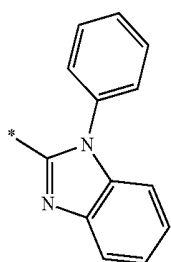
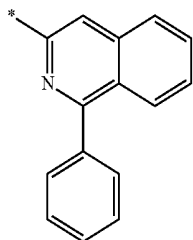
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Formula 5-43

Formula 5-44

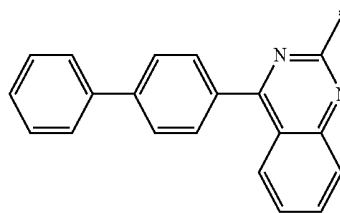


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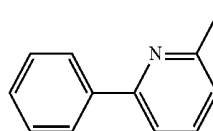


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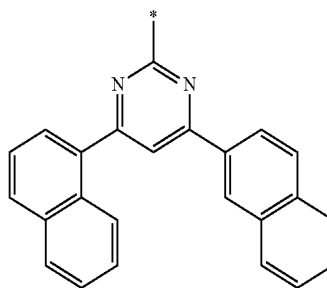
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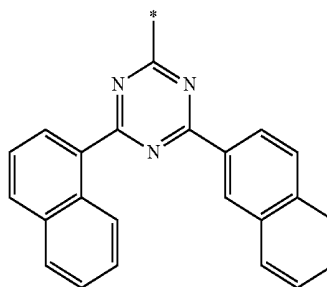
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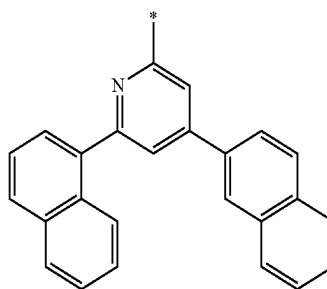
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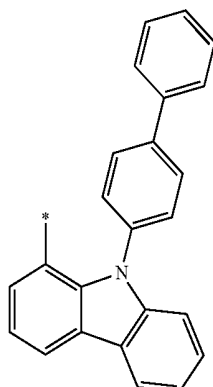
Formula 5-48



Formula 5-49



Formula 5-50



Formula 5-51

Formula 5-52

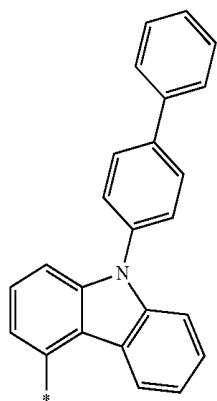
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Formula 5-54

Formula 5-55

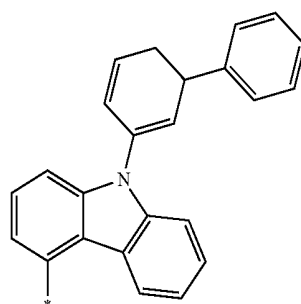
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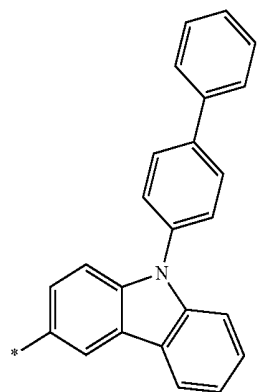


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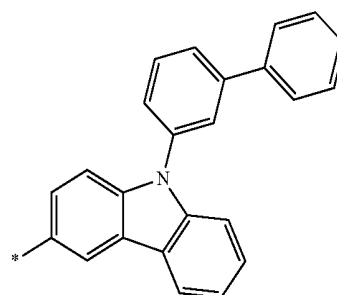
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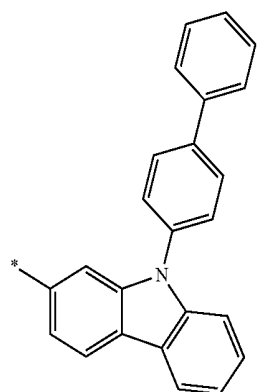
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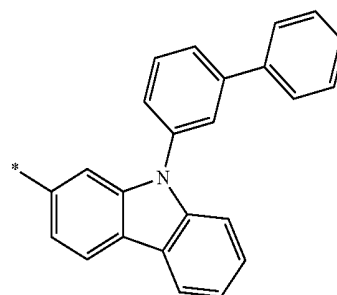
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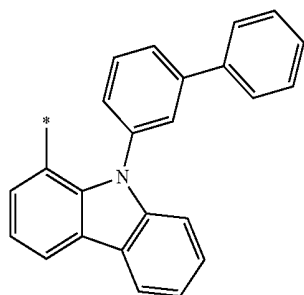
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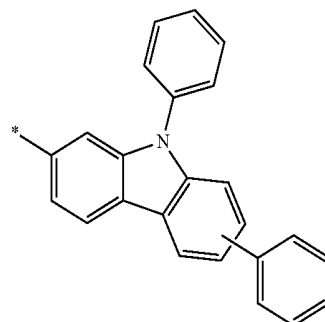
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Formula 5-63



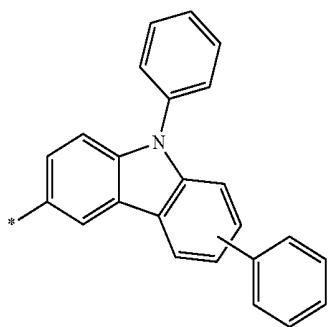
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Formula 5-64

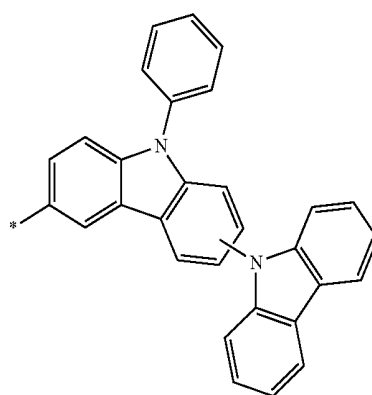
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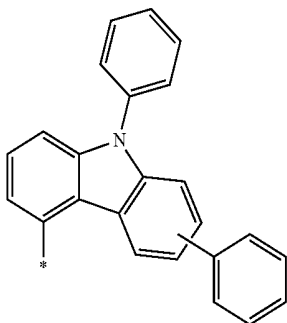
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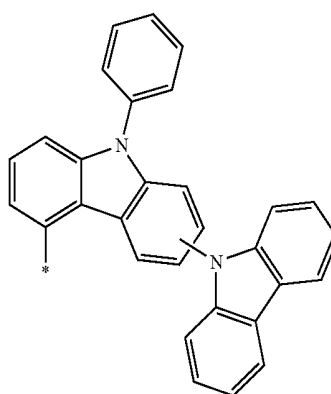


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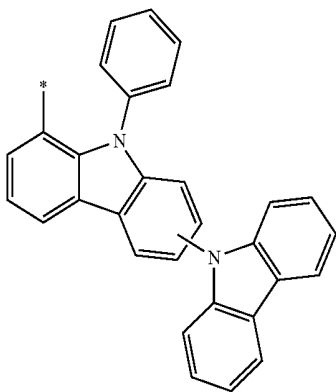
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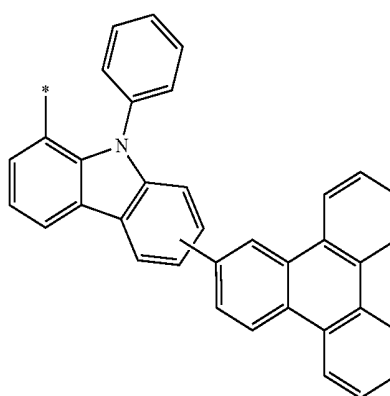
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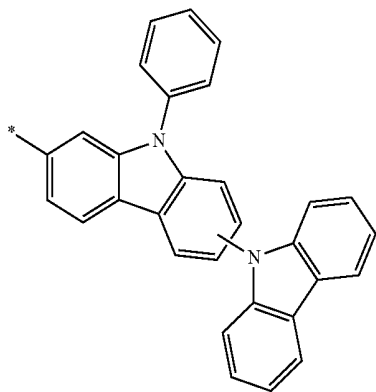
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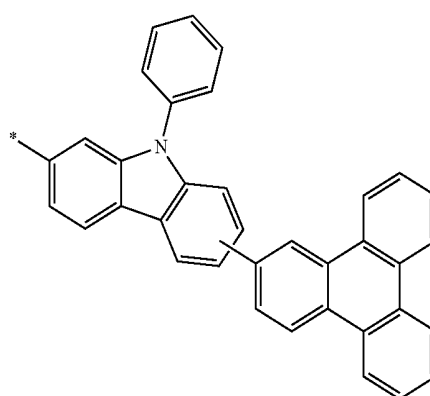
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Formula 5-69

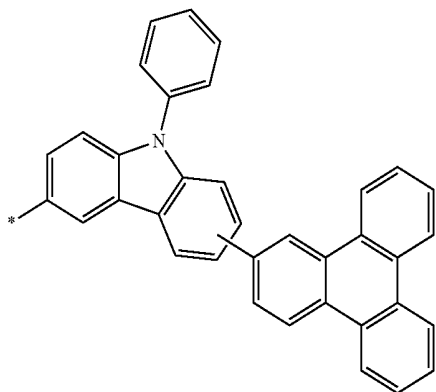


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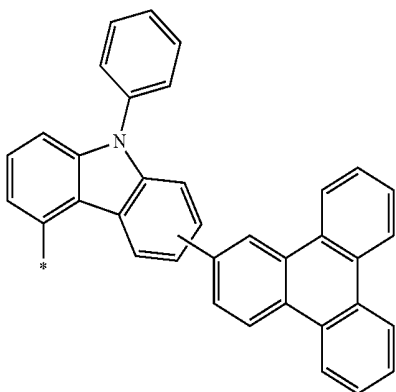


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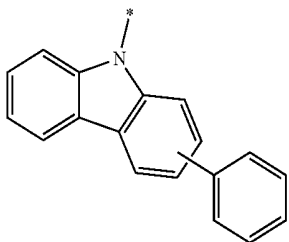
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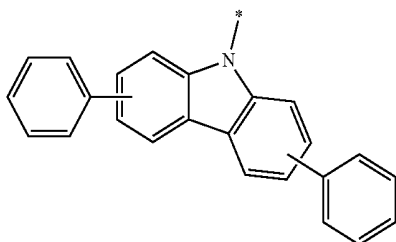
Formula 5-75



Formula 5-76

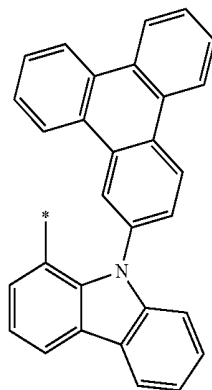


Formula 5-77

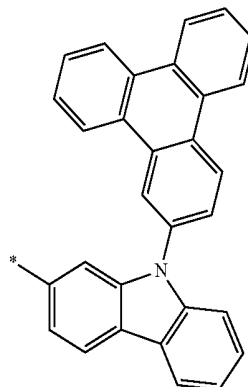


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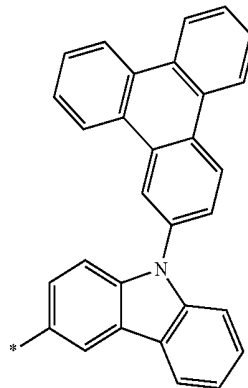
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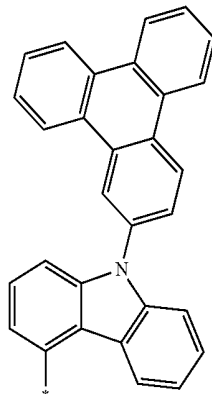
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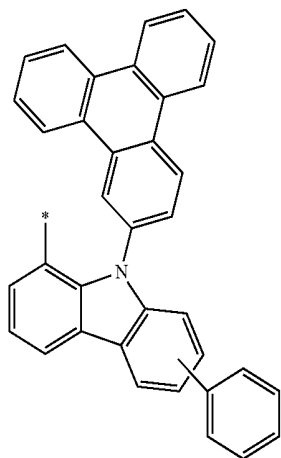
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Formula 5-81

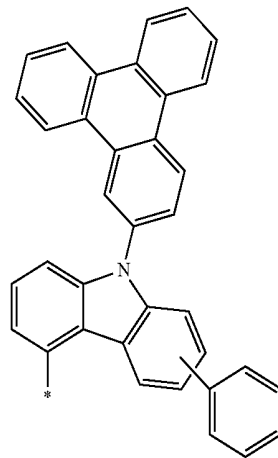


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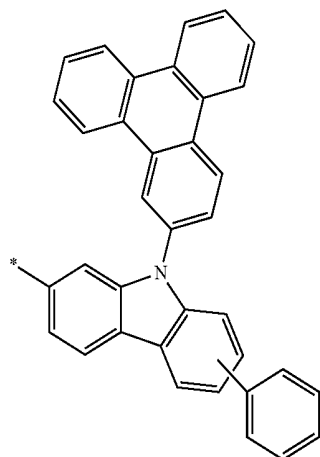


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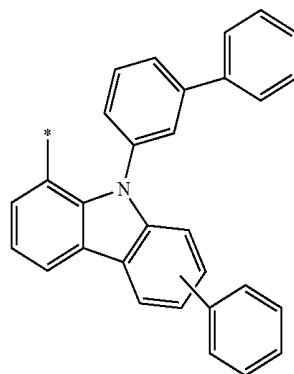
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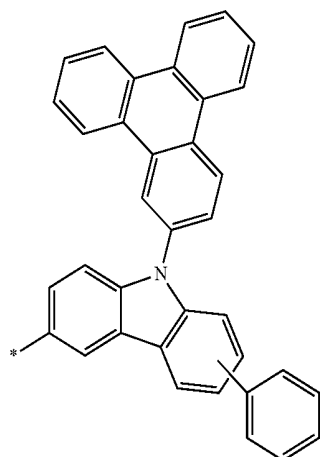
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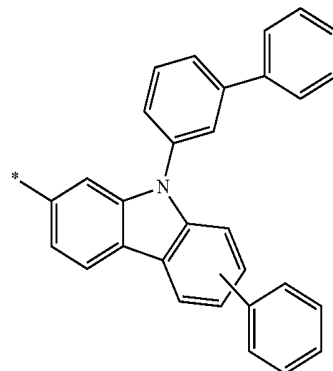
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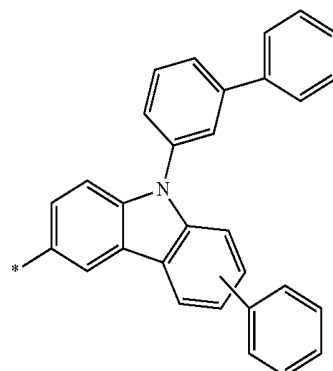
Formula 5-86



Formula 5-84

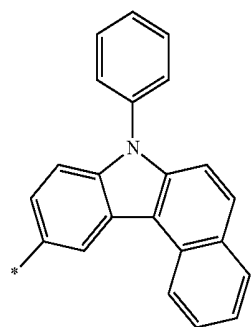
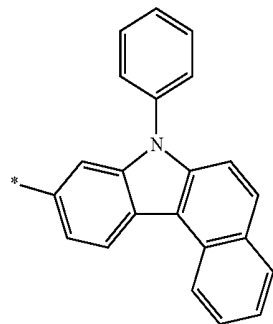
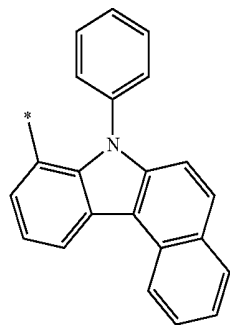
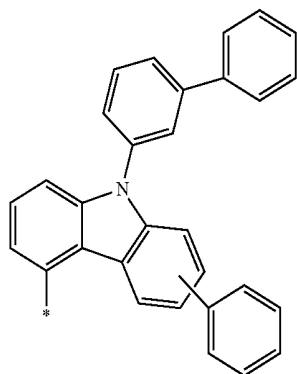


Formula 5-87



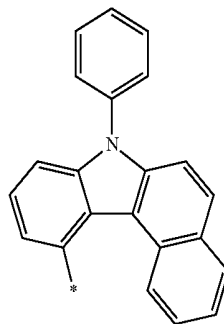
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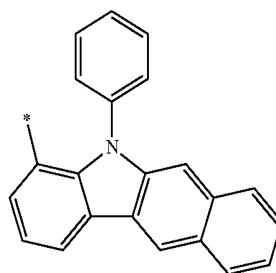


Formula 5-89

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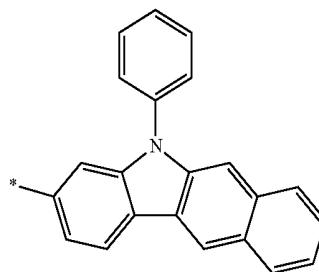


Formula 5-93



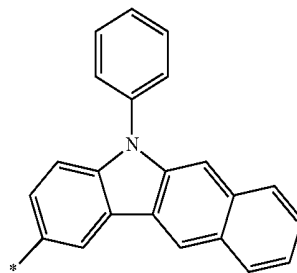
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Formula 5-90



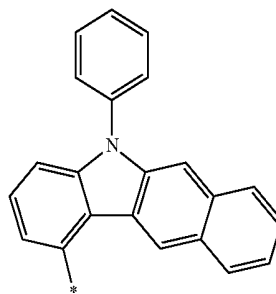
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Formula 5-91



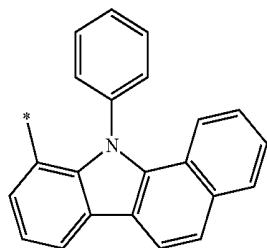
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Formula 5-92

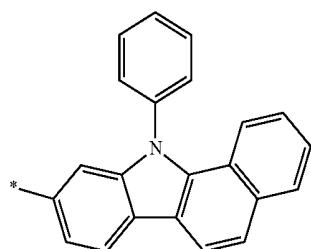


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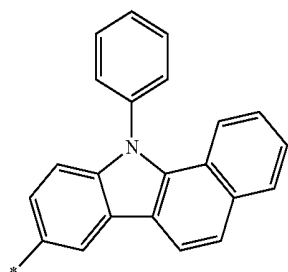
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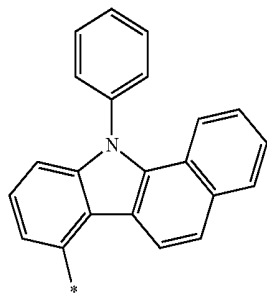
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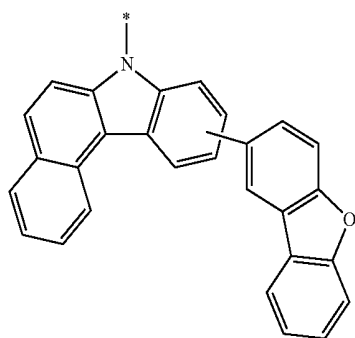
Formula 5-99



Formula 5-100

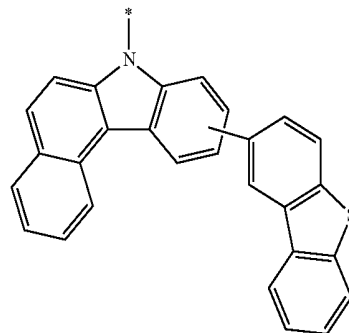


Formula 5-101

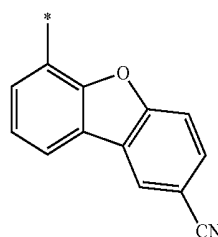


Formula 5-102

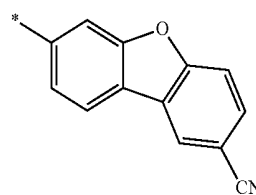
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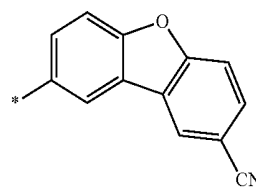
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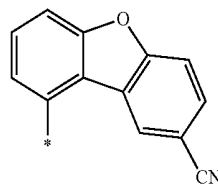
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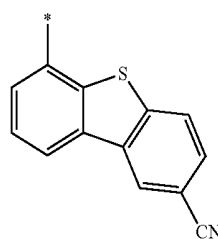
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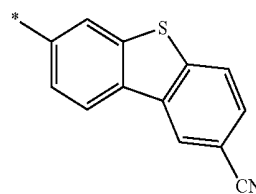
Formula 5-106



Formula 5-107

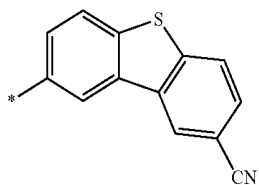


Formula 5-108

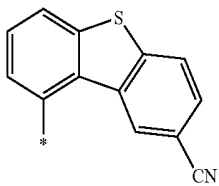


Formula 5-109

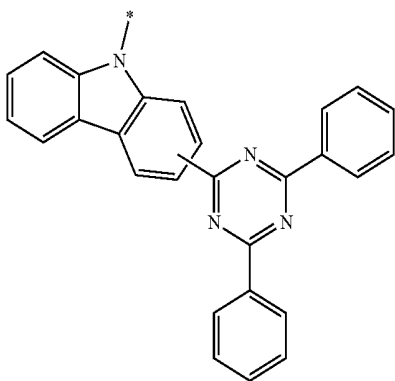
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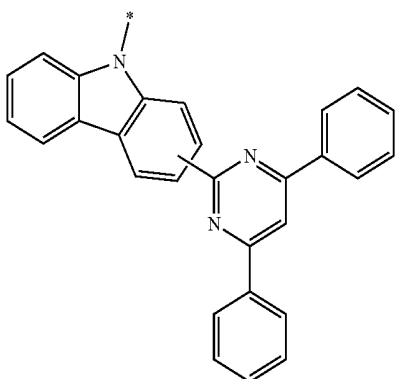
Formula 5-110



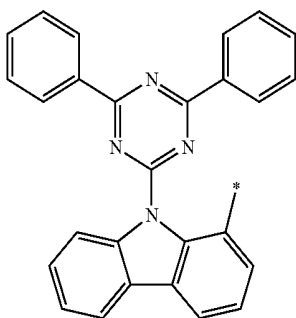
Formula 5-111



Formula 5-112

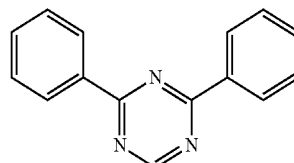


Formula 5-113

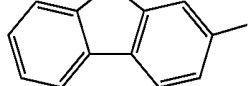


Formula 5-114

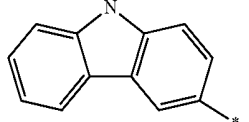
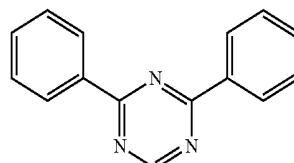
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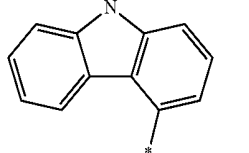
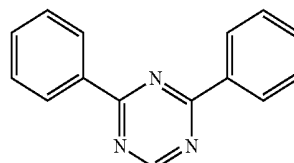
Formula 5-115



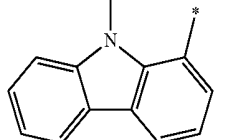
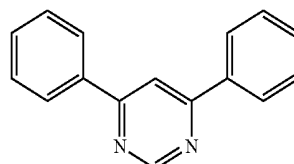
Formula 5-116



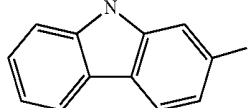
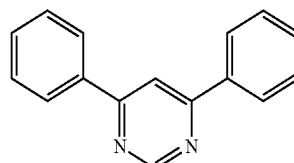
Formula 5-117



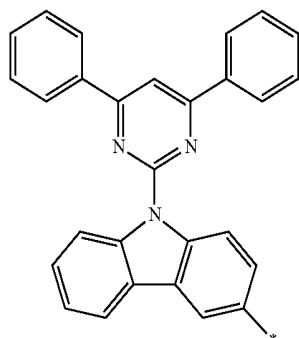
Formula 5-118



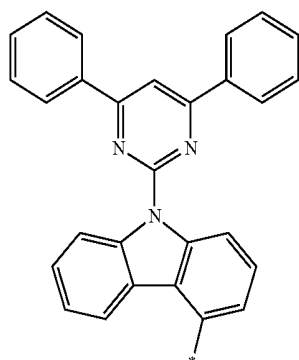
Formula 5-119



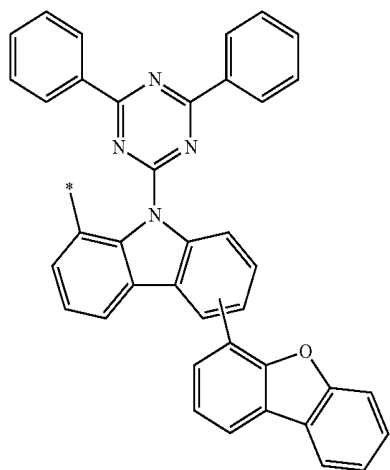
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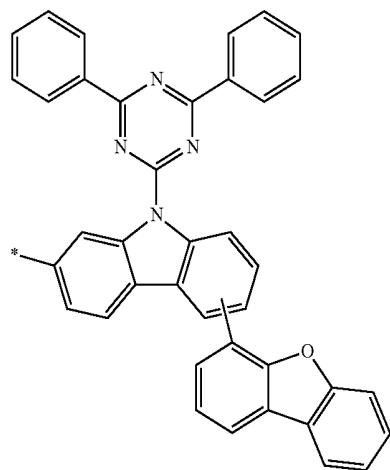
Formula 5-120



Formula 5-121

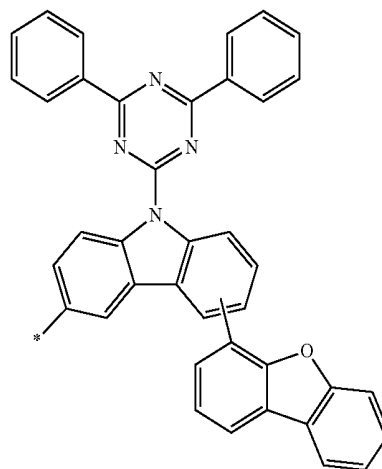


Formula 5-122

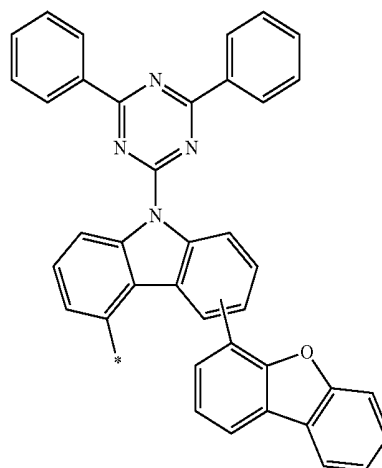


Formula 5-123

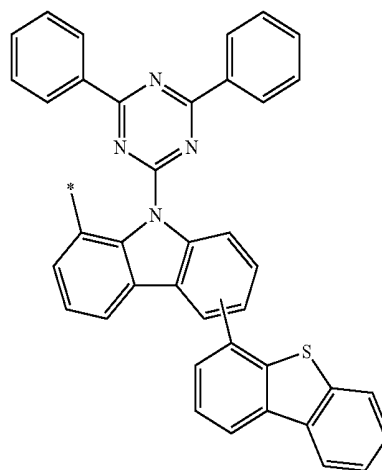
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Formula 5-124

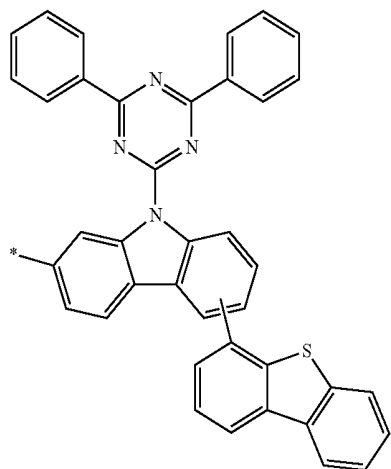


Formula 5-125



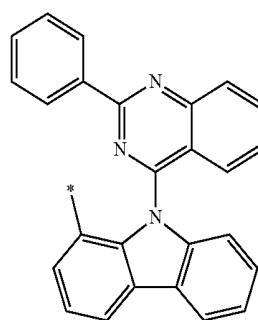
Formula 5-126

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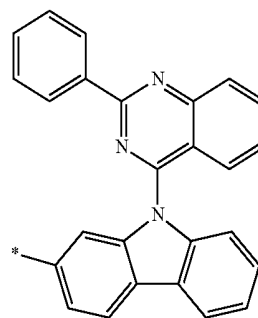
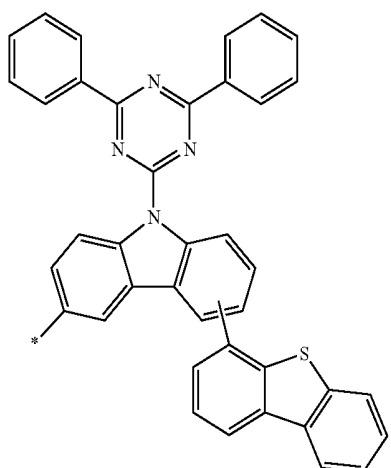
Formula 5-127

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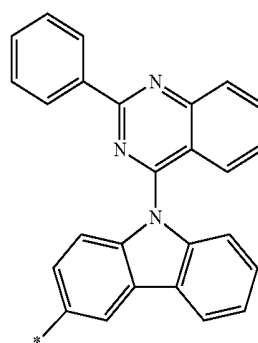
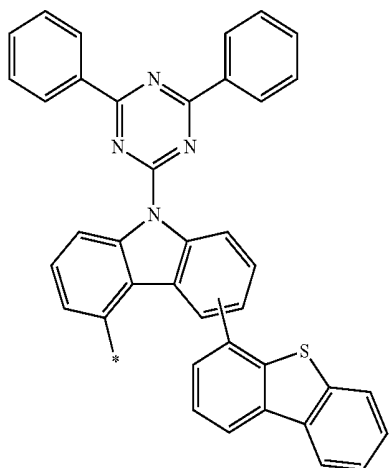
Formula 5-130

Formula 5-128



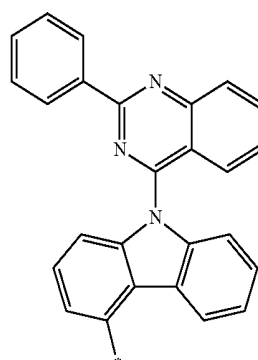
Formula 5-131

Formula 5-129



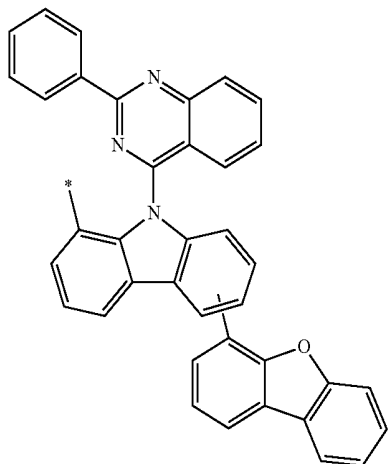
Formula 5-132

Formula 5-133



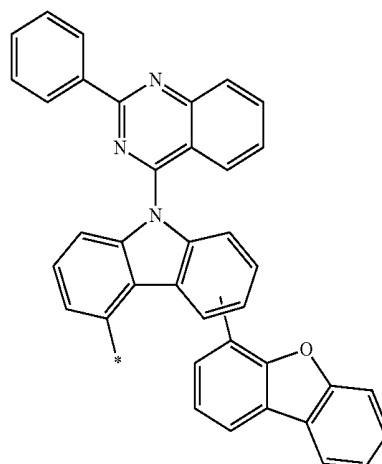
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Formula 5-134

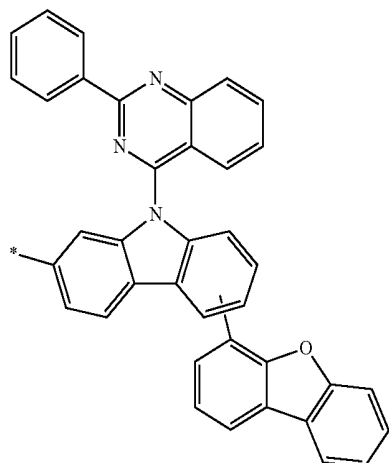


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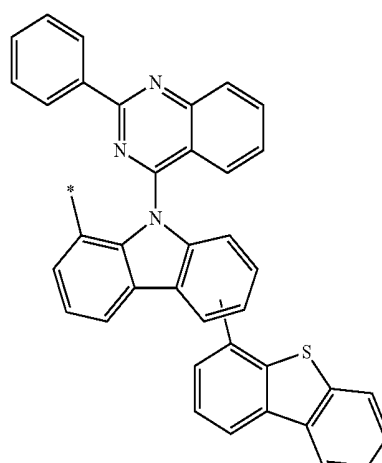
Formula 5-137



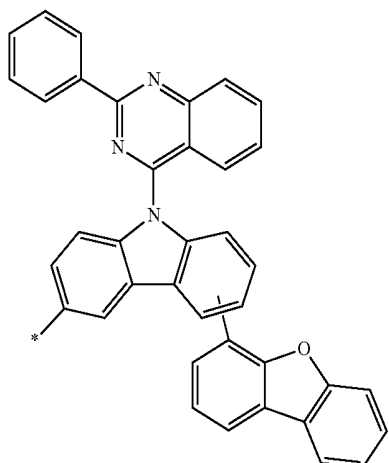
Formula 5-135



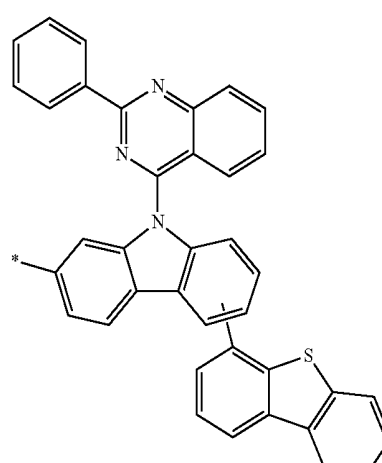
Formula 5-138



Formula 5-136

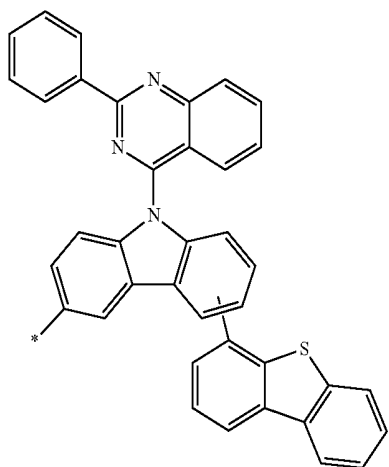


Formula 5-139

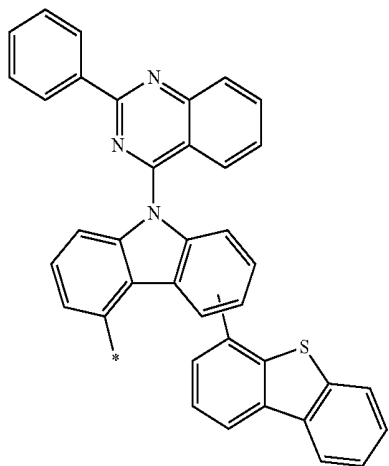


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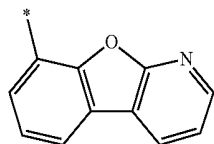
Formula 5-140



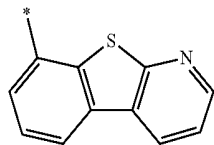
Formula 5-141



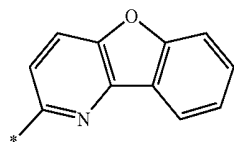
Formula 5-142



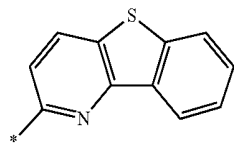
Formula 5-143



Formula 5-144



Formula 5-145



[0136] In Formula 1 above,  $R_3$  may be not a substituted or unsubstituted morpholinyl group.

[0137] In Formula 1 above,  $b_1$ , which indicates the number of  $R_1$ s, may be an integer of 1 to 3, and in some embodiments, may be 1 or 2. For example,  $b_1$  may be 1. When  $b_1$  is 2 or greater, the at least two  $R_1$  may be identical to or different from each other.  $b_2$  and  $b_3$  in Formula 1 may be understood based on the description of  $b_1$  and the structure of Formula 1.

[0138] In some embodiments, in any of the formulae herein, at least one of substituents of the substituted  $C_3$ - $C_{10}$  cycloalkylene group, the substituted  $C_2$ - $C_{10}$  heterocycloalkylene group, the substituted  $C_3$ - $C_{10}$  cycloalkenylene group, the substituted  $C_2$ - $C_{10}$  heterocycloalkenylene group, the substituted  $C_6$ - $C_{60}$  arylene group, the substituted  $C_2$ - $C_{60}$  heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted  $C_1$ - $C_{60}$  alkyl group, the substituted  $C_1$ - $C_{60}$  alkenyl group, the substituted  $C_2$ - $C_{60}$  alkynyl group, the substituted  $C_1$ - $C_{60}$  alkoxy group, the substituted  $C_3$ - $C_{10}$  cycloalkyl group, the substituted  $C_2$ - $C_{10}$  heterocycloalkyl group, the substituted  $C_3$ - $C_{10}$  cycloalkenyl group, the substituted  $C_2$ - $C_{10}$  heterocycloalkenyl group, the substituted  $C_6$ - $C_{60}$  aryl group, the substituted  $C_6$ - $C_{60}$  aryloxy group, the substituted  $C_6$ - $C_{60}$  arylthio group, the substituted  $C_2$ - $C_{60}$  heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from

[0139] a deuterium,  $-F$ ,  $-Cl$ ,  $-Br$ ,  $-I$ , a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{60}$  alkyl group, a  $C_2$ - $C_{60}$  alkenyl group, a  $C_2$ - $C_{60}$  alkynyl group, and a  $C_1$ - $C_{60}$  alkoxy group,

[0140] a  $C_1$ - $C_{60}$  alkyl group, and a  $C_1$ - $C_{60}$  alkoxy group, each substituted with at least one of a deuterium,  $-F$ ,  $-Cl$ ,  $-Br$ ,  $-I$ , a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group,  $-N(Q_{11})(Q_{12})$ ,  $-Si(Q_{13})(Q_{14})(Q_{15})$ , and  $-B(Q_{16})(Q_{17})$ ,

[0141] a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group,

[0142] a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium,  $-F$ ,  $-Cl$ ,  $-Br$ ,  $-I$ , a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{60}$  alkyl group, a  $C_1$ - $C_{60}$  alkoxy group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group,  $-N(Q_{21})(Q_{22})$ ,  $-Si(Q_{23})(Q_{24})(Q_{25})$ , and  $-B(Q_{26})(Q_{27})$ , and

[0143]  $-N(Q_{31})(Q_{32})$ ,  $-Si(Q_{33})(Q_{34})(Q_{35})$ , and  $-B(Q_{36})(Q_{37})$ ;

[0144]  $Q_{11}$  to  $Q_{17}$ ,  $Q_{21}$  to  $Q_{27}$ , and  $Q_{31}$  to  $Q_{37}$  may be each independently selected from a hydrogen, a  $C_1$ - $C_{60}$  alkyl group, a  $C_1$ - $C_{60}$  alkoxy group, a  $C_3$ - $C_{10}$  cycloalkyl group, a

$C_6-C_{60}$  aryl group, a  $C_6-C_{60}$  aryloxy group, a  $C_6-C_{60}$  arylthio group, a  $C_2-C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0145] In some other embodiments, in any of the formulae herein, at least one of substituents of the substituted  $C_3-C_{10}$  cycloalkylene group, the substituted  $C_1-C_{10}$  heterocycloalkylene group, the substituted  $C_3-C_{10}$  cycloalkenylene group, the substituted  $C_1-C_{10}$  heterocycloalkenylene group, the substituted  $C_6-C_{60}$  arylene group, the substituted  $C_2-C_{60}$  heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted  $C_1-C_{60}$  alkyl group, the substituted  $C_2-C_{60}$  alkenyl group, the substituted  $C_2-C_{60}$  alkynyl group, the substituted  $C_1-C_{60}$  alkoxy group, the substituted  $C_3-C_{10}$  cycloalkyl group, the substituted  $C_2-C_{10}$  heterocycloalkyl group, the substituted  $C_3-C_{10}$  cycloalkenyl group, the substituted  $C_2-C_{10}$  heterocycloalkenyl group, the substituted  $C_6-C_{60}$  aryl group, the substituted  $C_6-C_{60}$  aryloxy group, the substituted  $C_6-C_{60}$  arylthio group, the substituted  $C_2-C_{60}$  heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from

[0146] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a hydrazine group, a  $C_1-C_{60}$  alkyl group, a  $C_2-C_{60}$  alkenyl group, a  $C_2-C_{60}$  alkynyl group, and a  $C_1-C_{60}$  alkoxy group,

[0147] a  $C_1-C_{60}$  alkyl group, and a  $C_1-C_{60}$  alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a dibenzofluorenyl group, a phenaleny group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —N(Q<sub>11</sub>)(Q<sub>12</sub>), —Si(Q<sub>13</sub>)(Q<sub>14</sub>)(Q<sub>15</sub>), and —B(Q<sub>16</sub>)(Q<sub>17</sub>),

[0148] a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl

group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a dibenzofluorenyl group, a phenaleny group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group,

[0149] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a dibenzofluorenyl group, a phenaleny group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthroli-nyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1-C_{60}$  alkyl group, a  $C_1-C_{60}$  alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a dibenzofluorenyl group, a phenaleny group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyre-

nyl group, a chrysenyl group, a naphthacenylyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenylyl group, a pentacenylyl group, a rubicenylyl group, a coronenylyl group, an ovalenylyl group, a pyrrolylyl group, a thiophenylyl group, a furanylyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinylyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group,  $-N(Q_{21})(Q_{22})$ ,  $-Si(Q_{23})(Q_{24})(Q_{25})$ , and  $-B(Q_{26})(Q_{27})$ , and

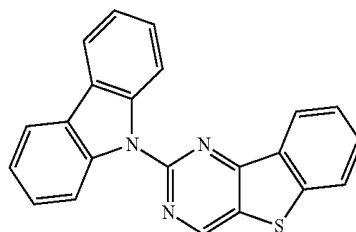
**[0150]**  $-N(Q_{31})(Q_{32})$ ,  $-Si(Q_{33})(Q_{34})(Q_{35})$ , and  $-B(Q_{36})(Q_{37})$ ;

**[0151]**  $Q_1$  to  $Q_7$ ,  $Q_{11}$  to  $Q_{17}$ ,  $Q_{21}$  to  $Q_{27}$ , and  $Q_{31}$  to  $Q_{37}$  may be each independently selected from a hydrogen, a  $C_1$ - $C_{60}$  alkyl group, a  $C_2$ - $C_{60}$  alkenyl group, a  $C_2$ - $C_{60}$  alkynyl group, a  $C_1$ - $C_{60}$  alkoxy group, a phenyl group, a pentalenylyl group, an indenyl group, a naphthyl group, an azulenylyl group, a heptalenylyl group, an indacenylyl group, an acenaphthyl group, a fluorenylyl group, a spiro-fluorenylyl group, a dibenzofluorenylyl group, a dibenzofluorenylyl group, a phenalenylyl group, a phenanthrenyl group, an anthracenylyl group, a fluoranthenylyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenylyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenylyl group, a pentacenylyl group, a rubicenylyl group, a coronenylyl group, an ovalenylyl group, a pyrrolylyl group, a thiophenylyl group, a furanylyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinylyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

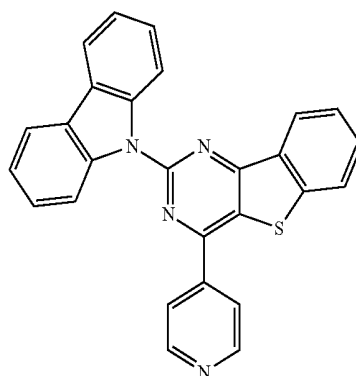
**[0152]** In some embodiments, the condensed cyclic compound of Formula 1 above may be one of Compounds listed as below, but is not limited thereto:

**[0153]** [Group I]

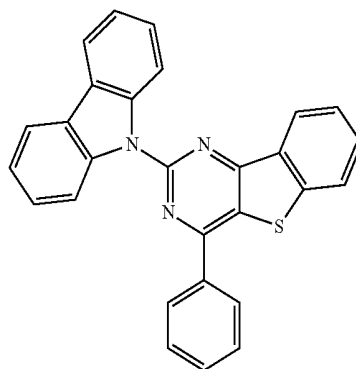
**[0154]** Group of  $X_1=S$  in Formula 1-1



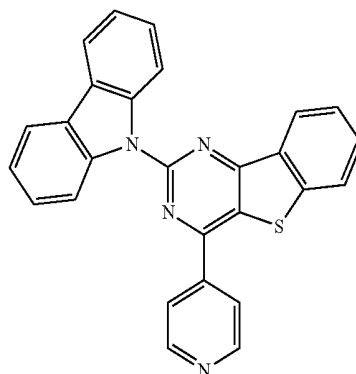
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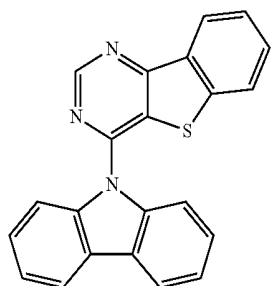


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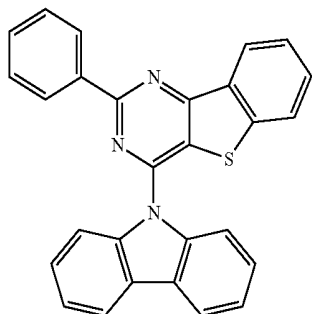


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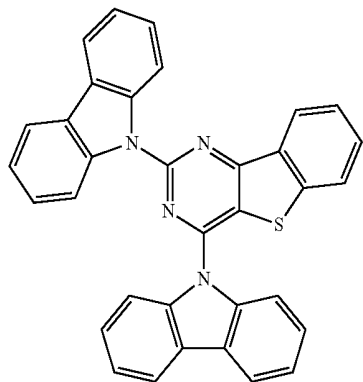
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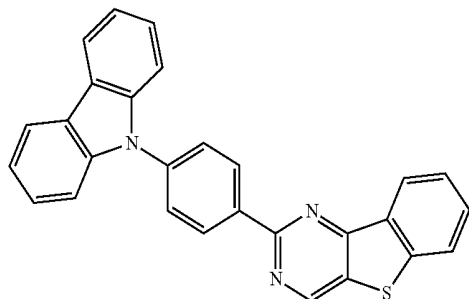
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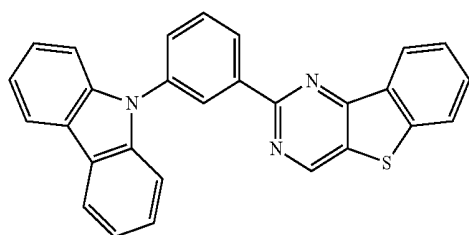
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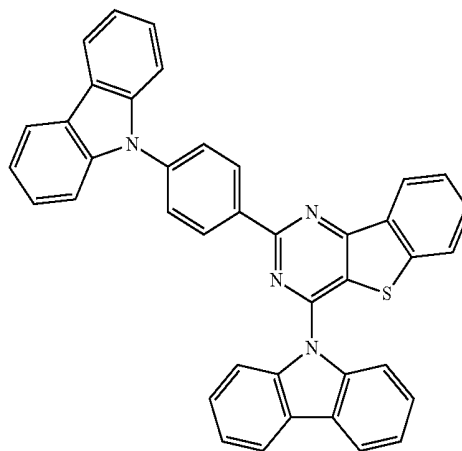


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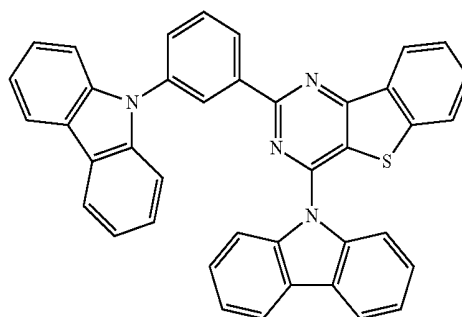


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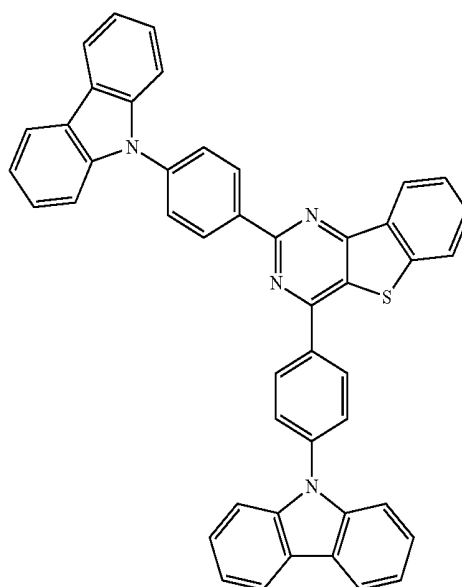
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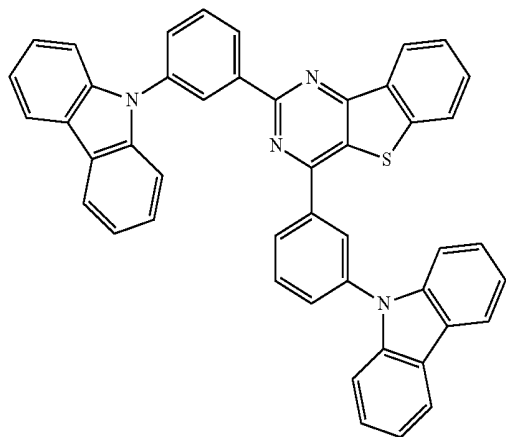
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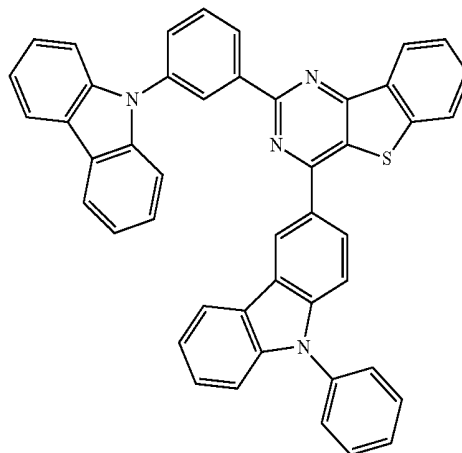
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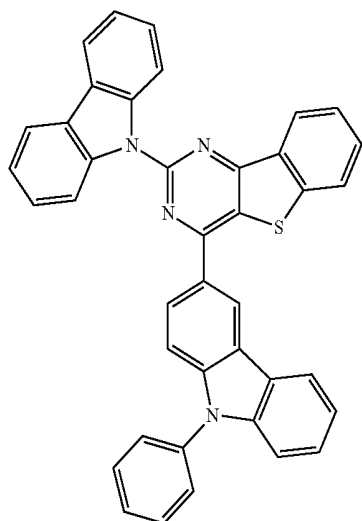


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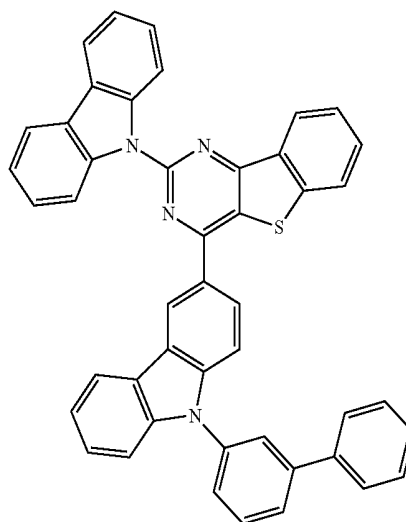
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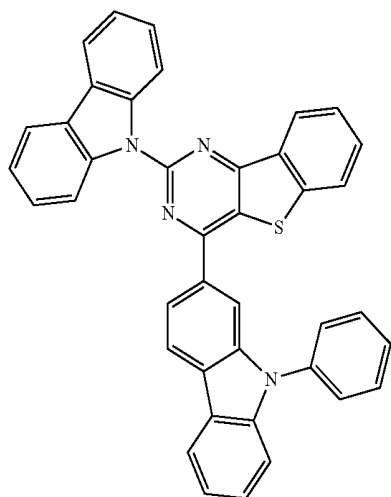
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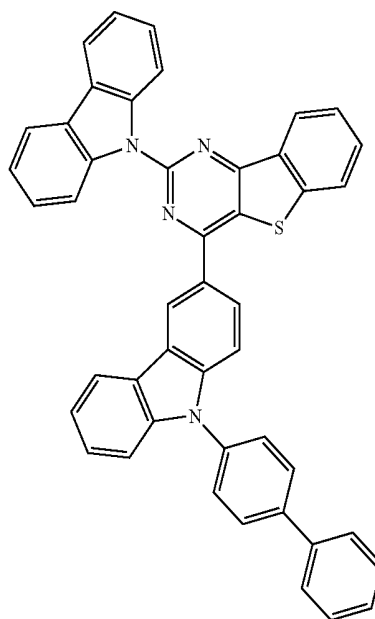
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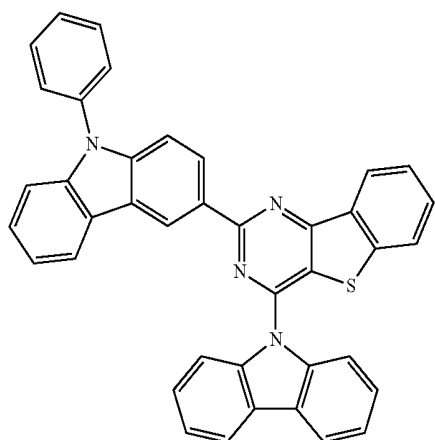
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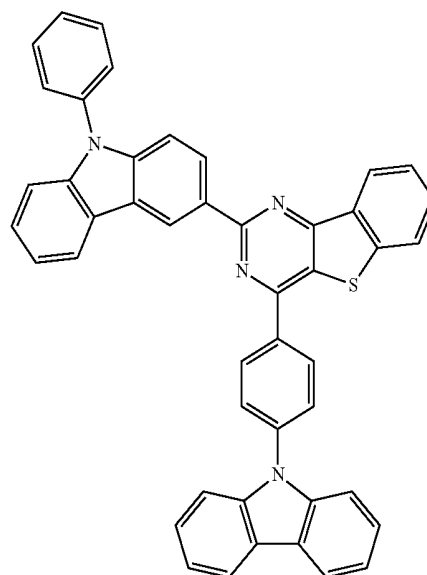


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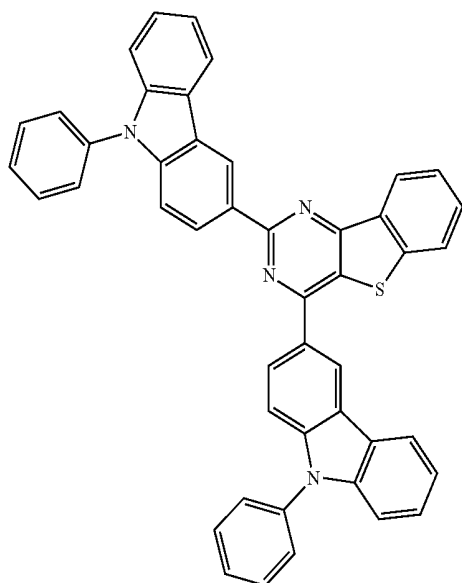
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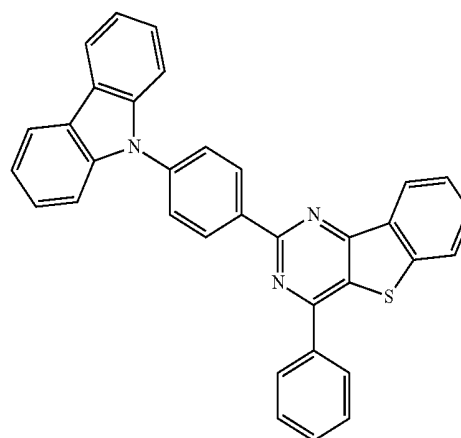


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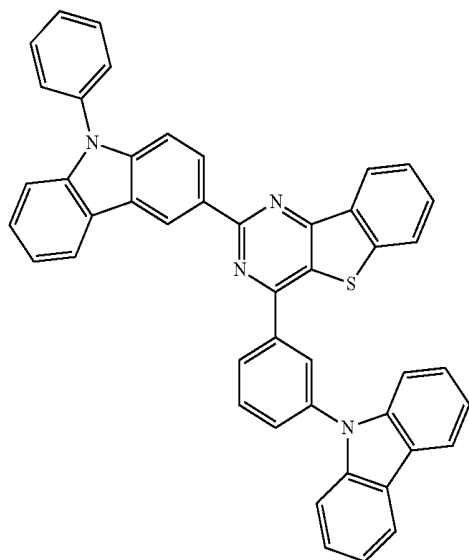
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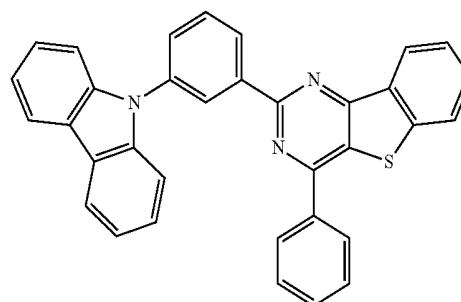
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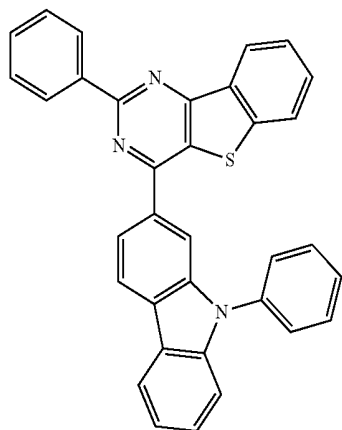


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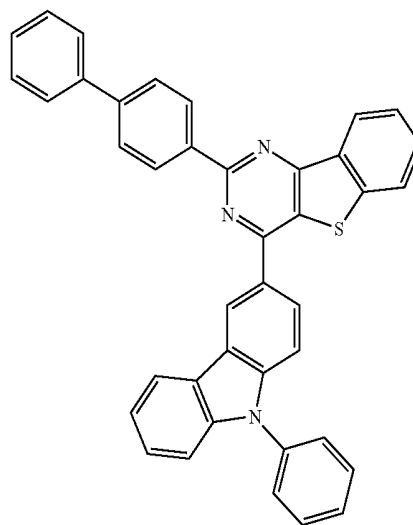
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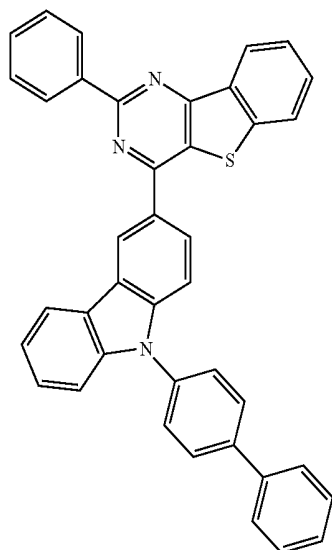


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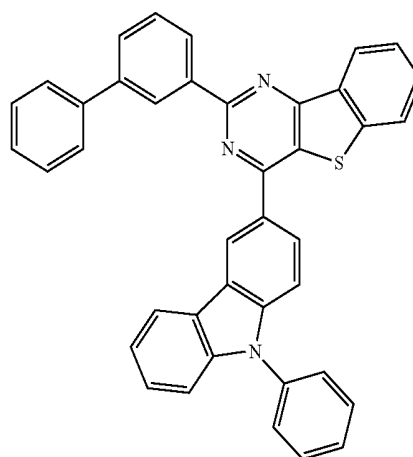
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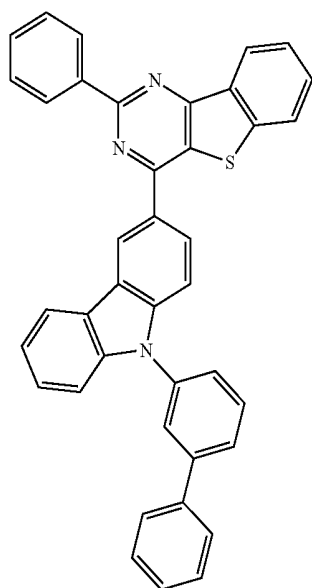
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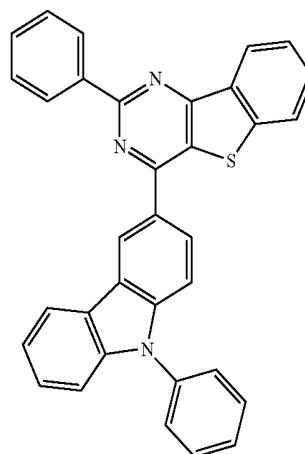
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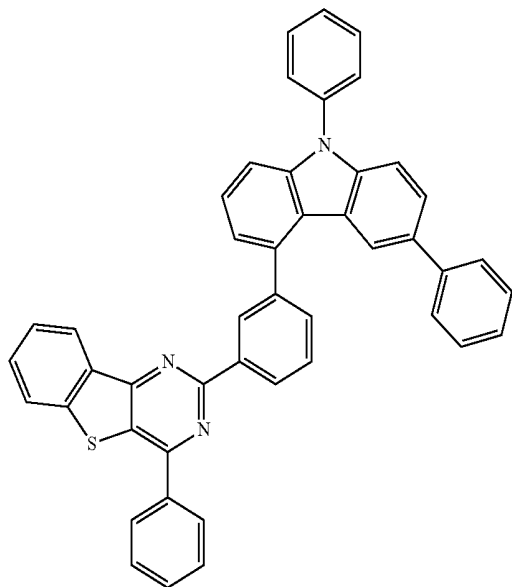
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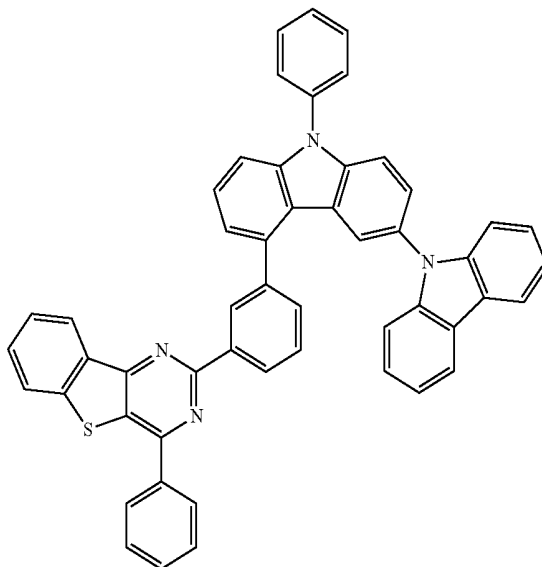
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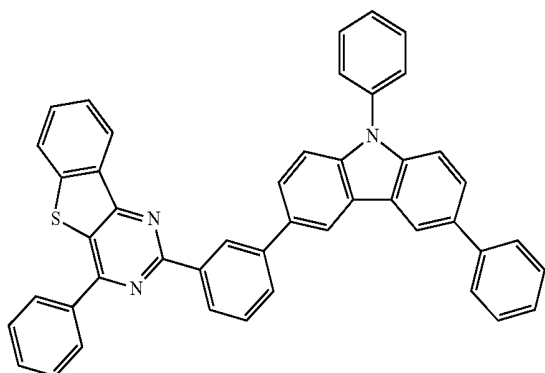


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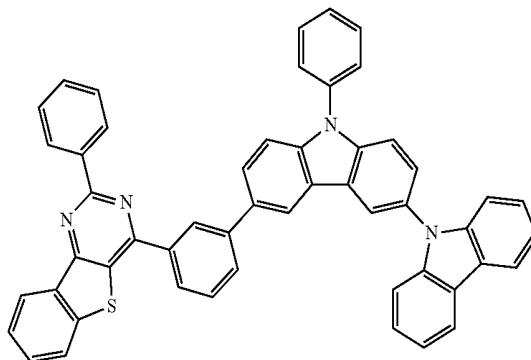
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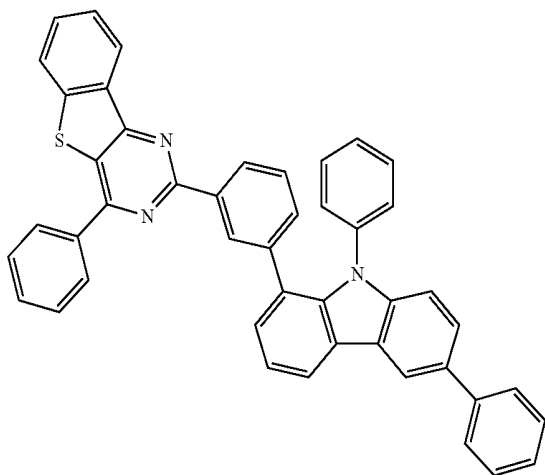
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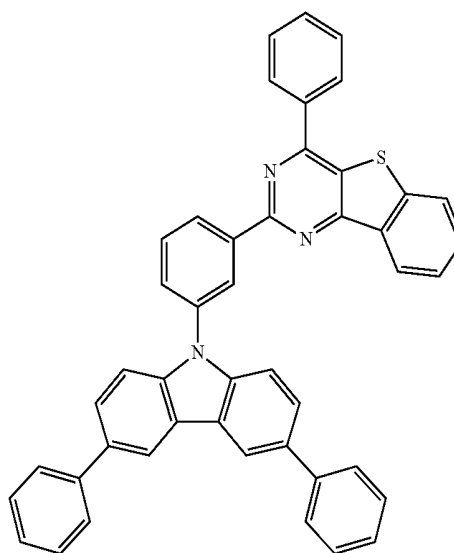
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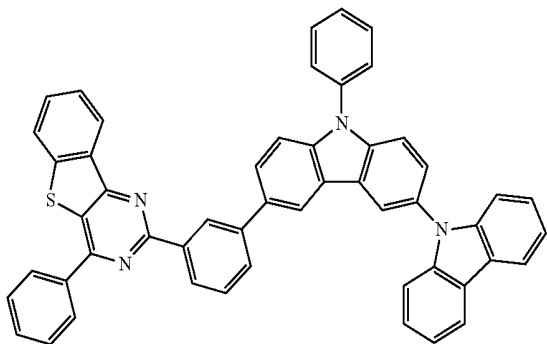


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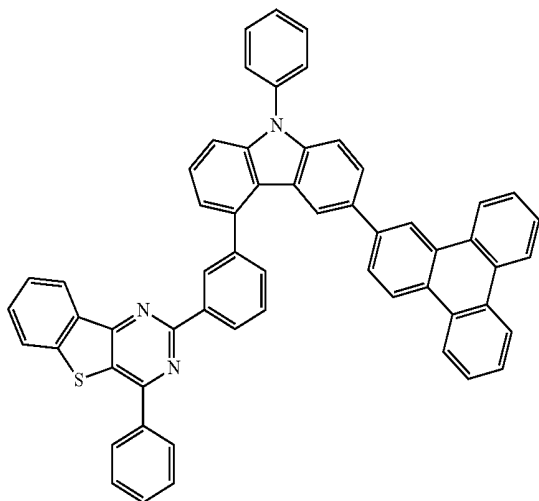


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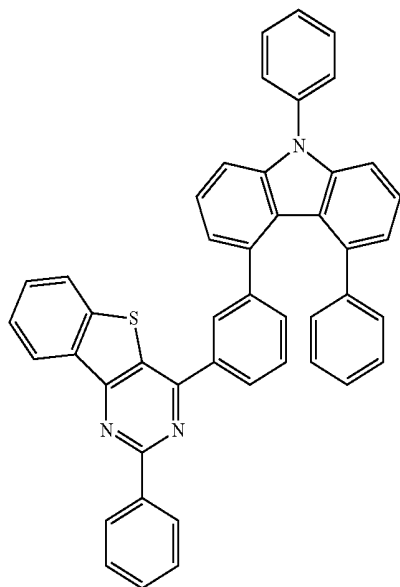
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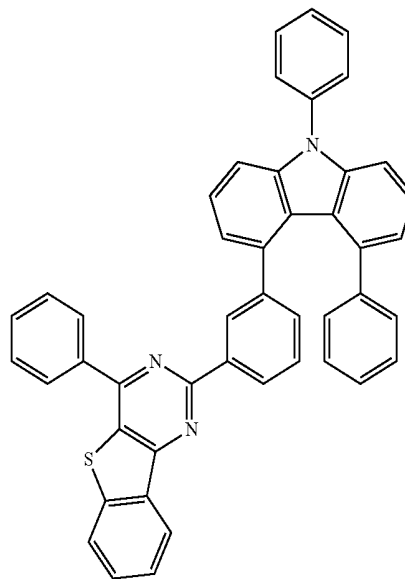


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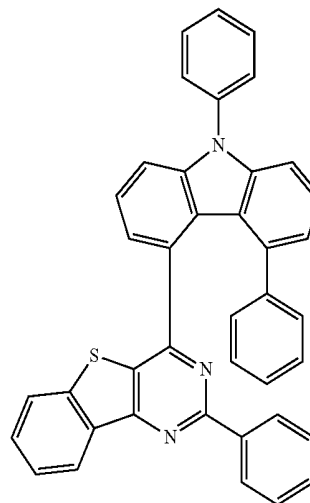


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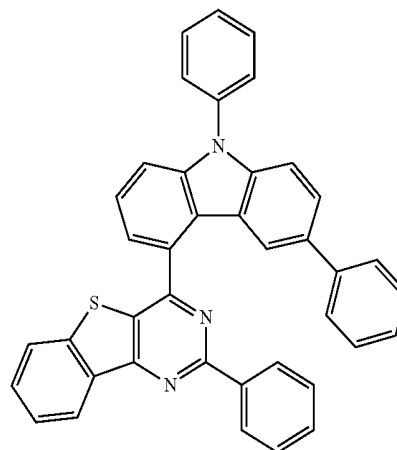
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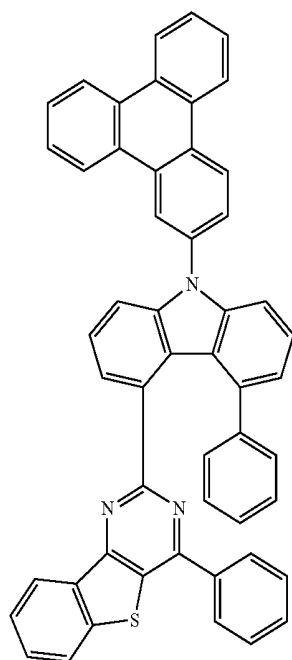
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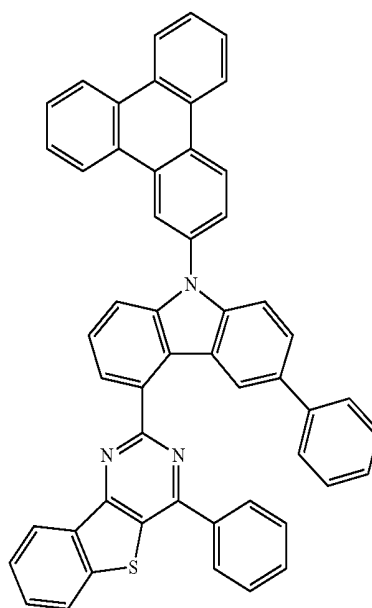


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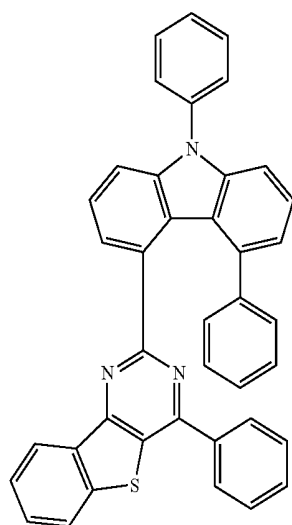


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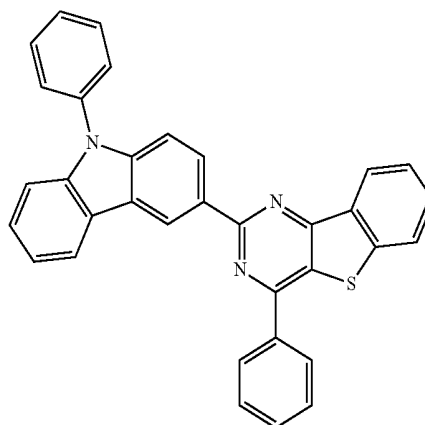


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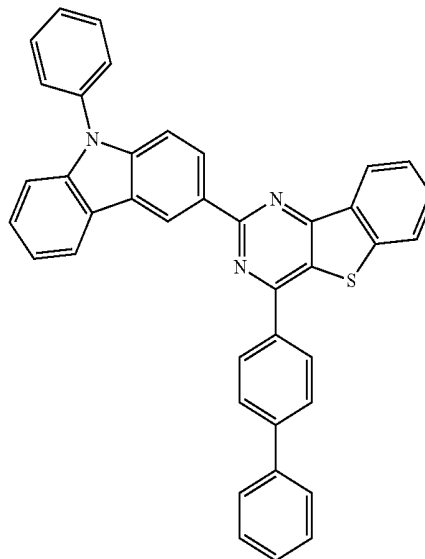
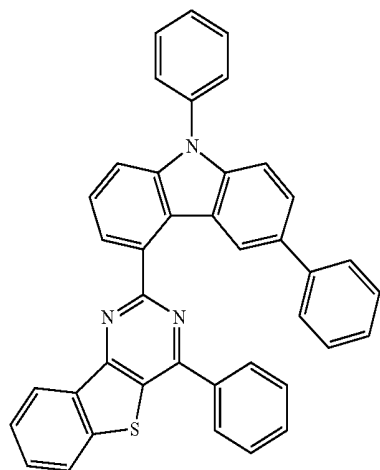
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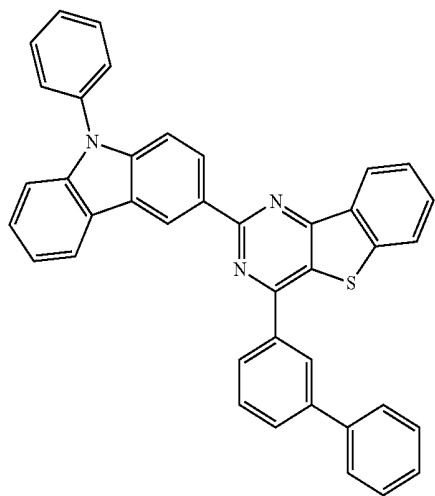
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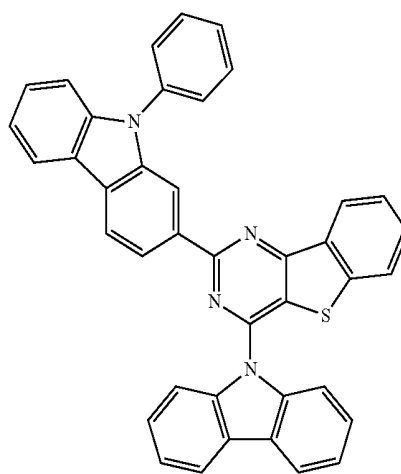
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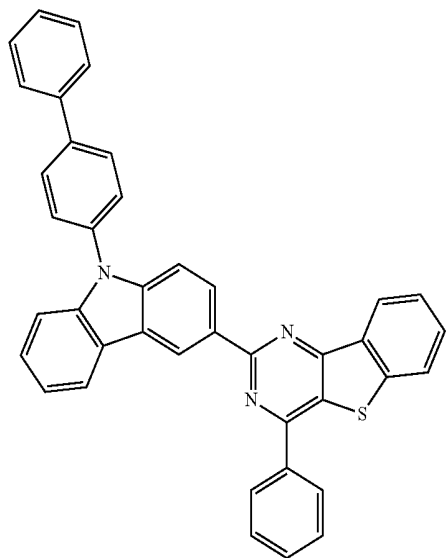


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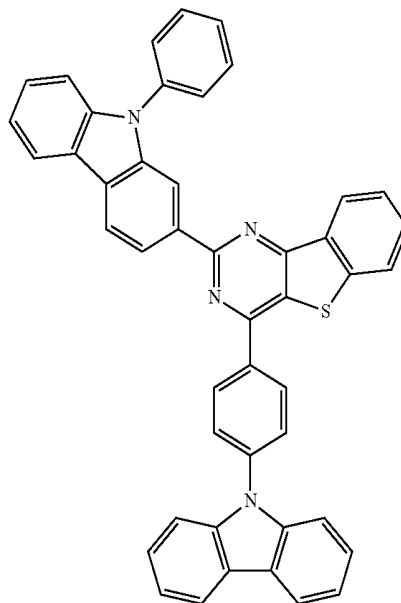
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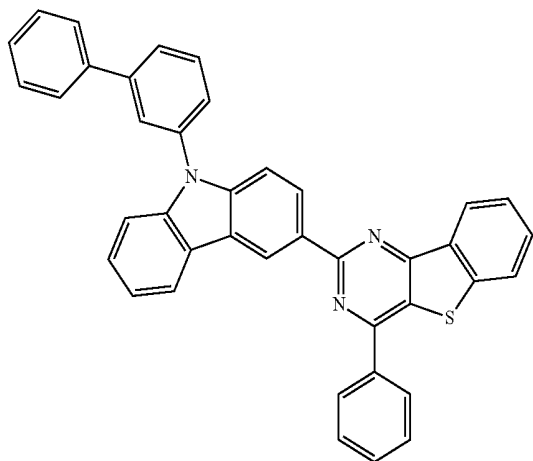
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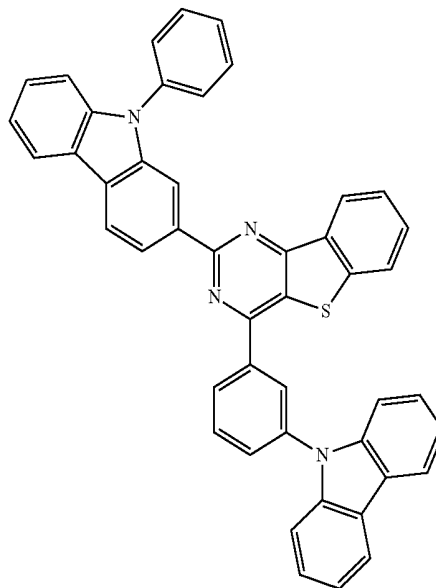
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a-5

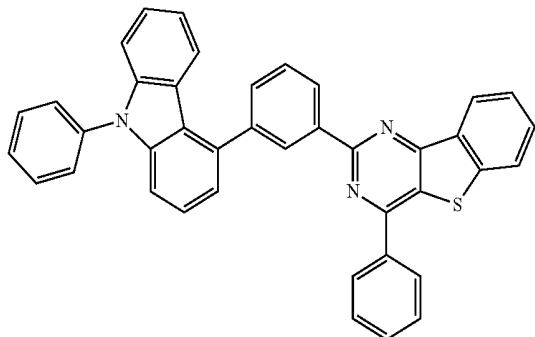


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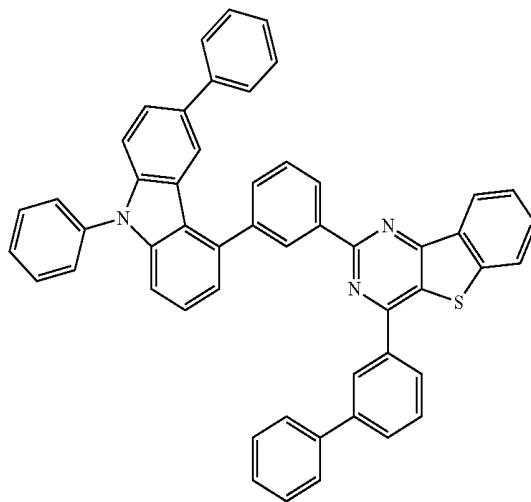
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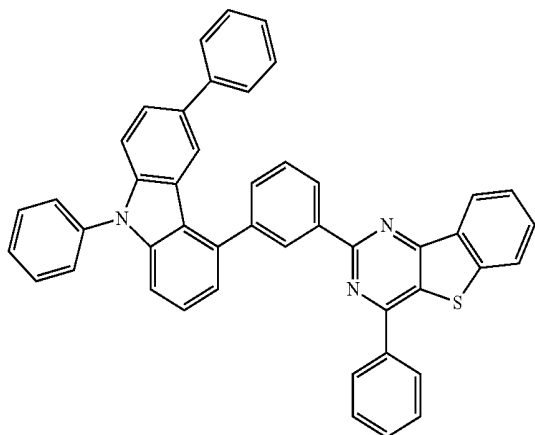


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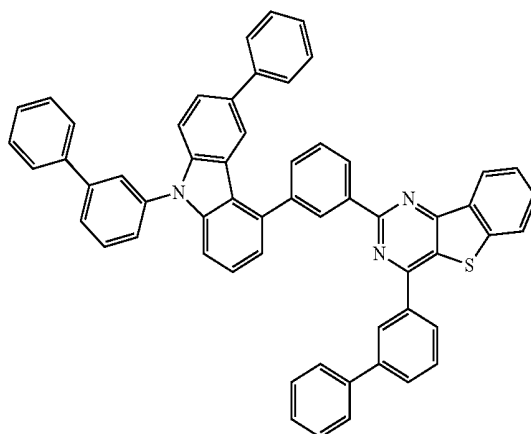
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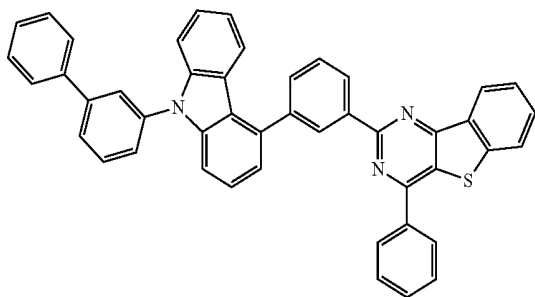
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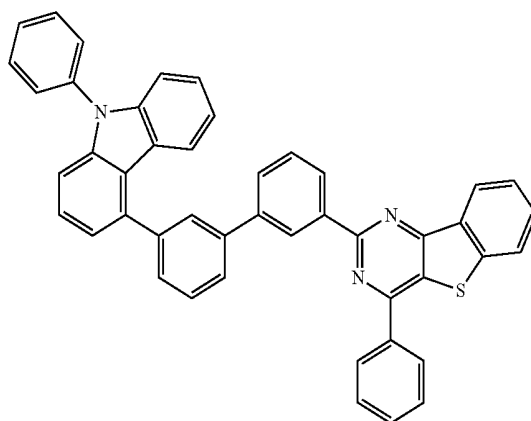
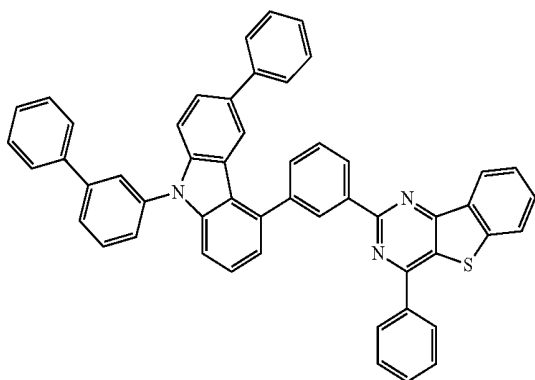


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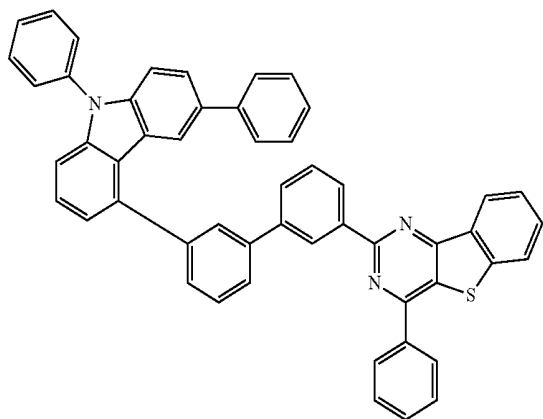
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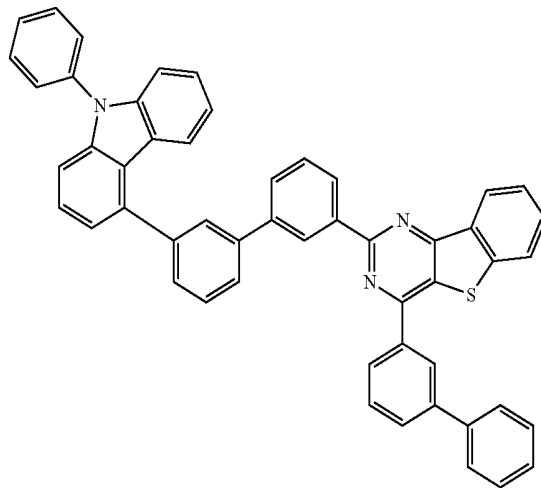
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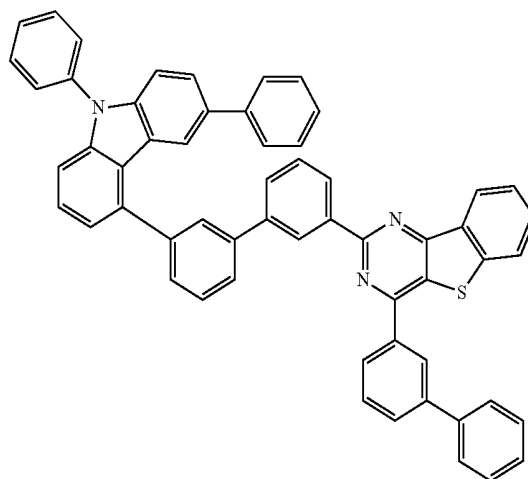
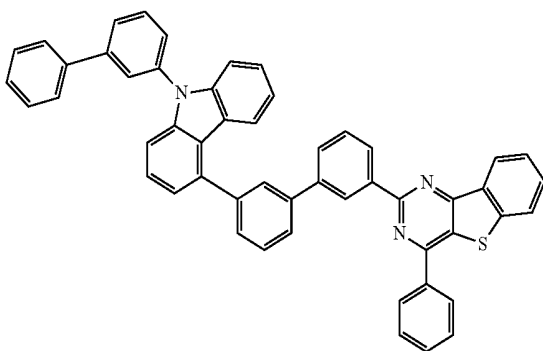
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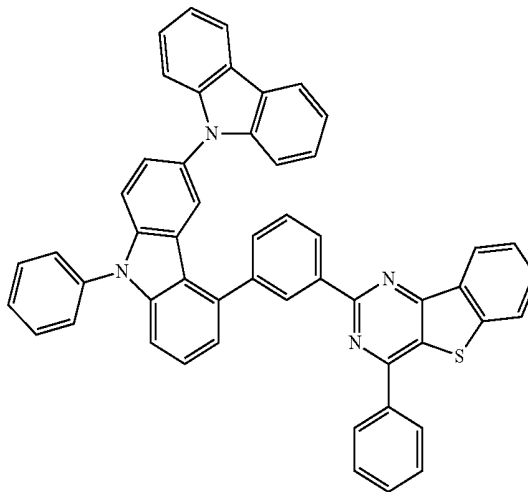
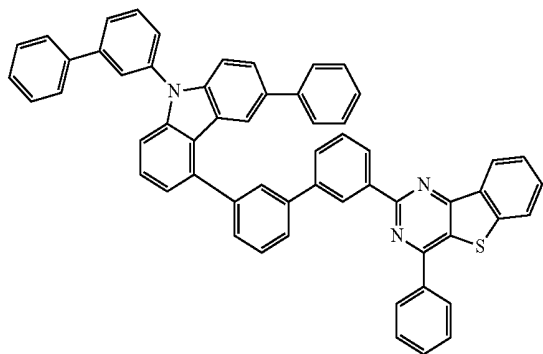
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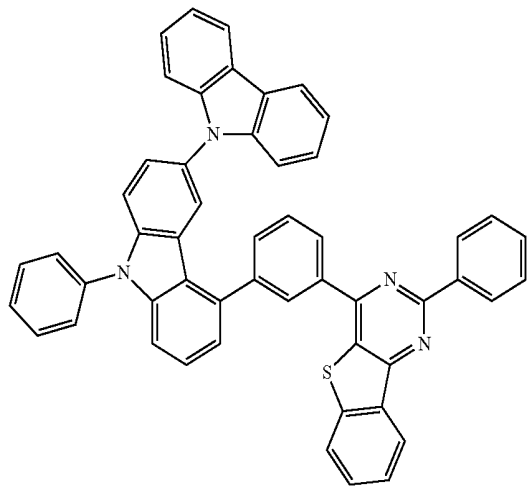
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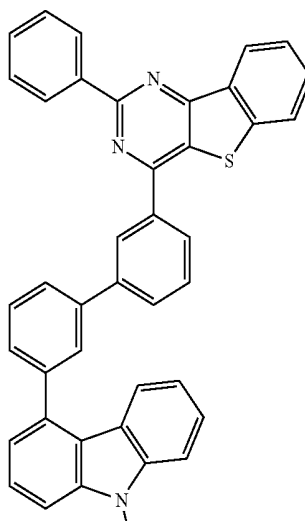
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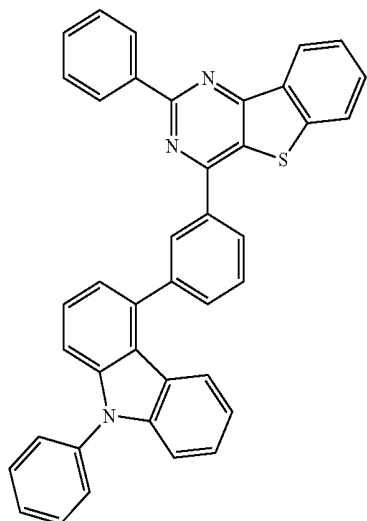


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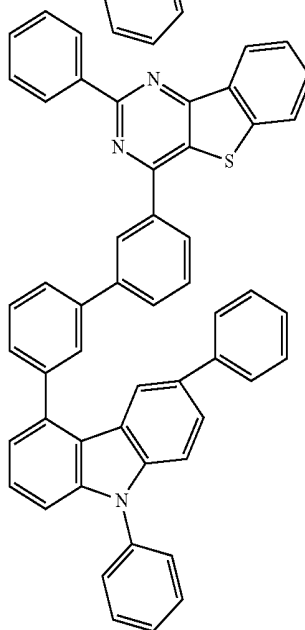
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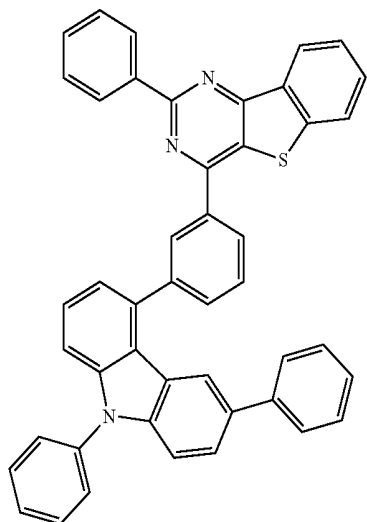
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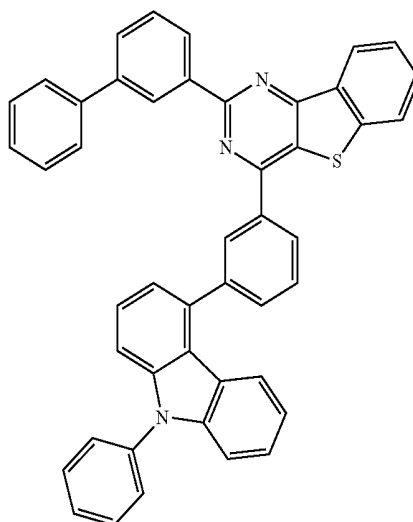
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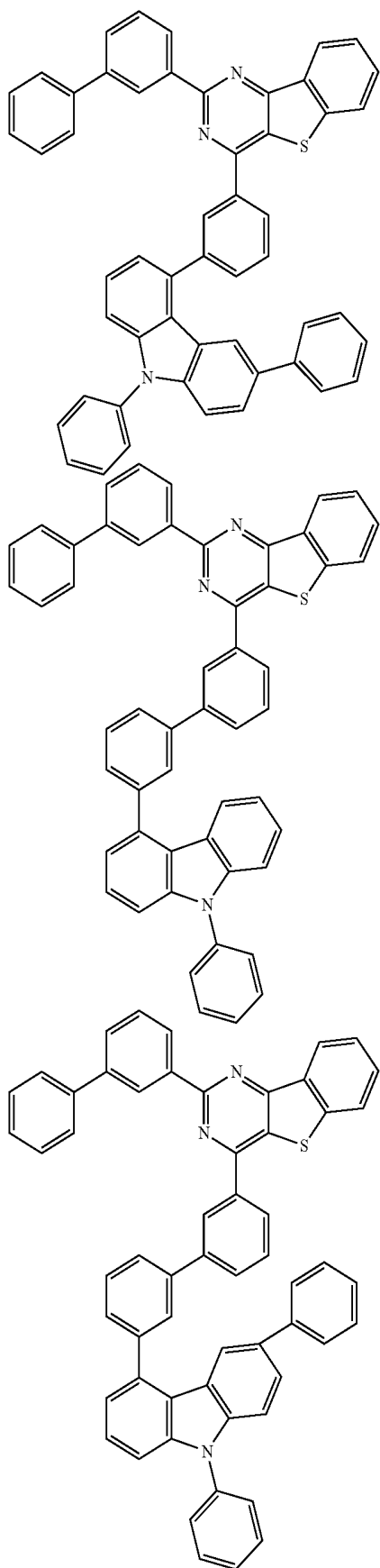
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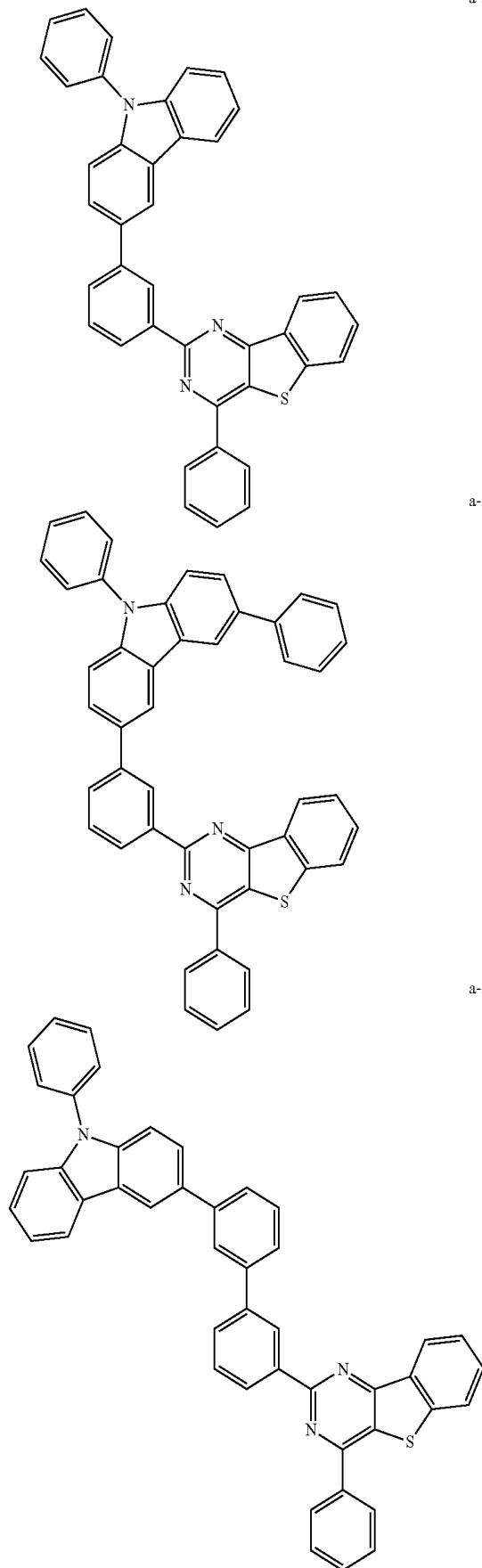


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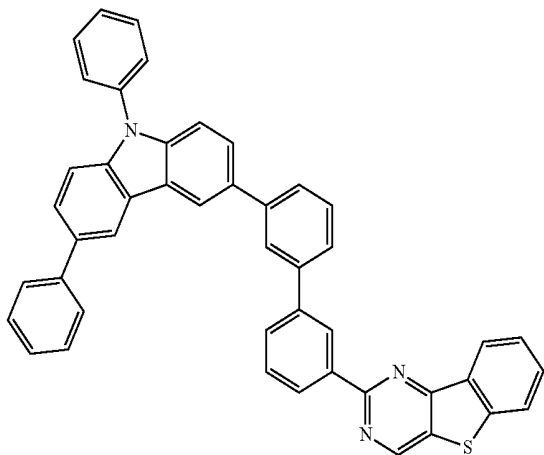
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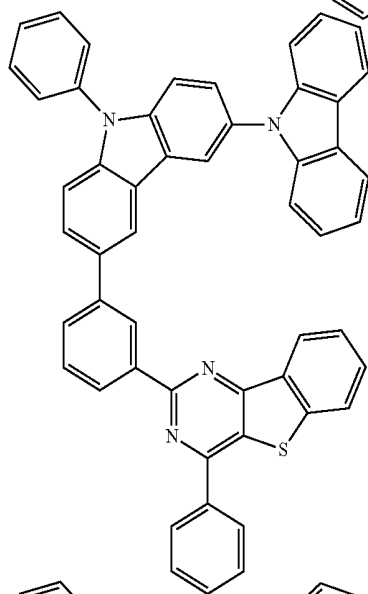
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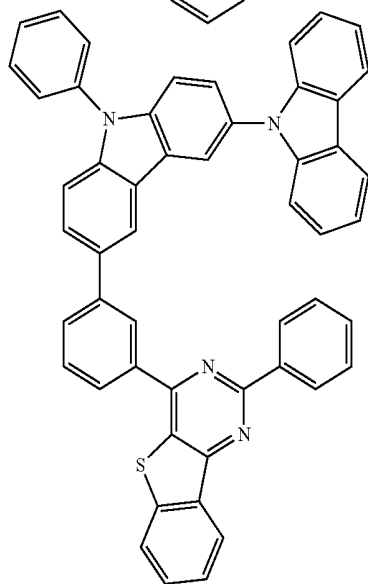
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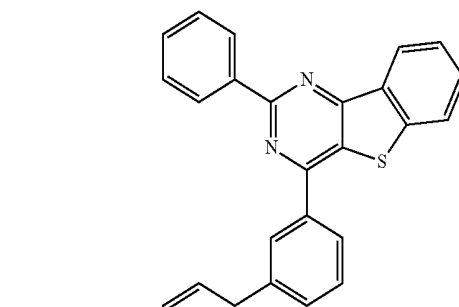


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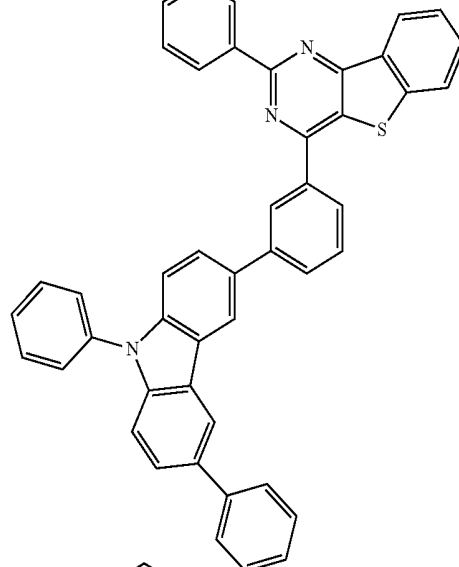


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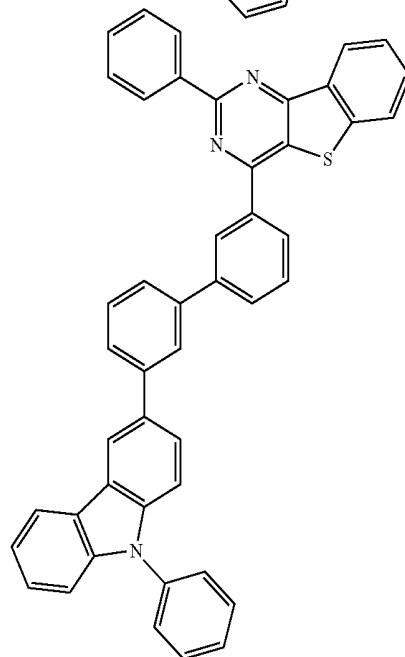
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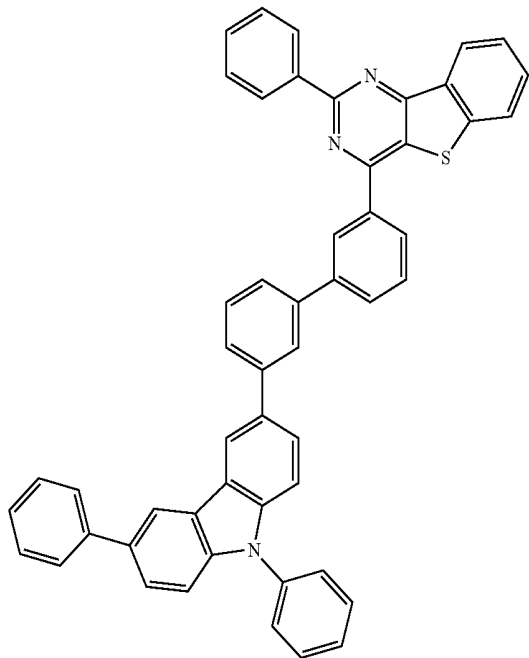


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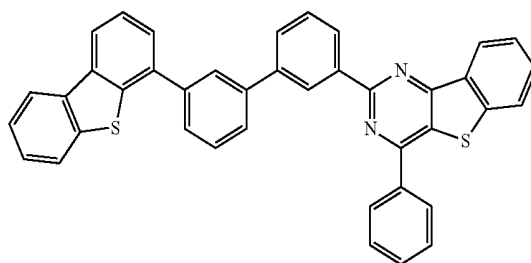
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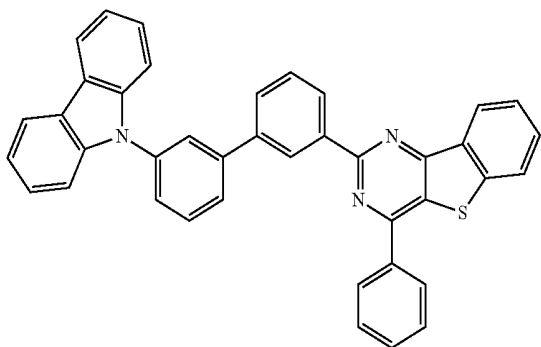


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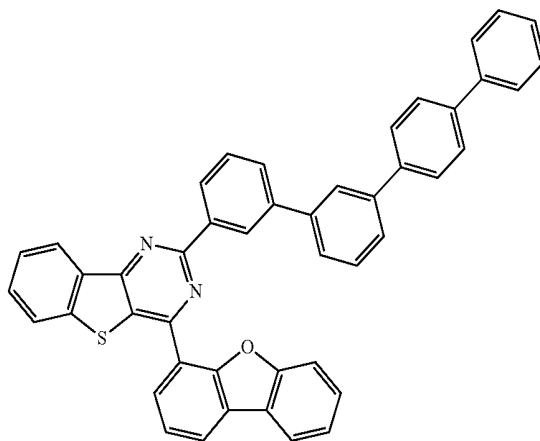
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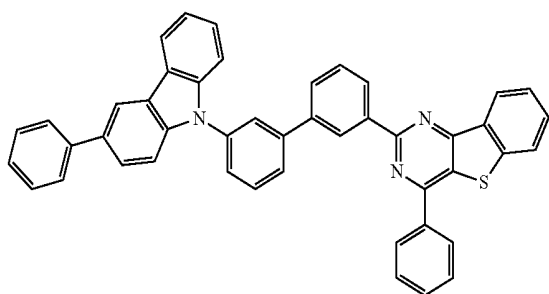
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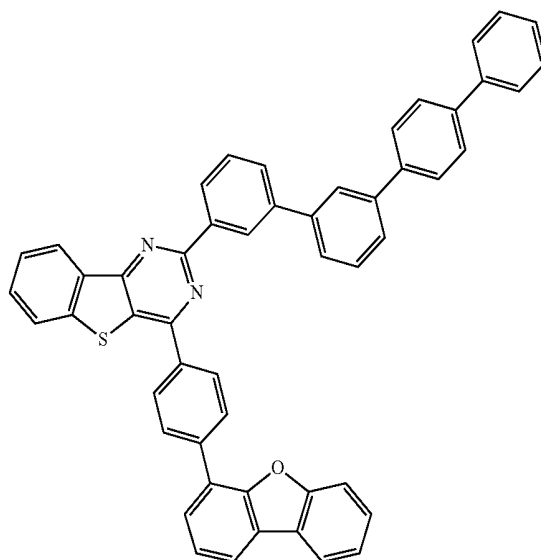
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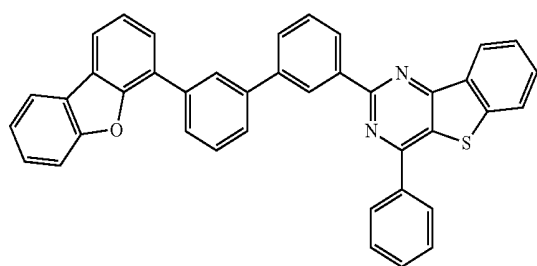
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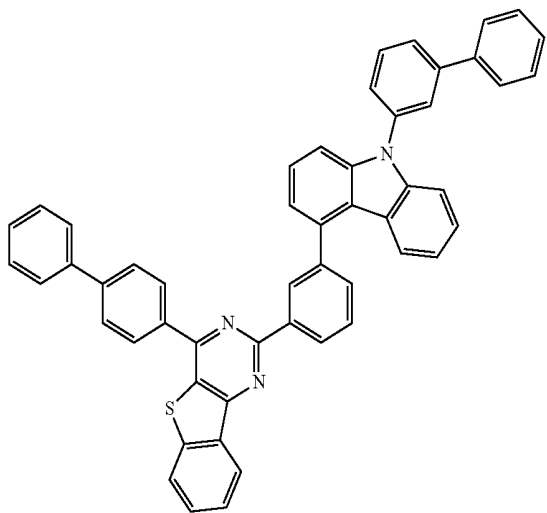


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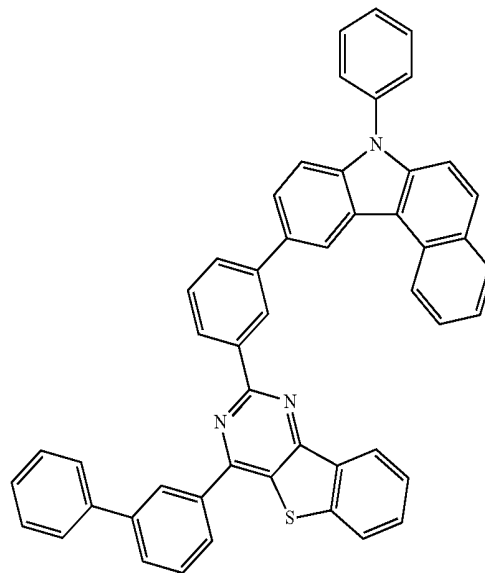
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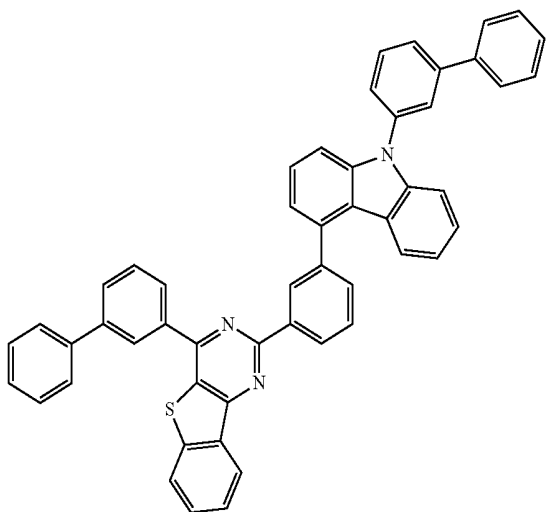


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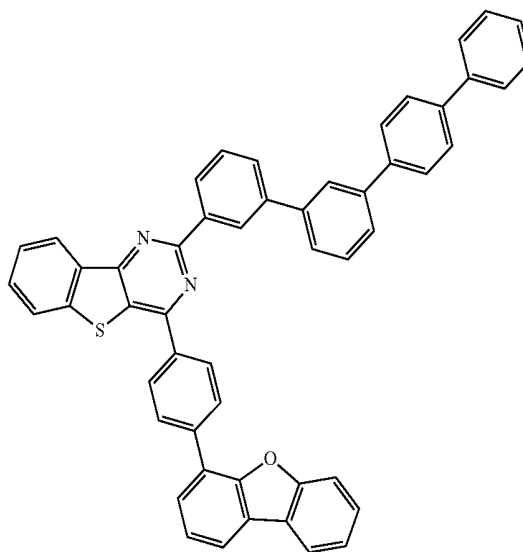
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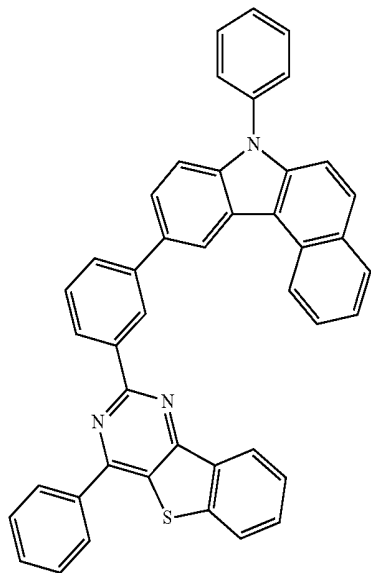
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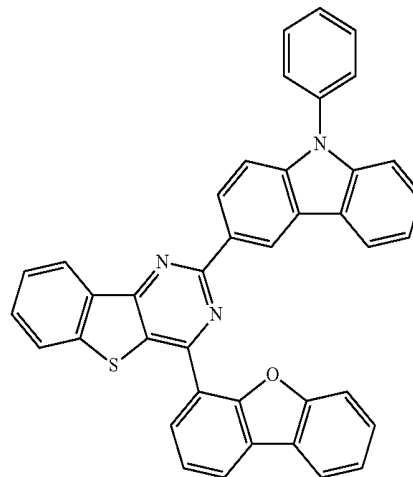
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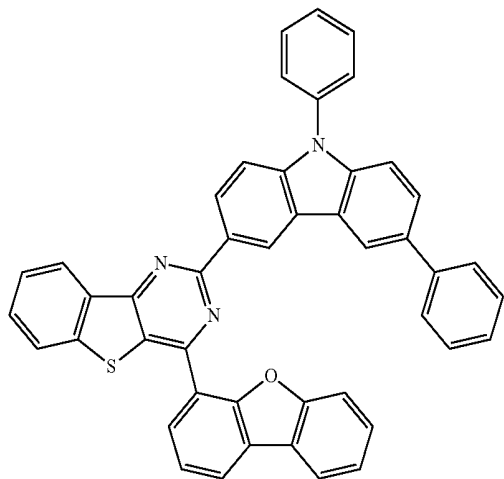


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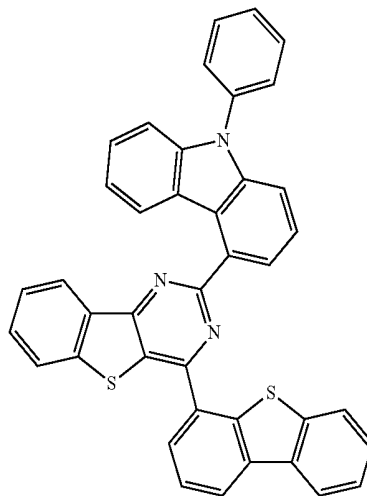
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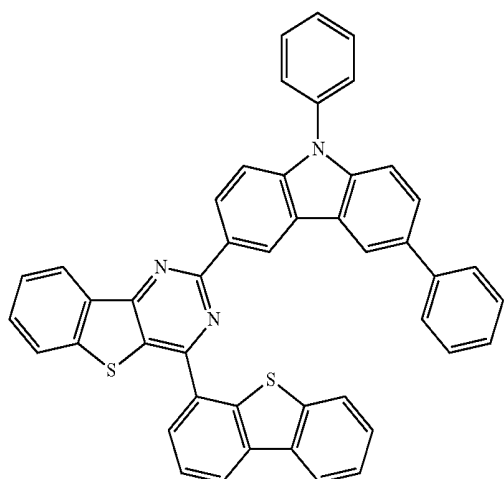


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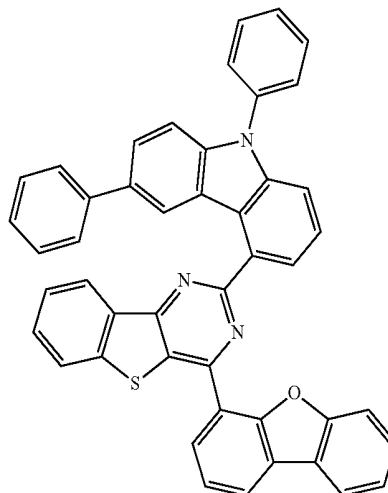
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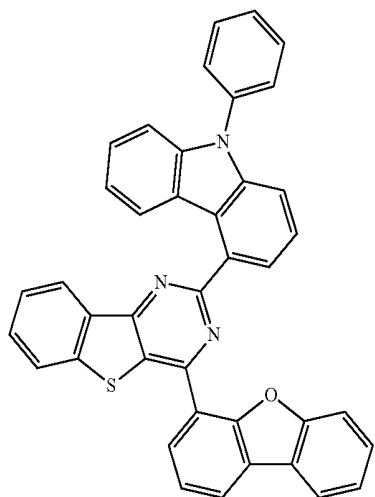
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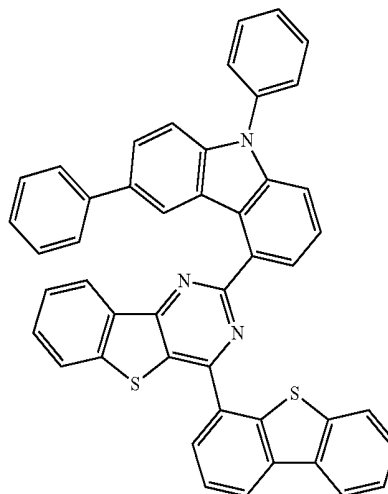
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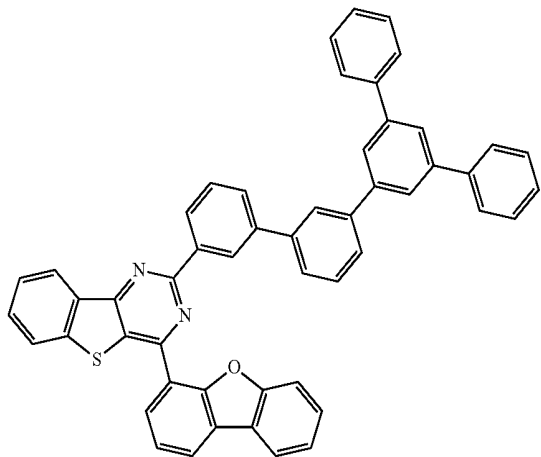


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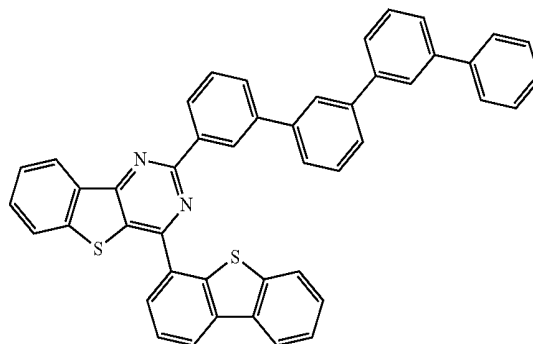
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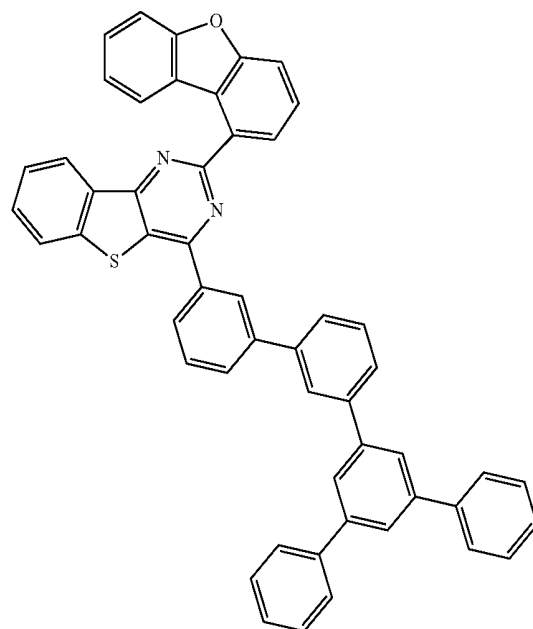


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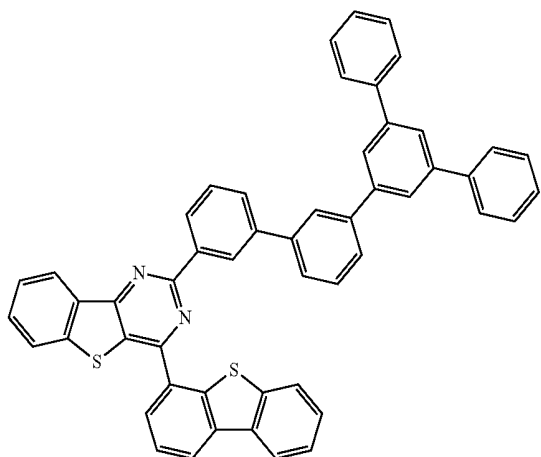
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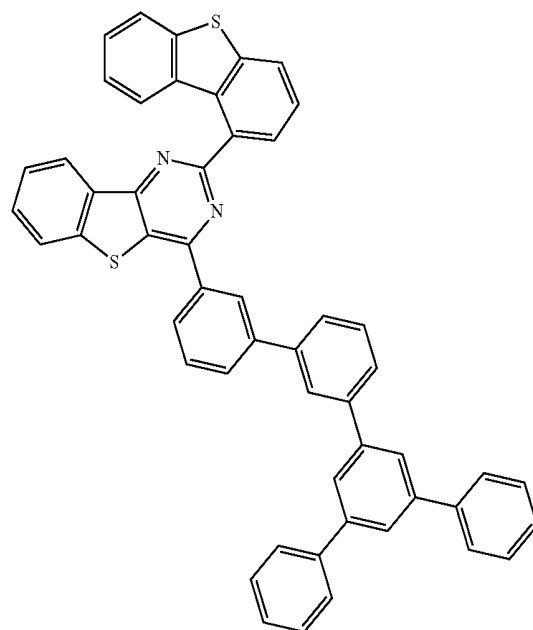
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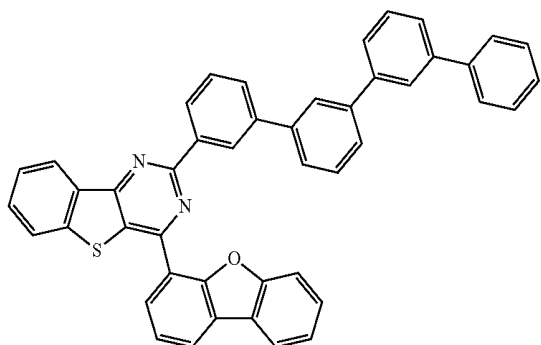
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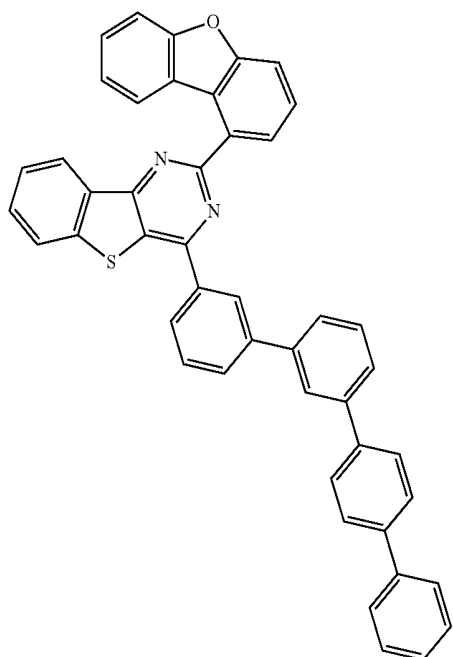
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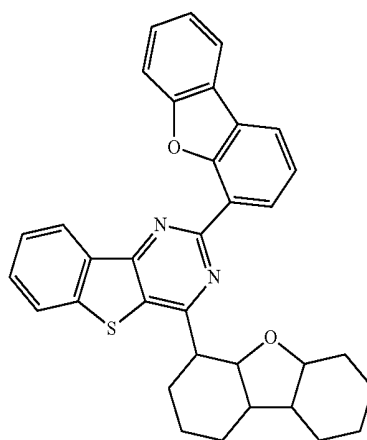


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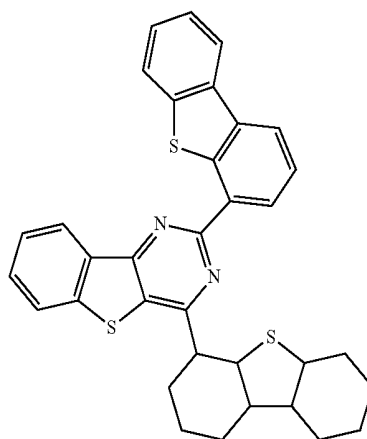
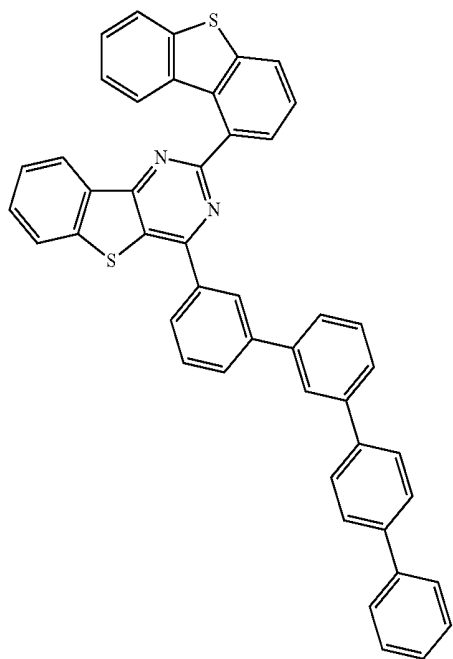
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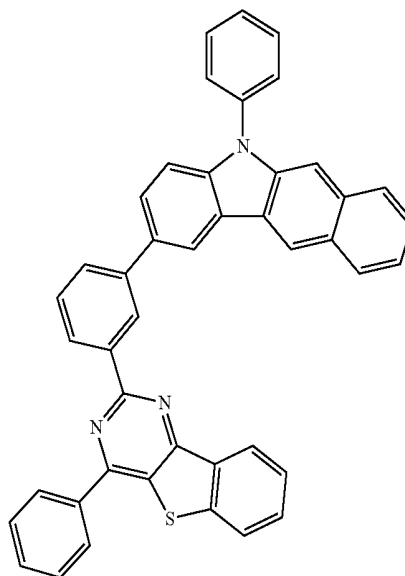
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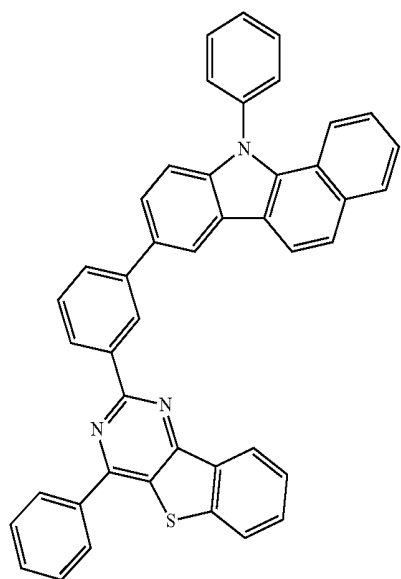


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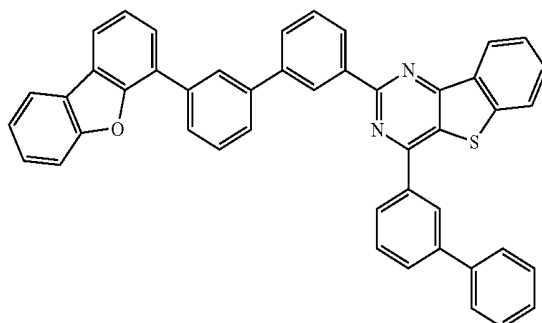


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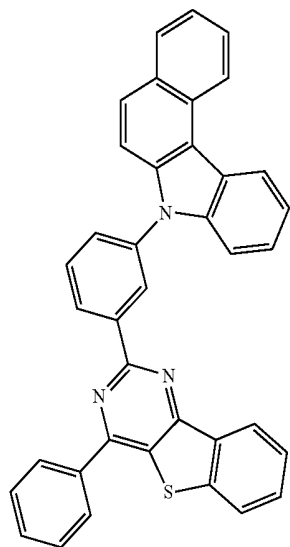


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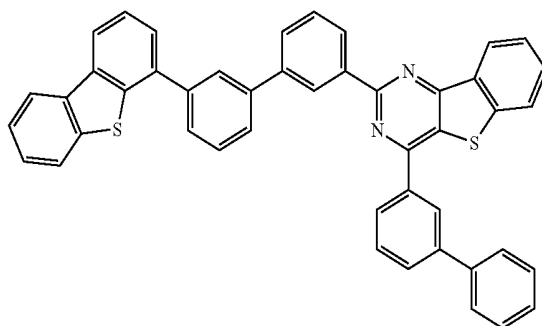
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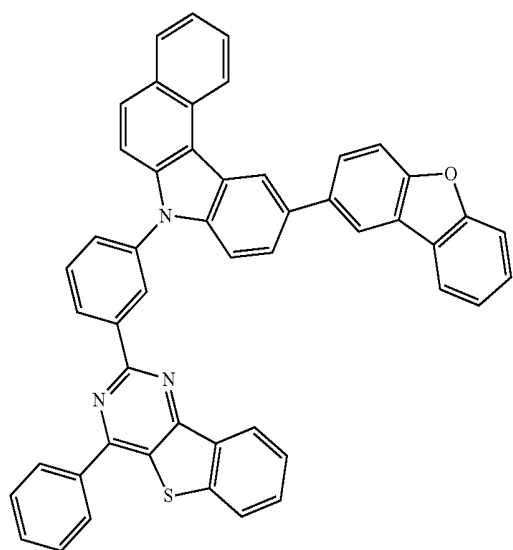
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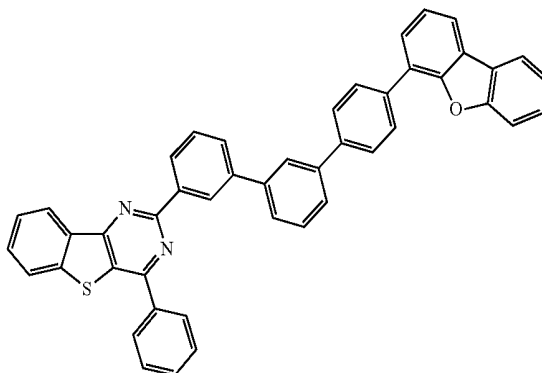
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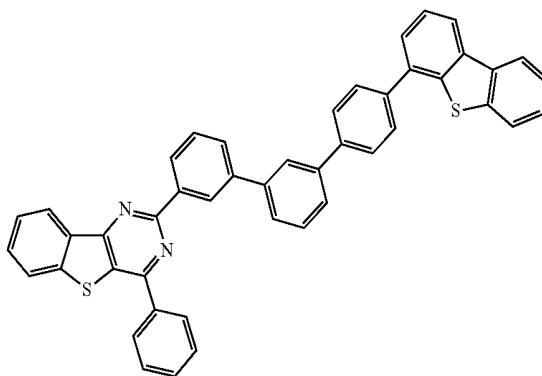
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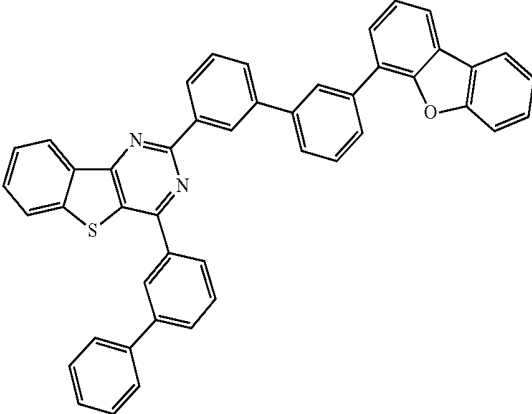
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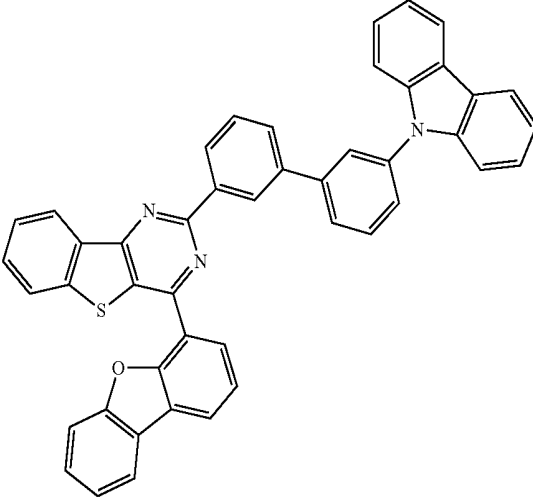
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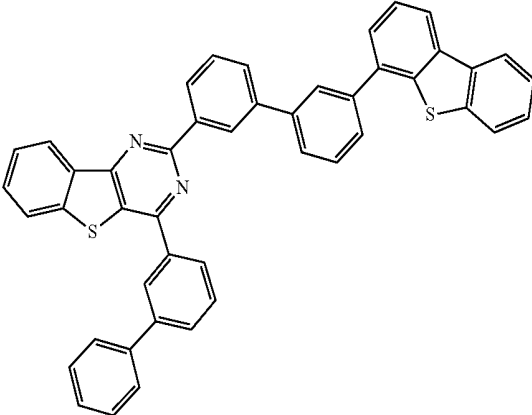


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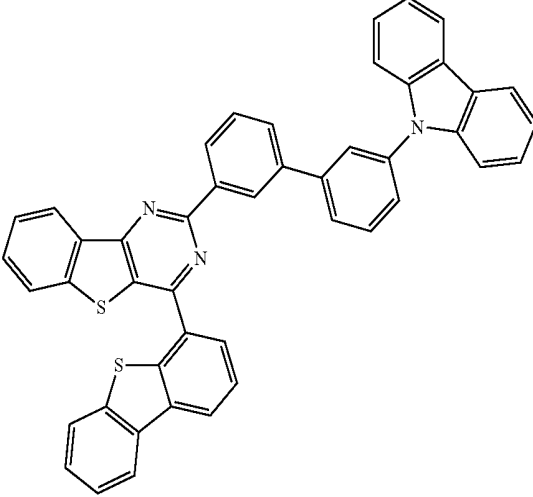
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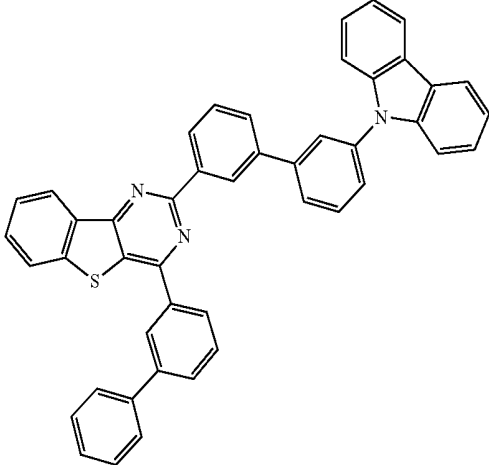
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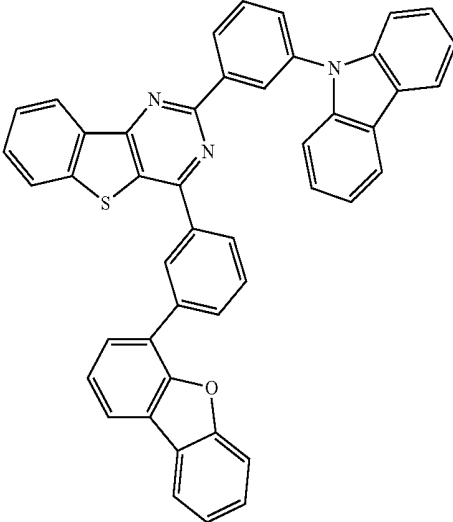
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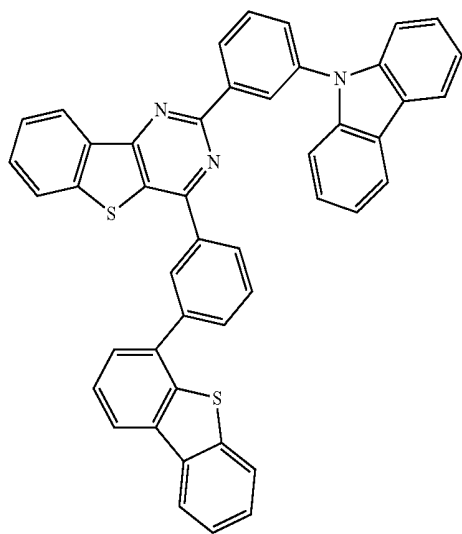


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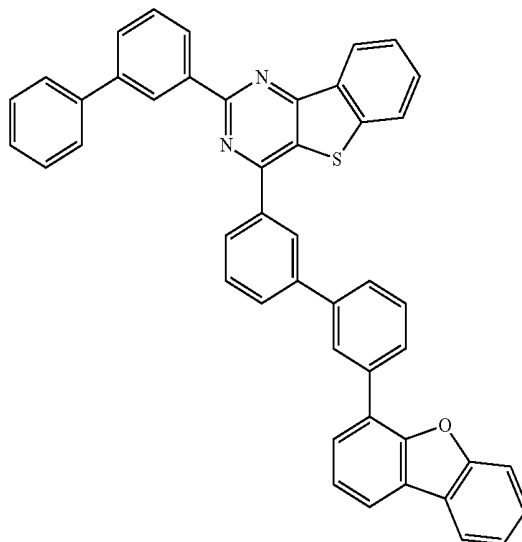
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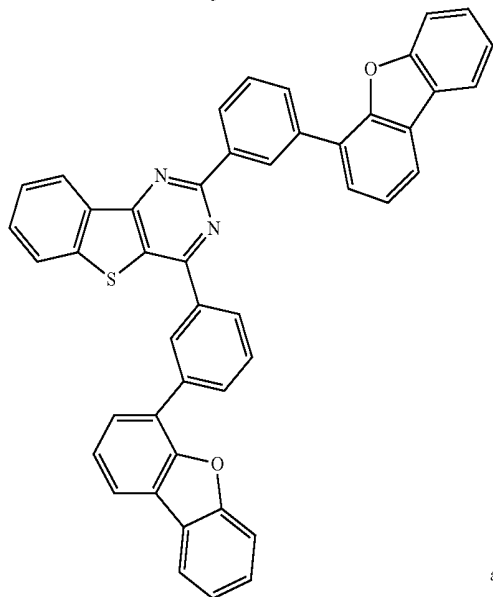


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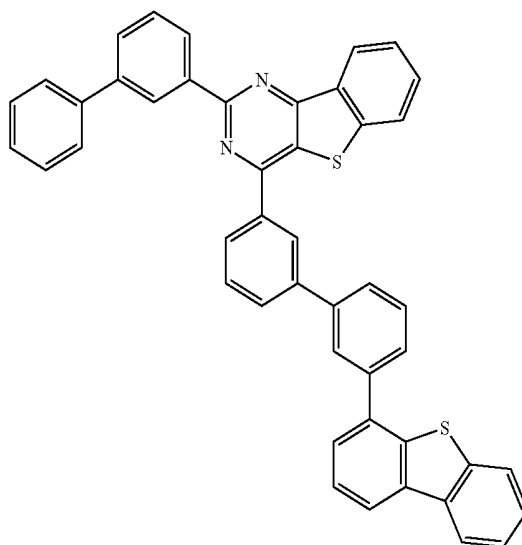
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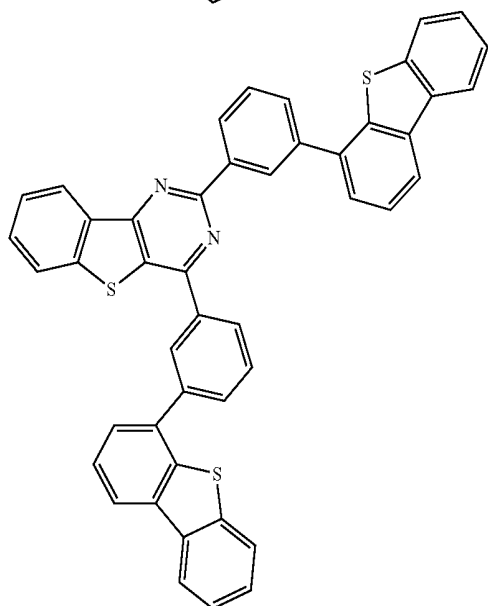
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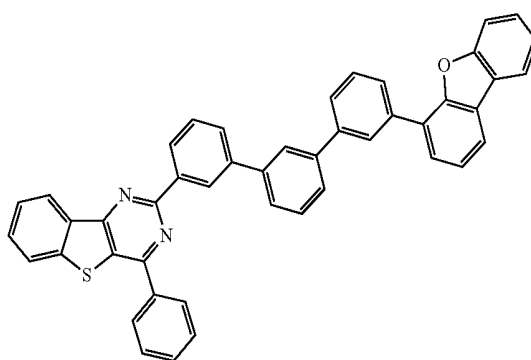
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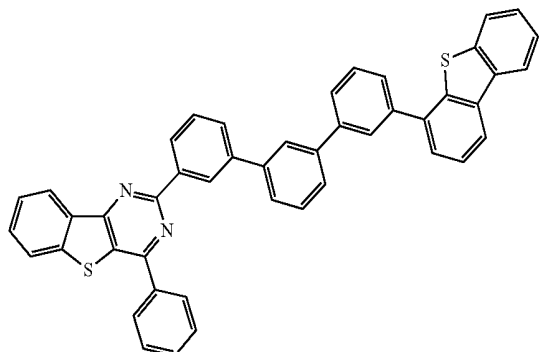


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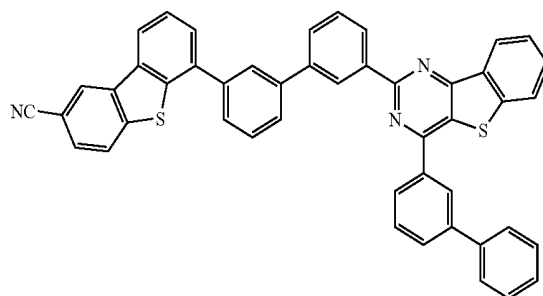
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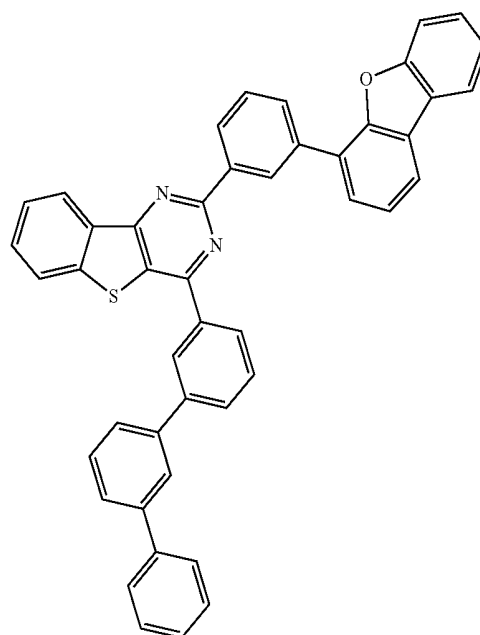


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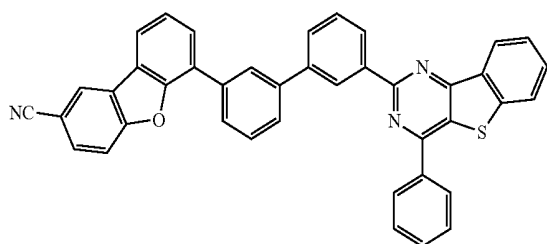
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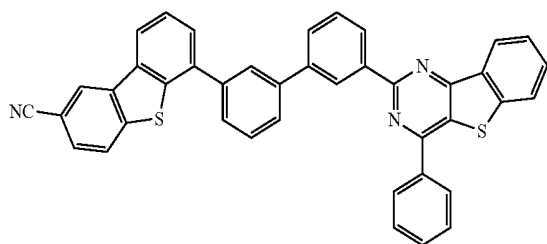
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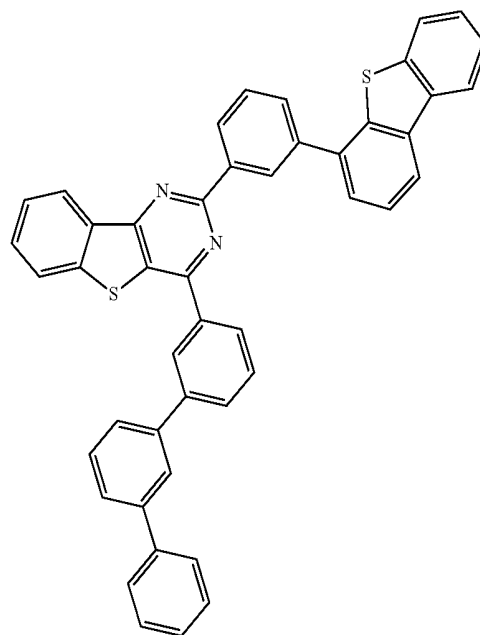
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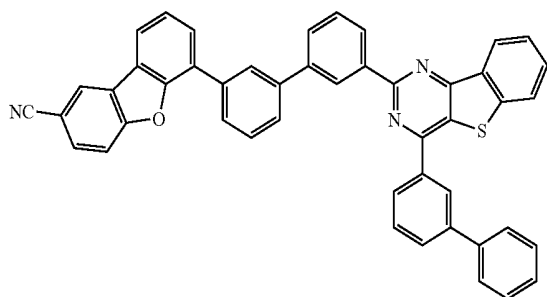
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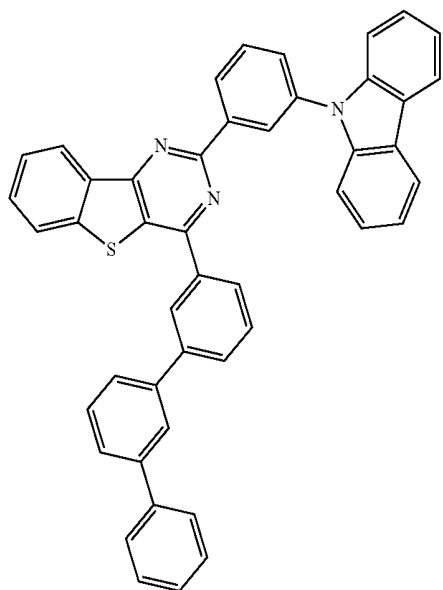
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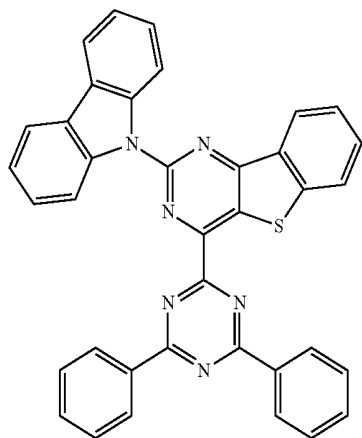
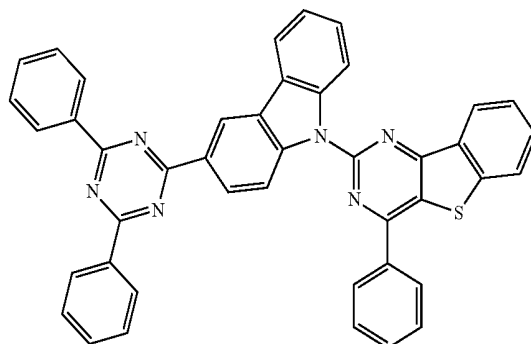
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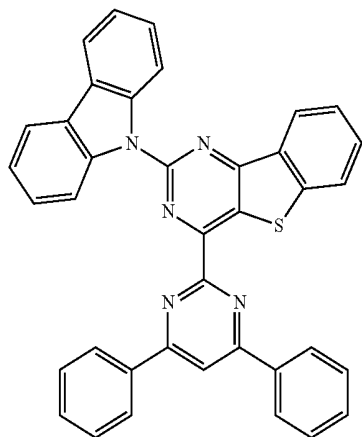
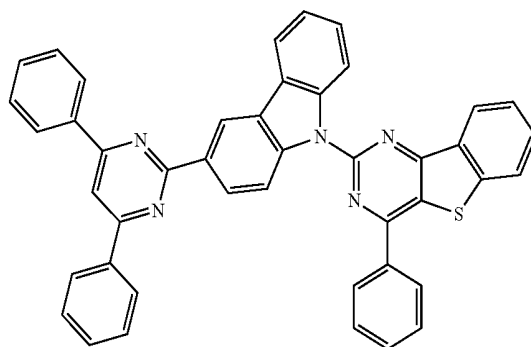
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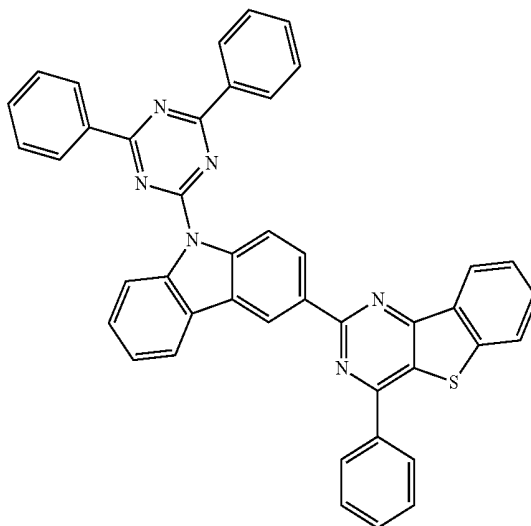
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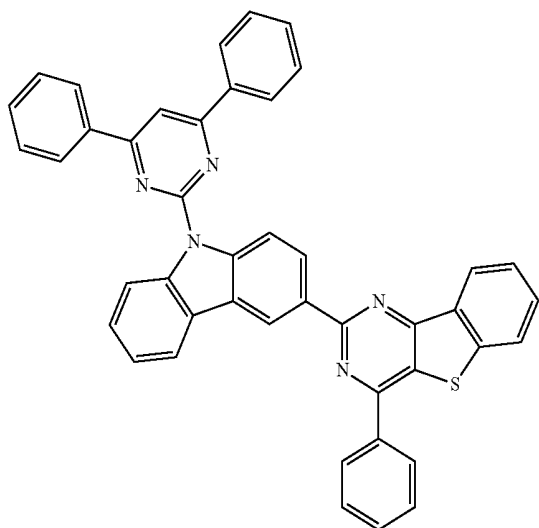


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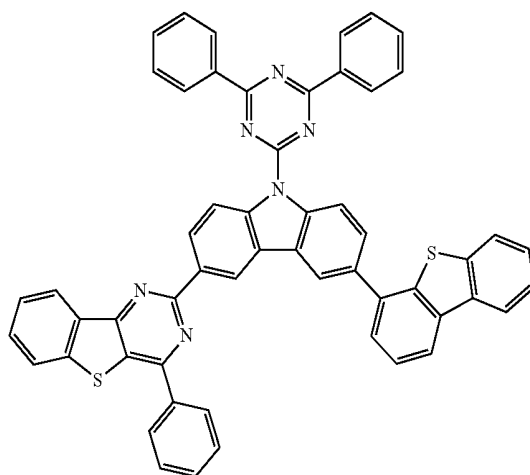
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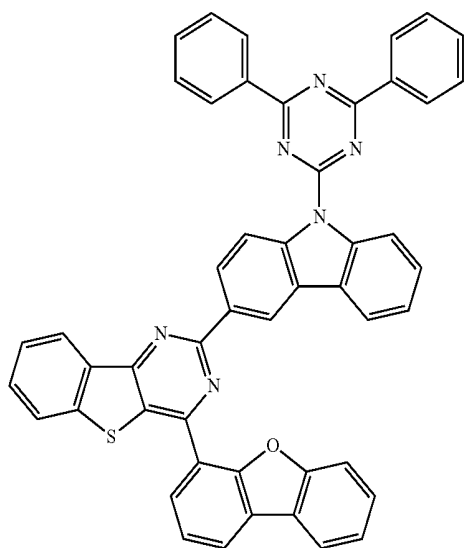


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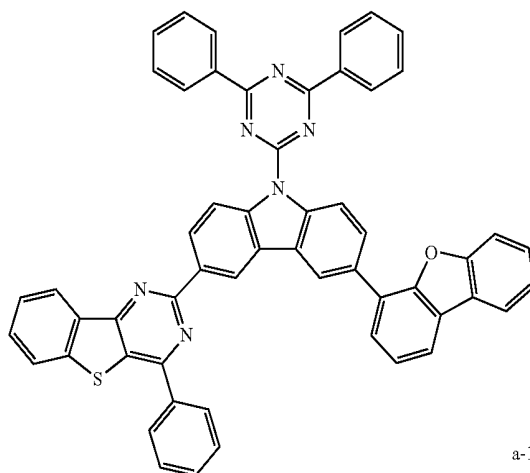
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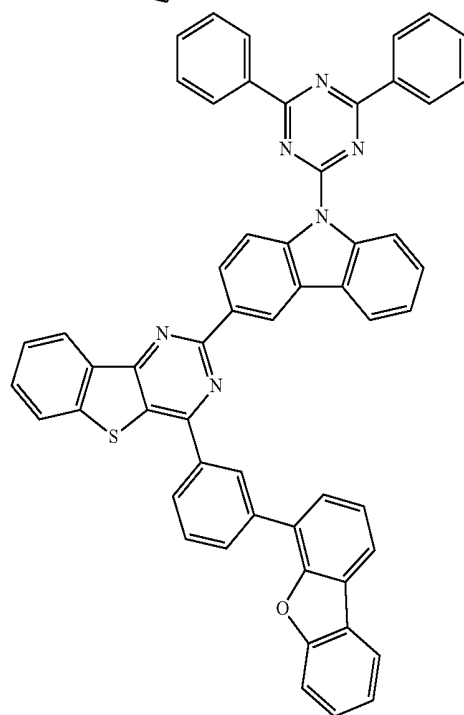
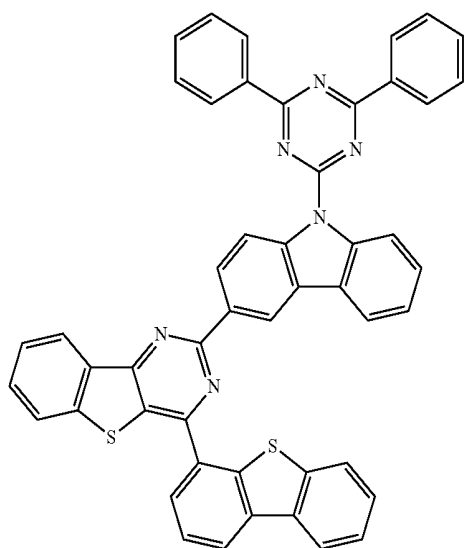


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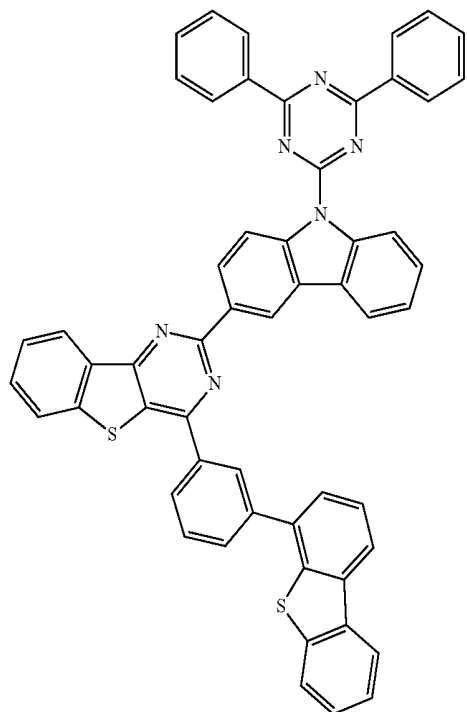
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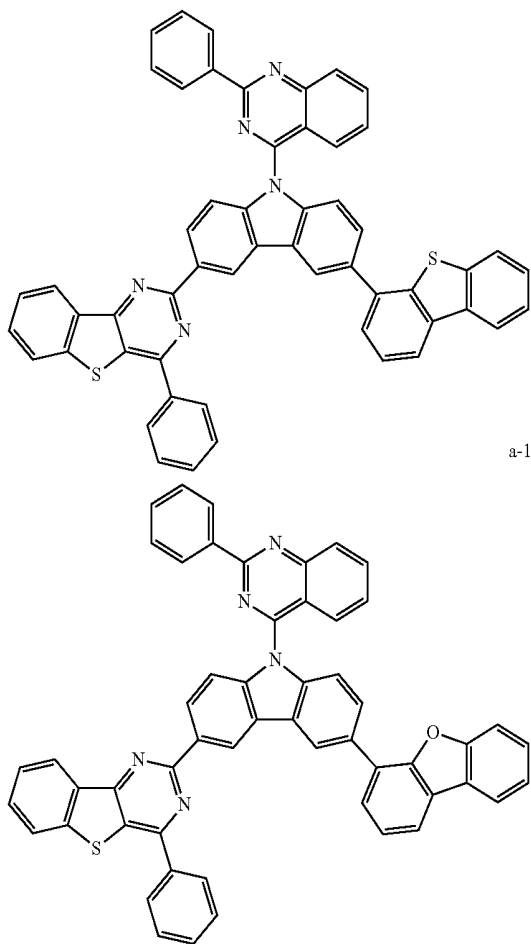


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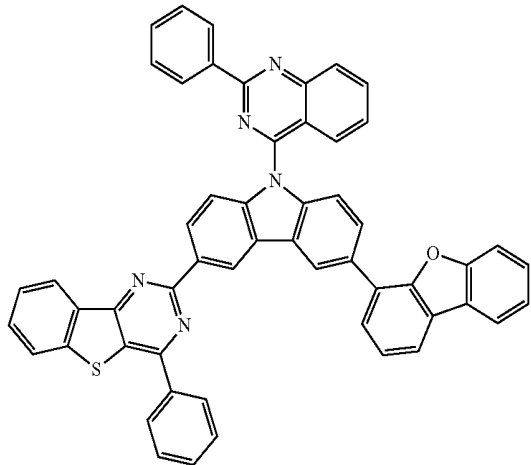
a-108



a-109

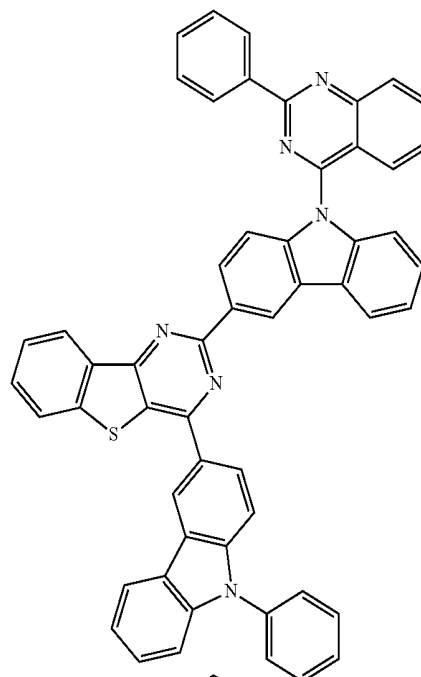


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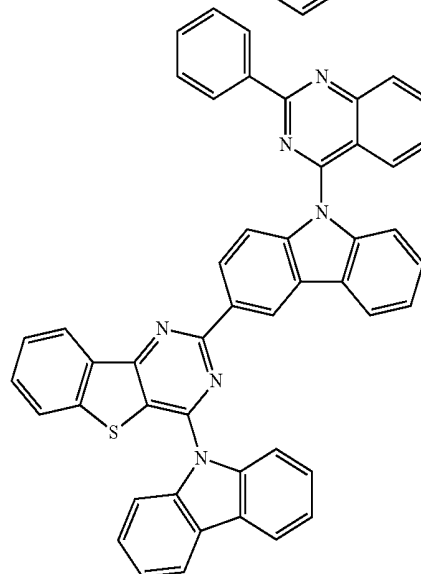


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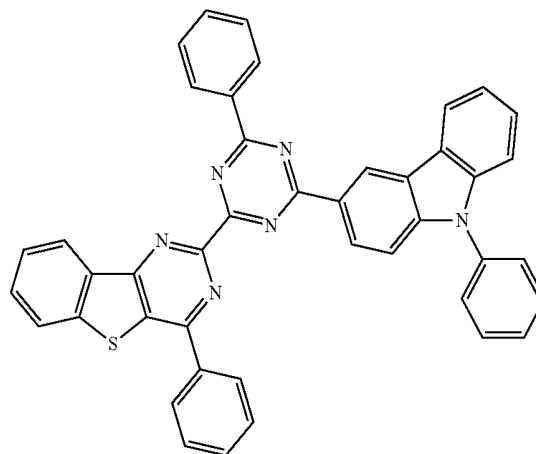
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a-112

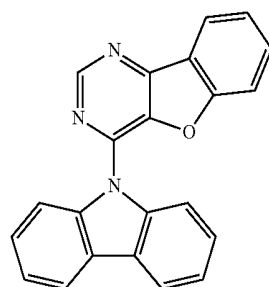
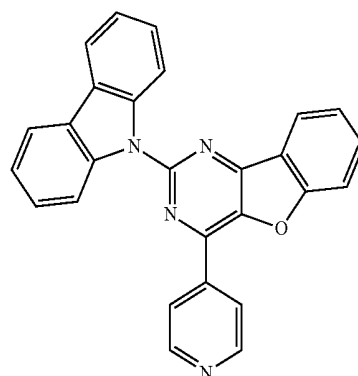
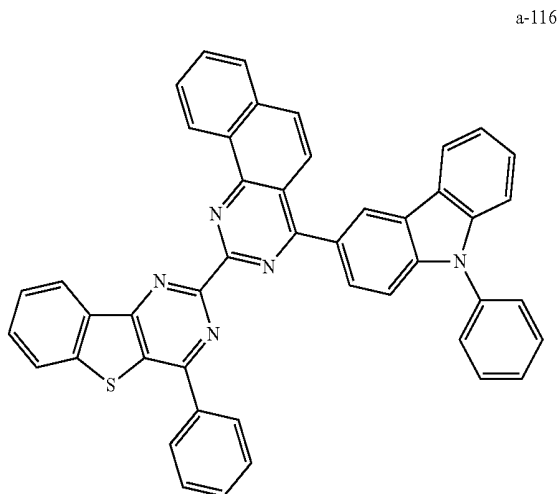
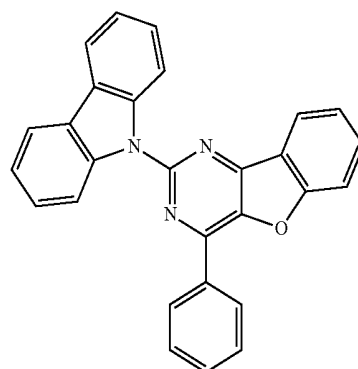
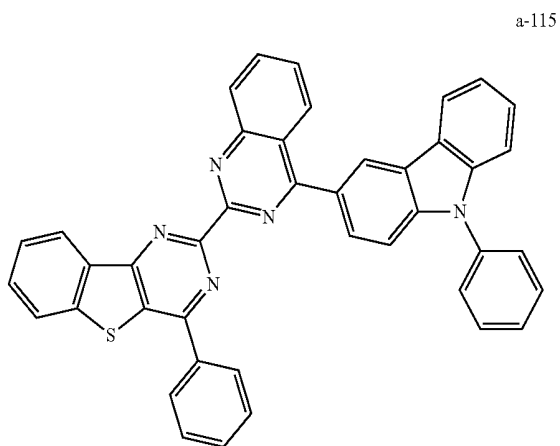
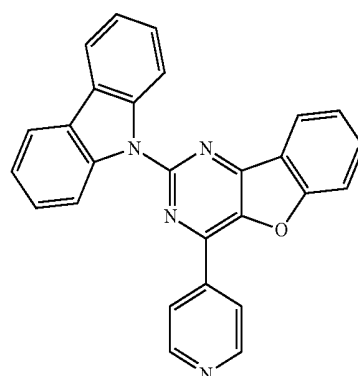
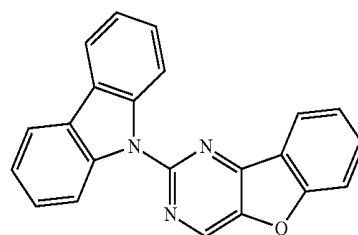
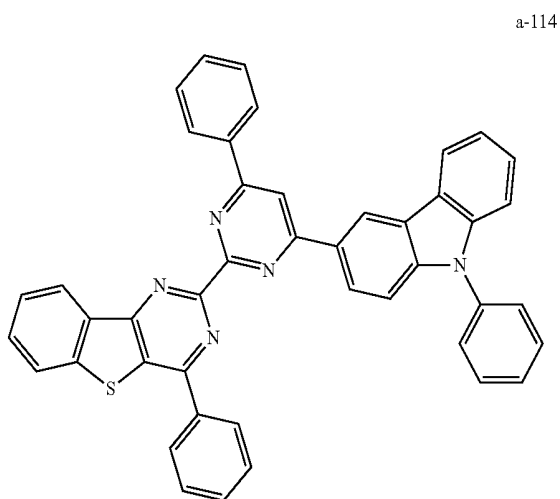


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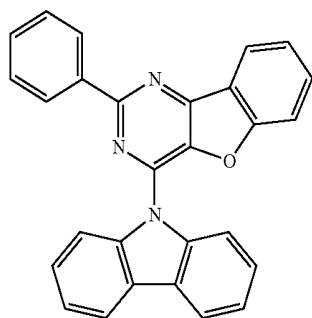


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[0155] Group of  $X_1=O$  in Formula 1-1

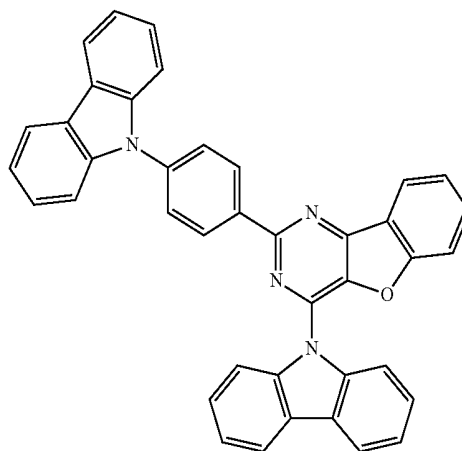


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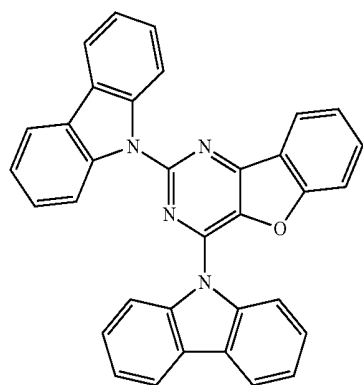


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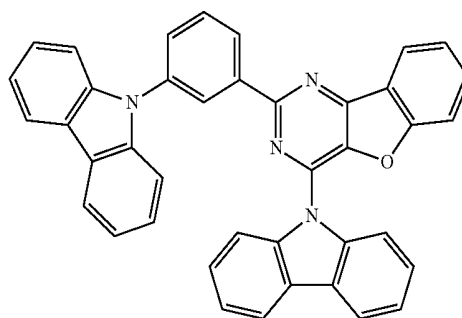
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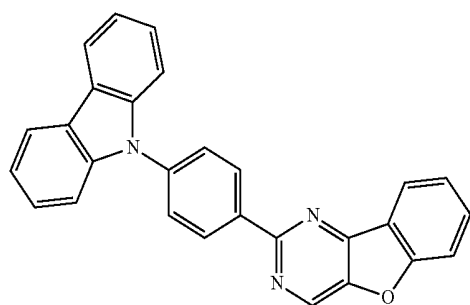
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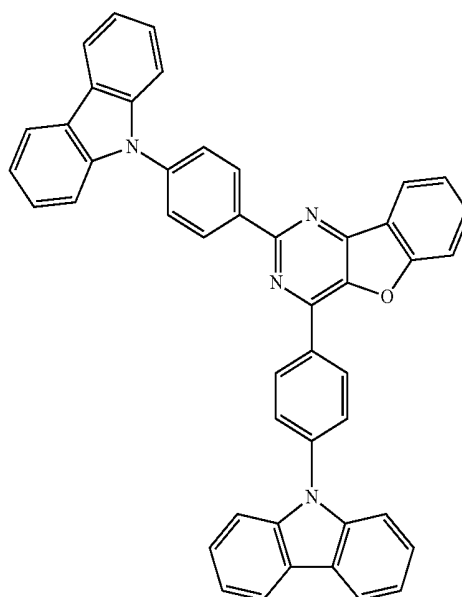
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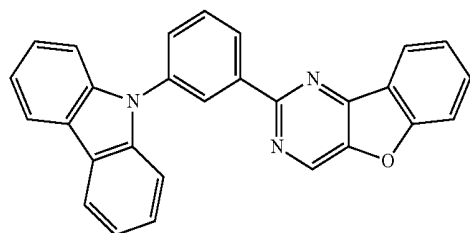
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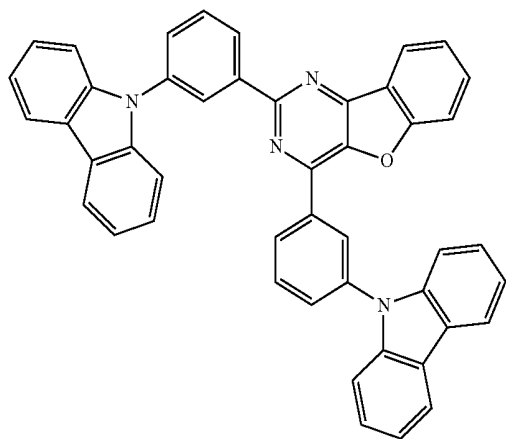
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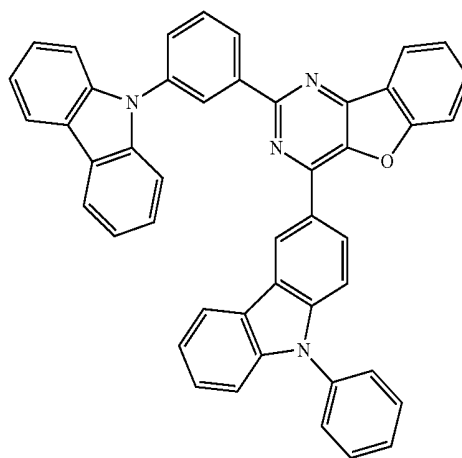
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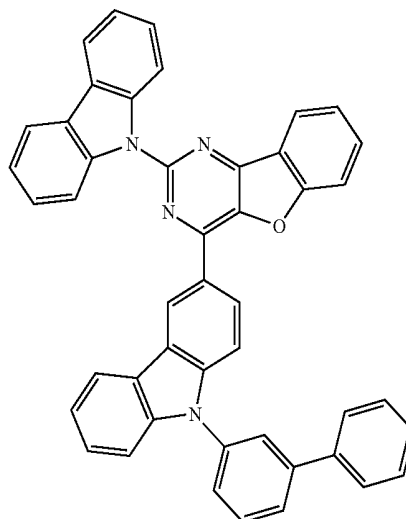
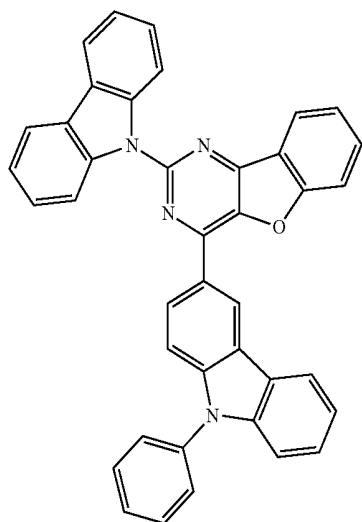
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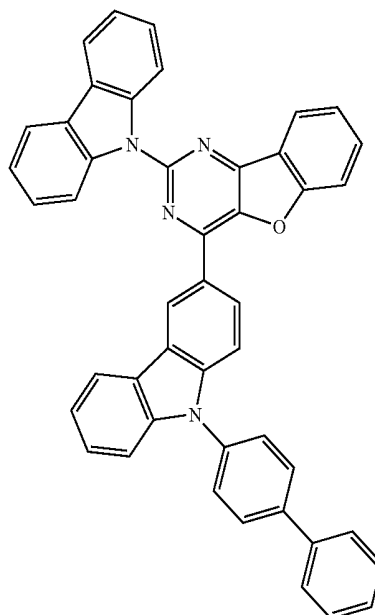
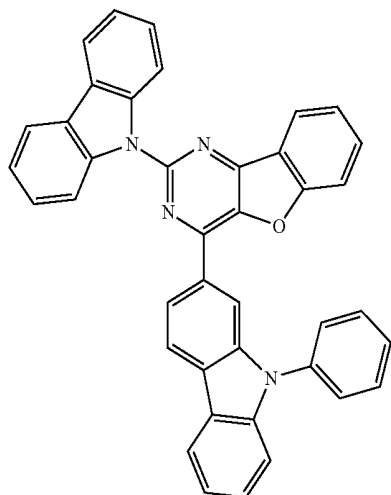
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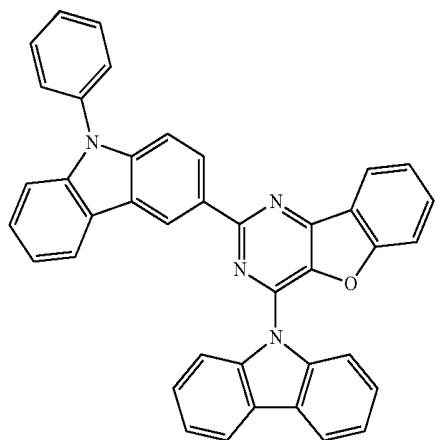


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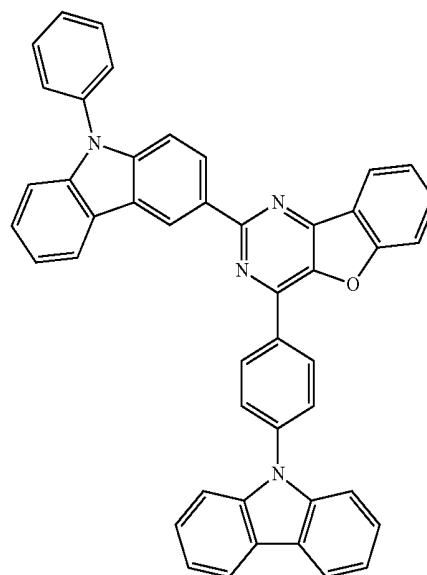


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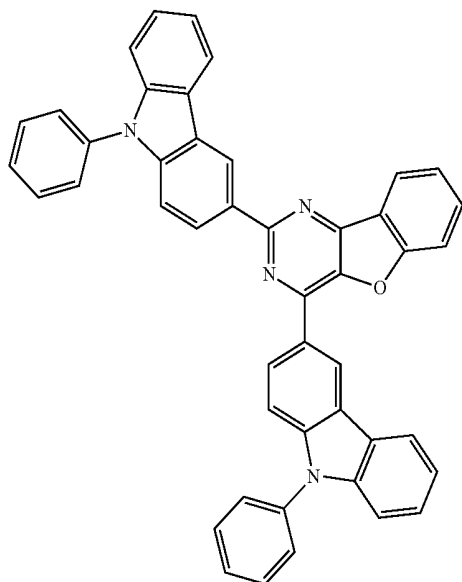


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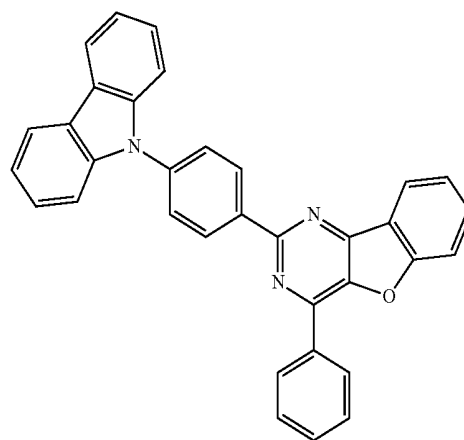
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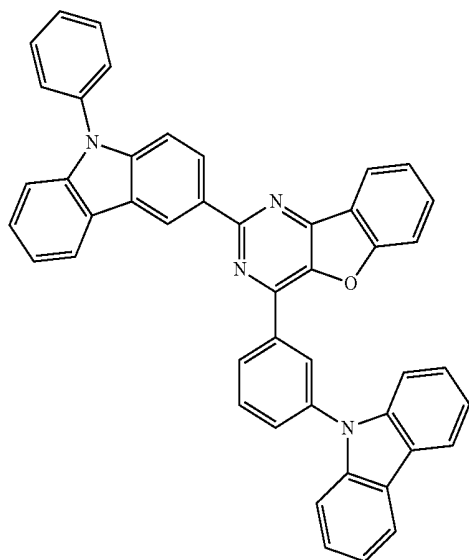
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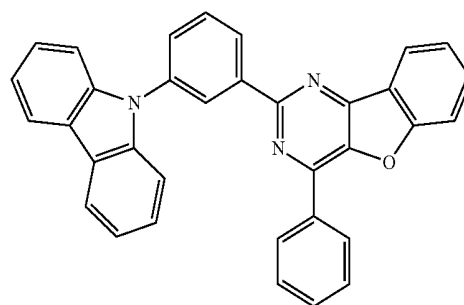
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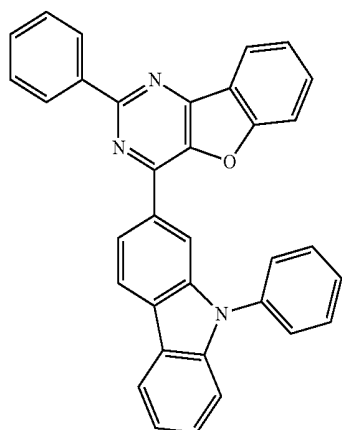


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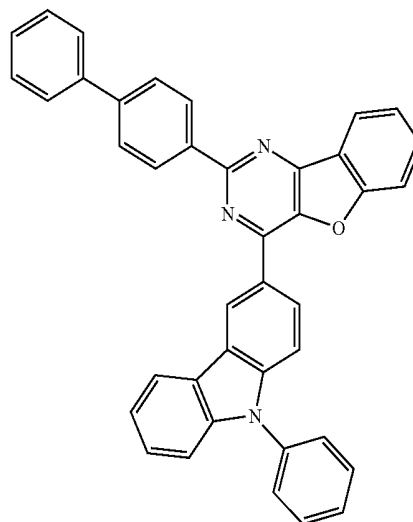
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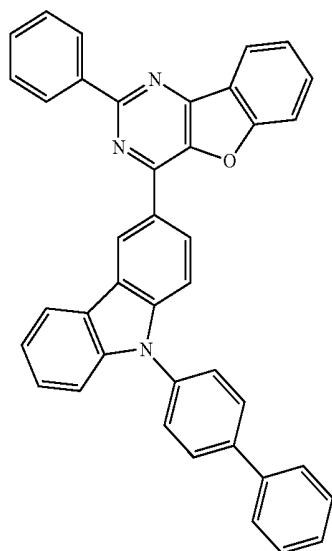


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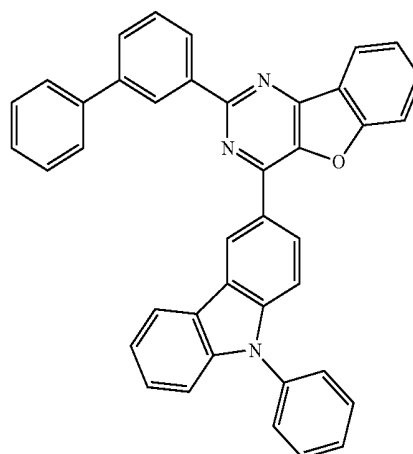
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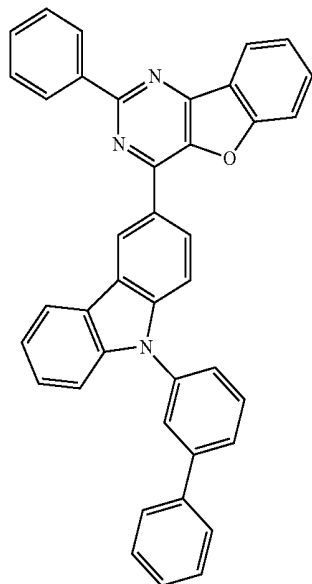
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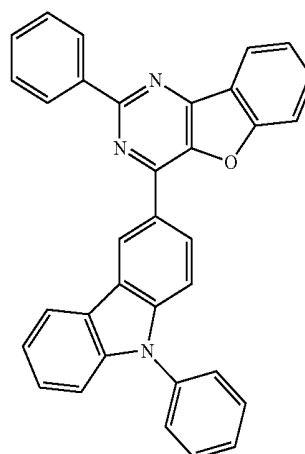
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291



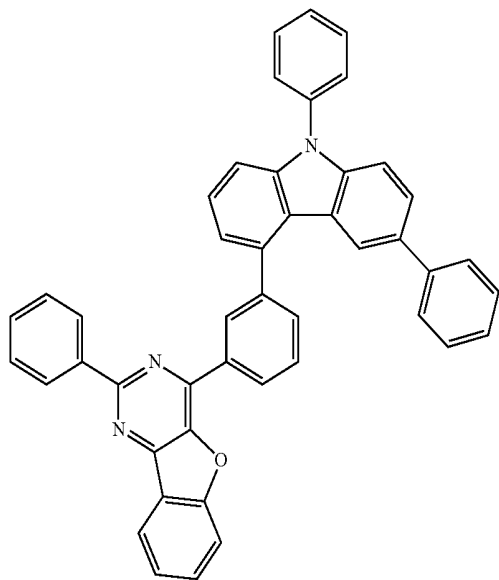
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292

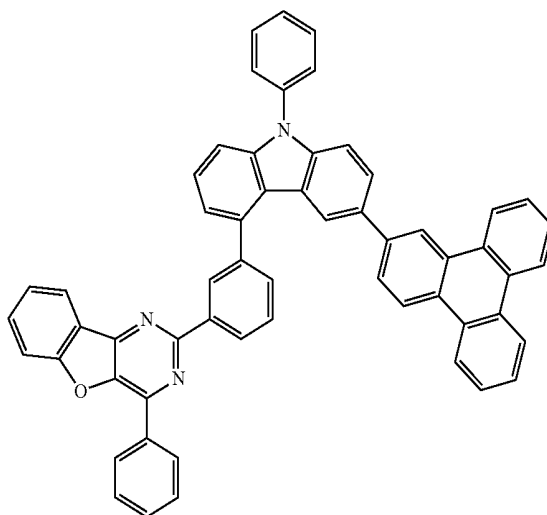
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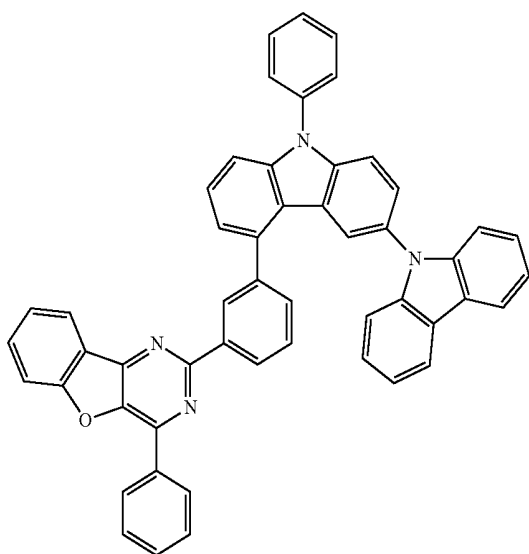
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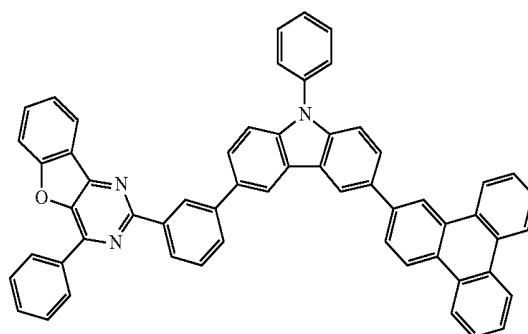


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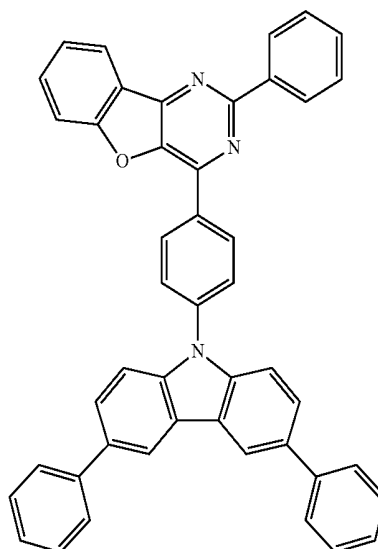
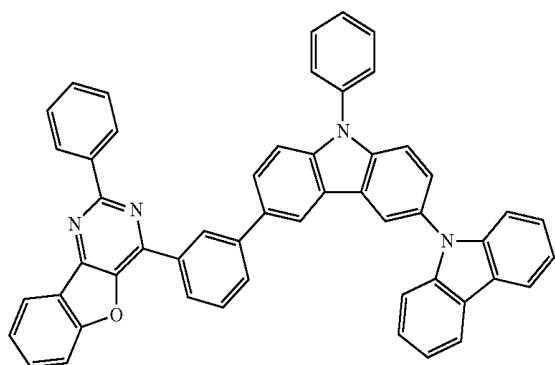
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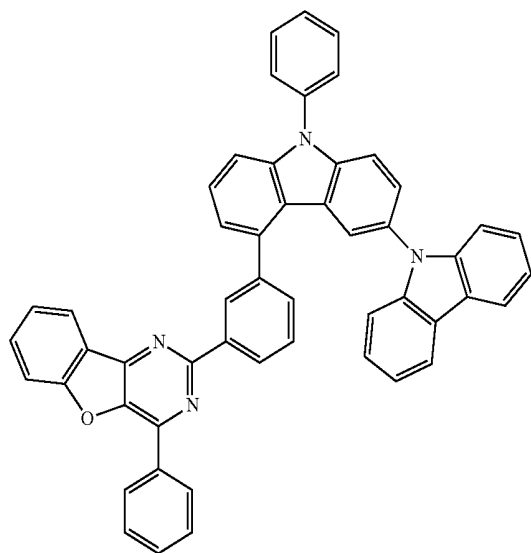


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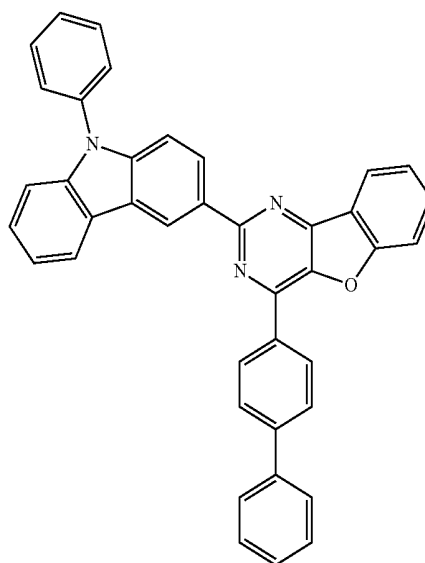
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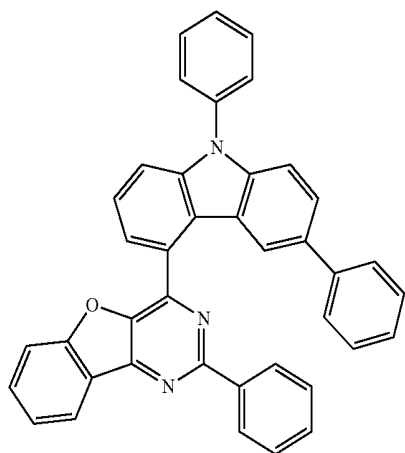


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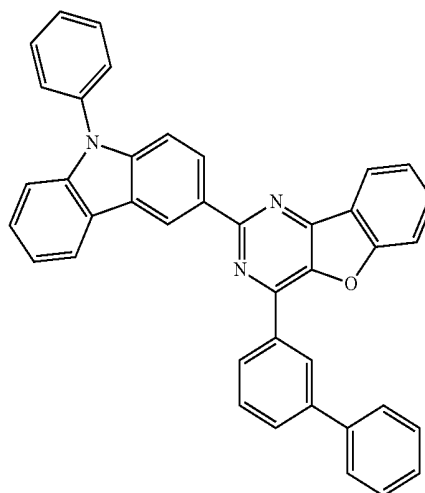
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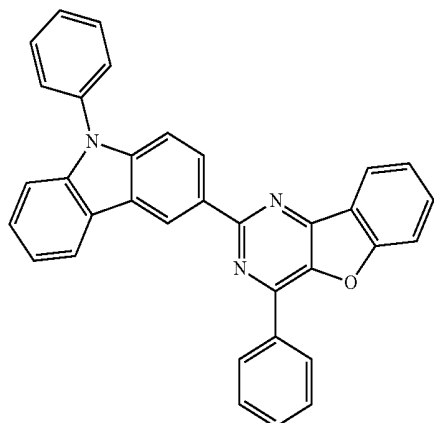
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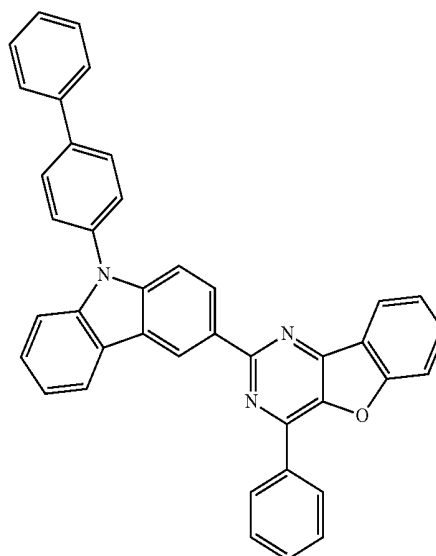
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b-1

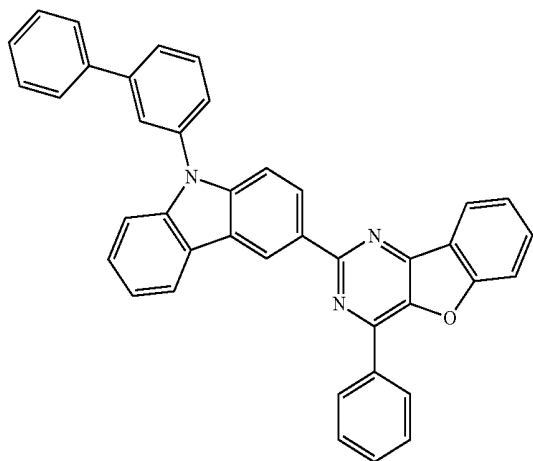


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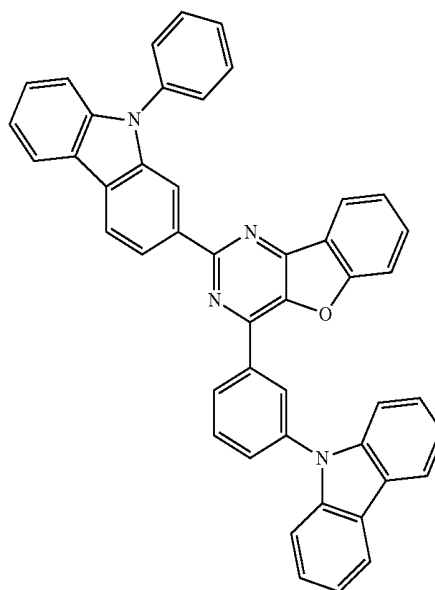
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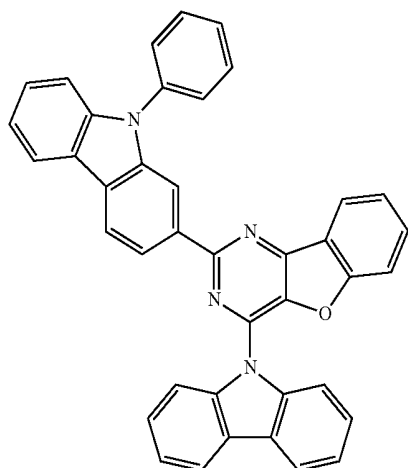


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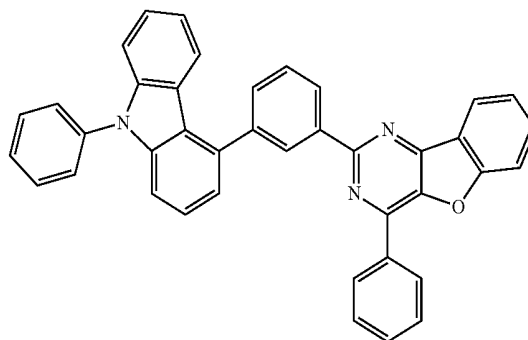
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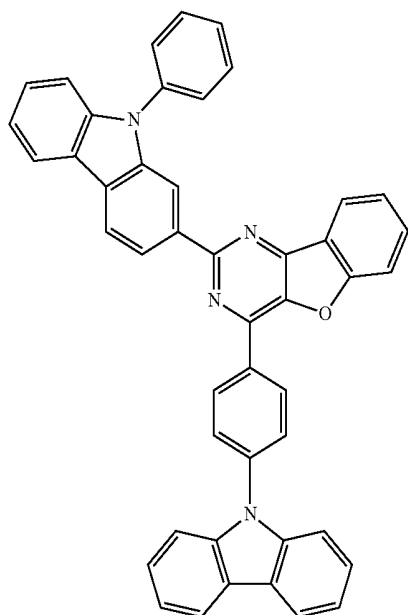
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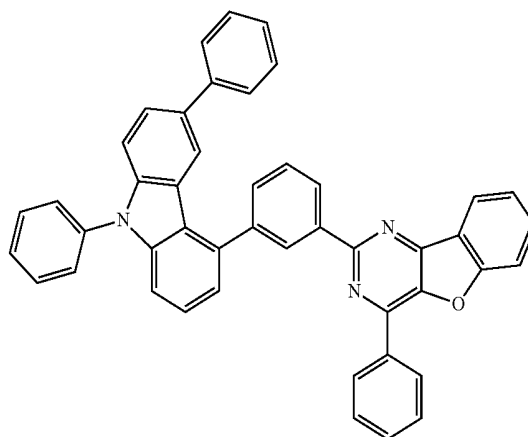
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b-7

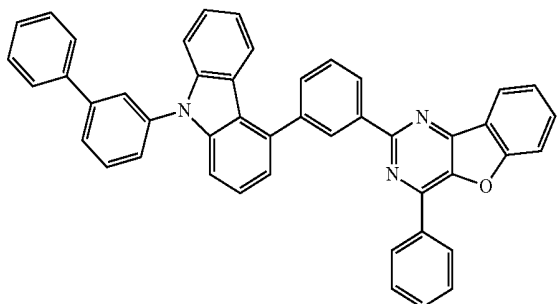


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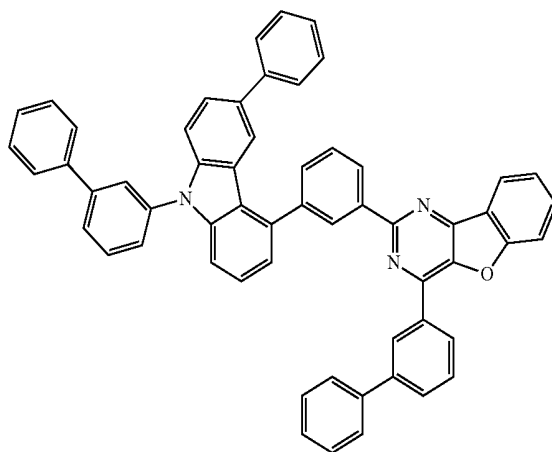
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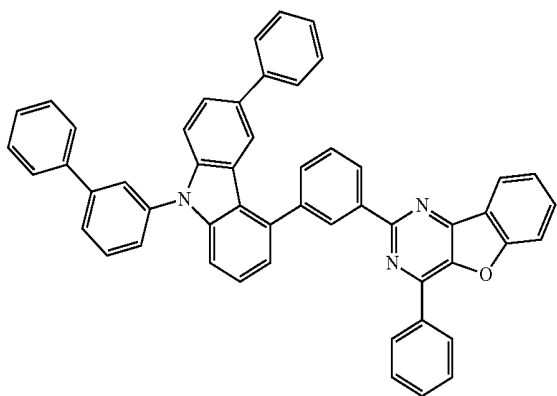


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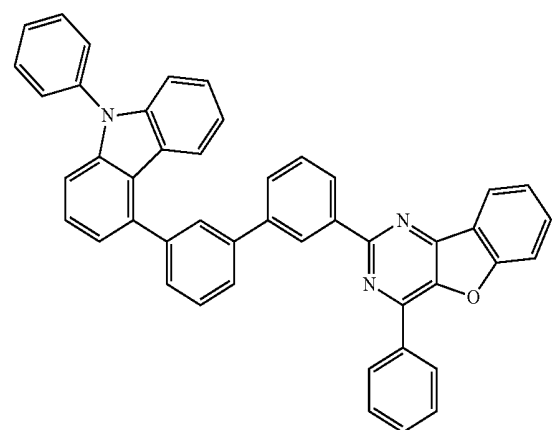
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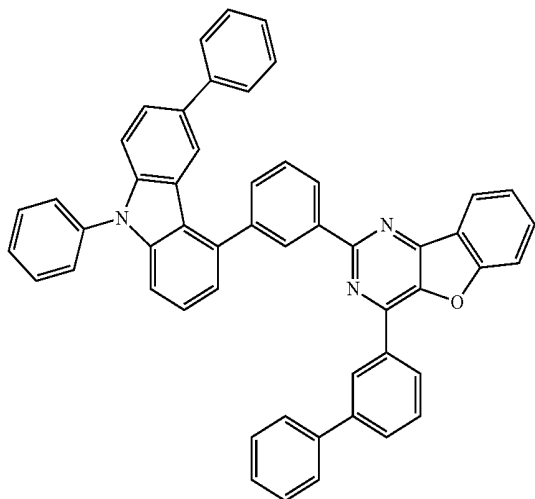
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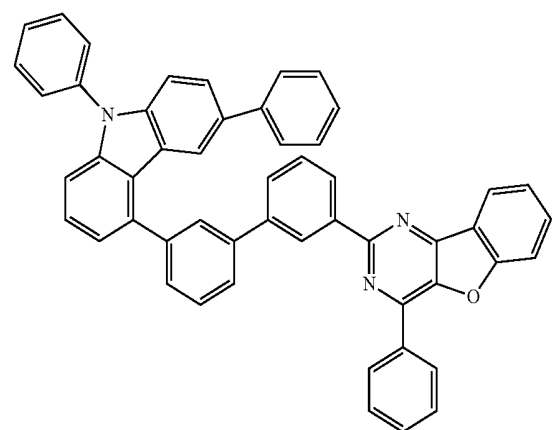
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b-13

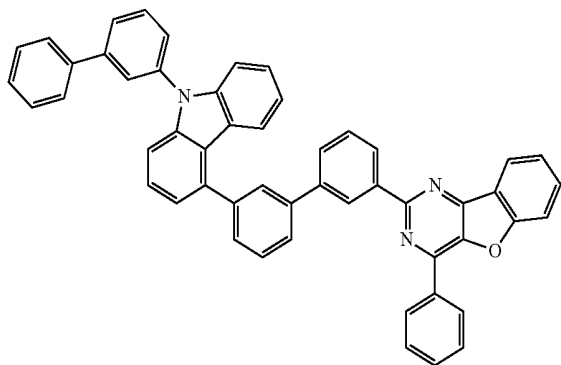


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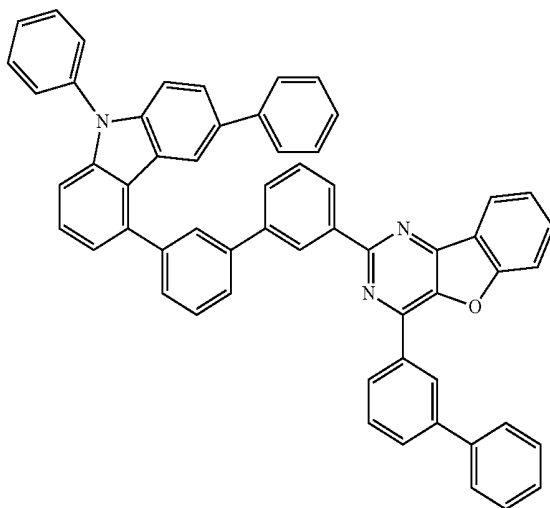
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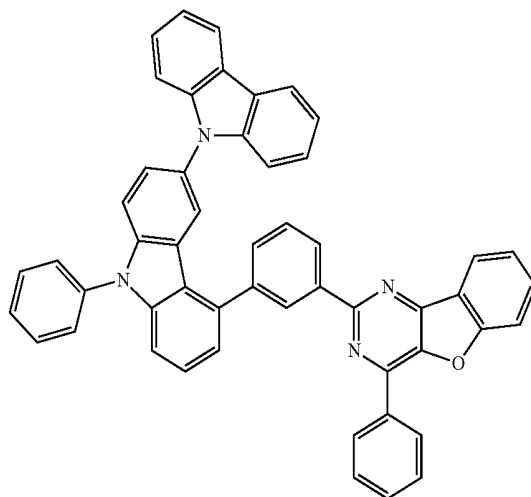
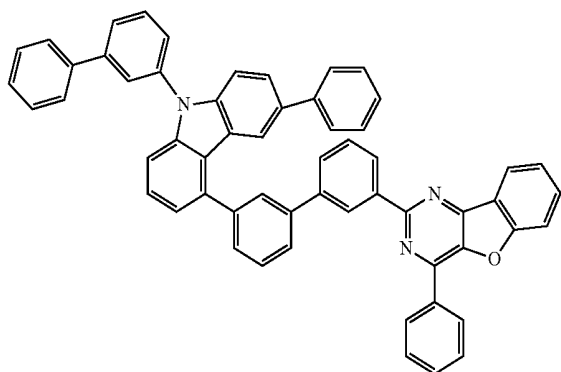
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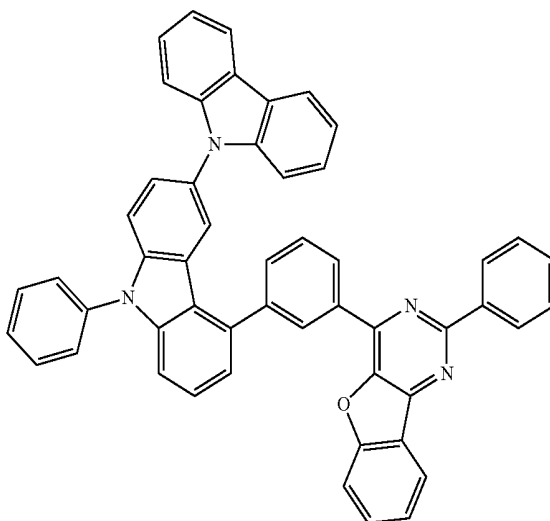
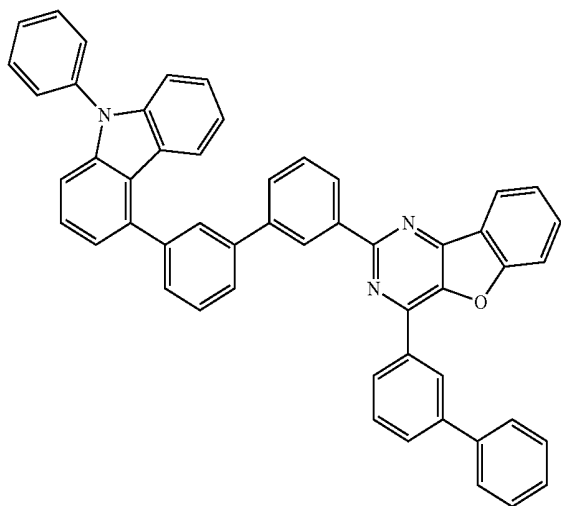
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b-21

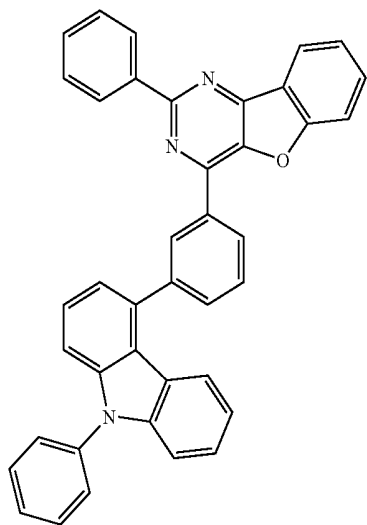


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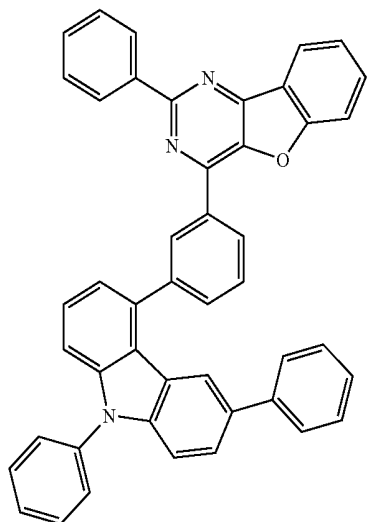
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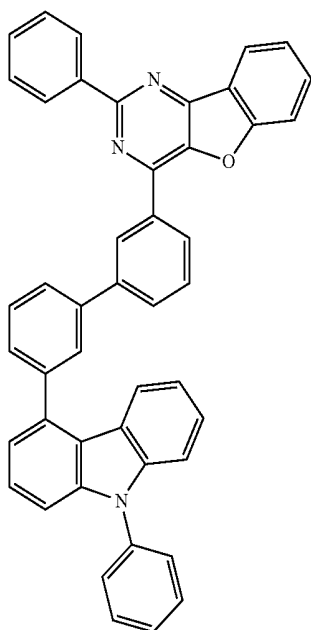
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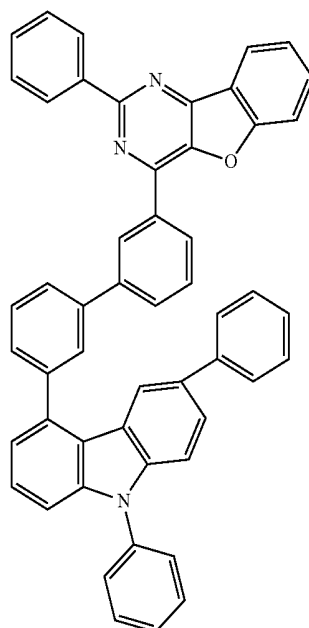


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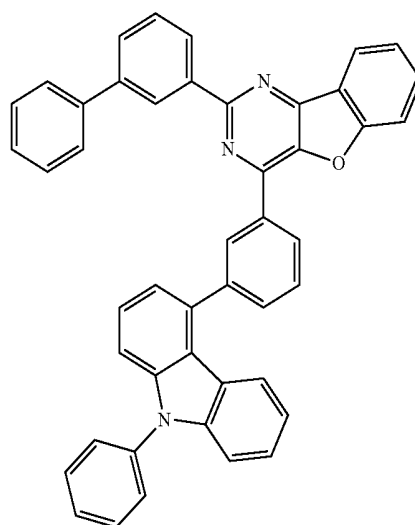


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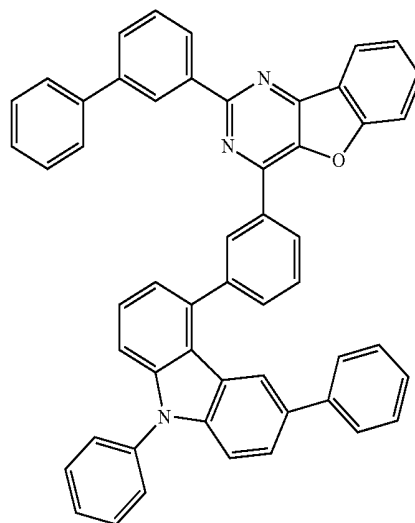
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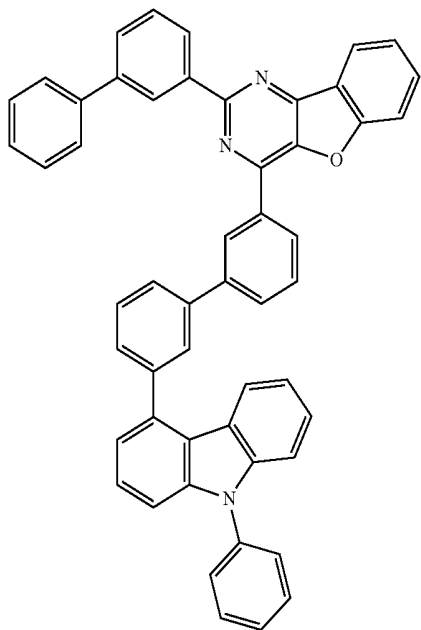


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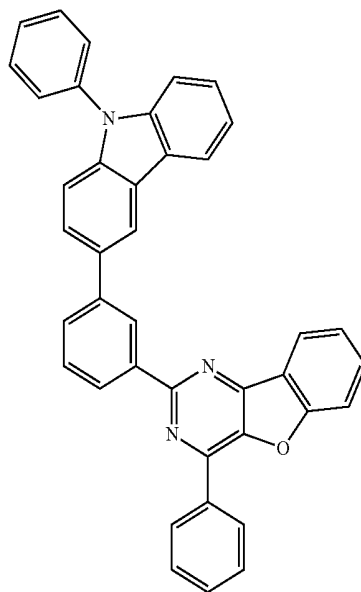
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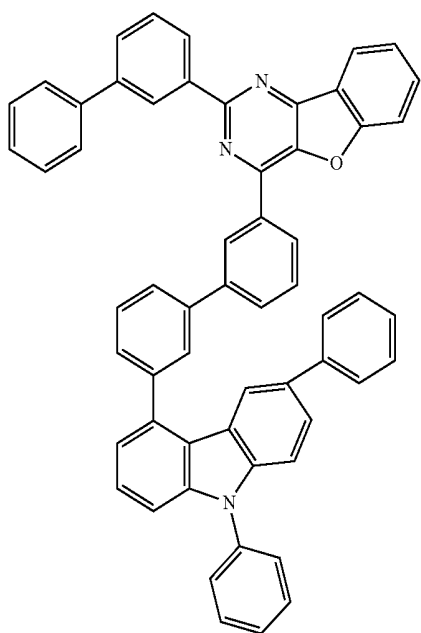


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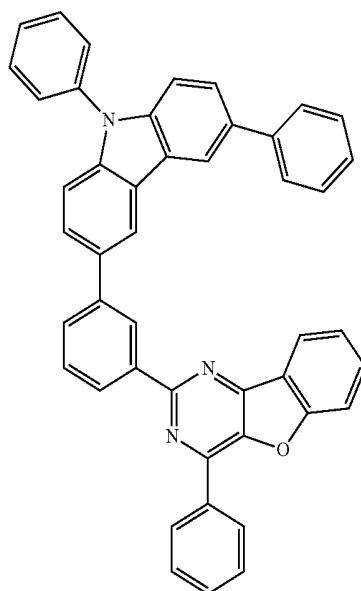
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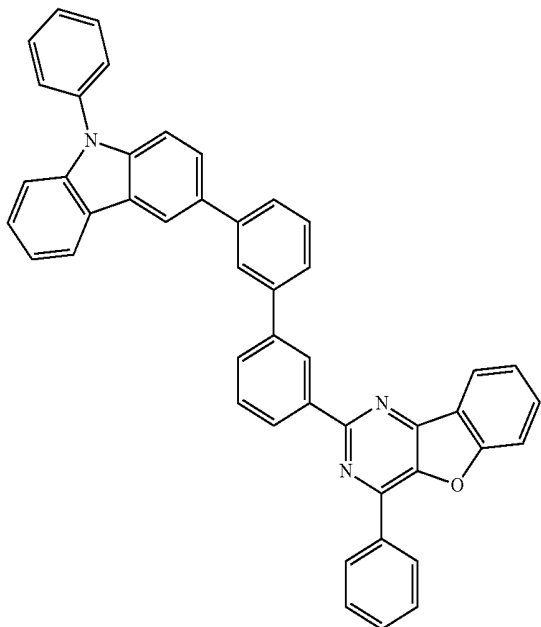
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b-32

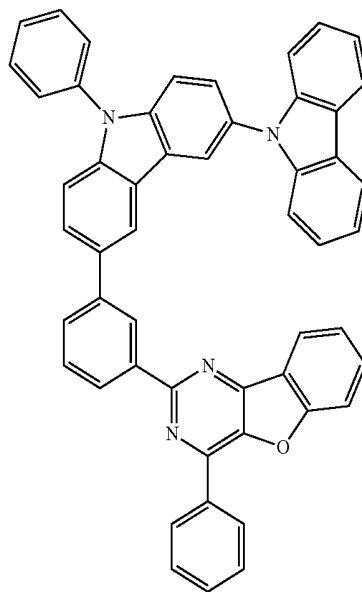
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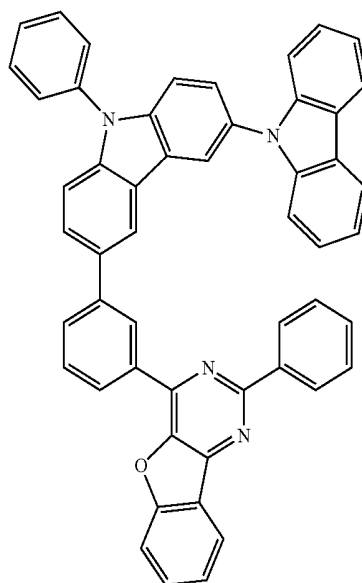


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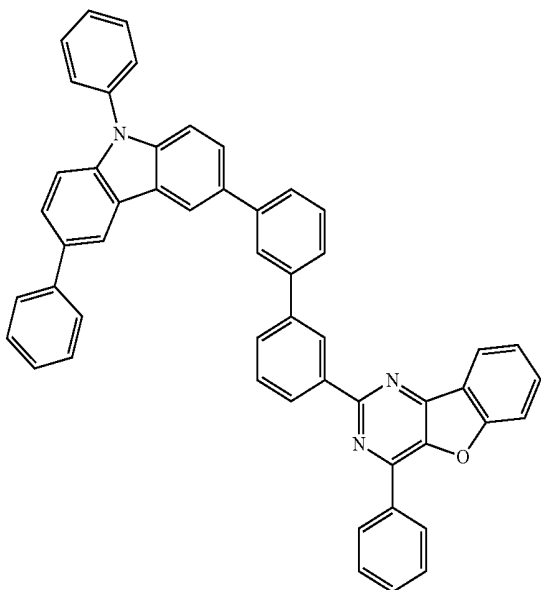
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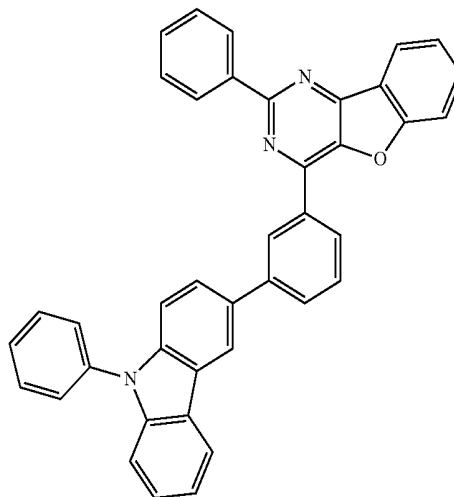
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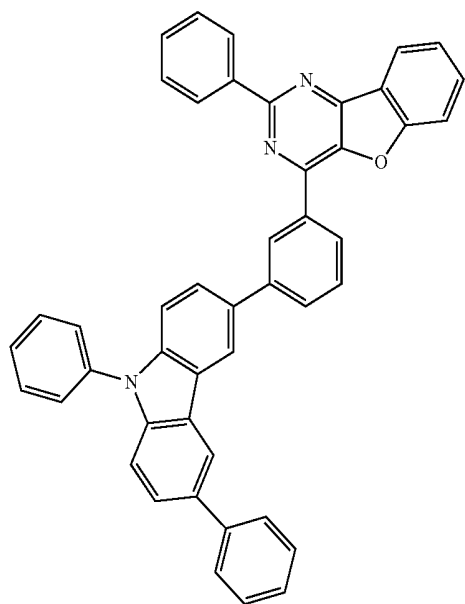
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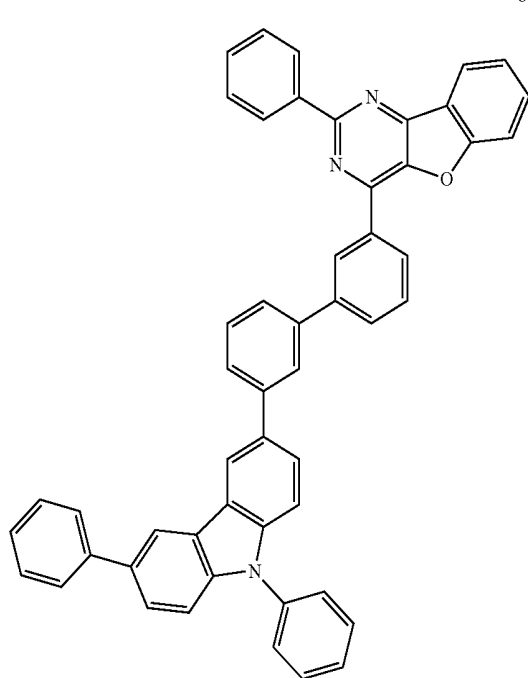
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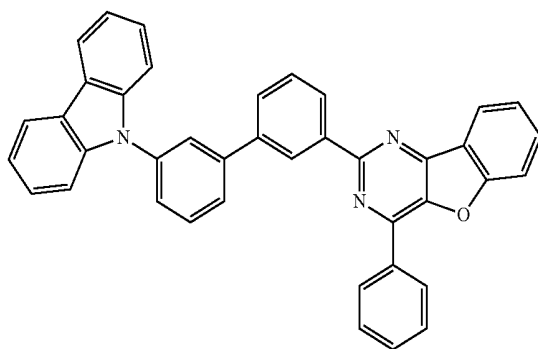
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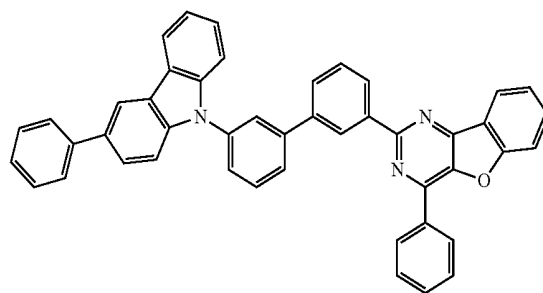
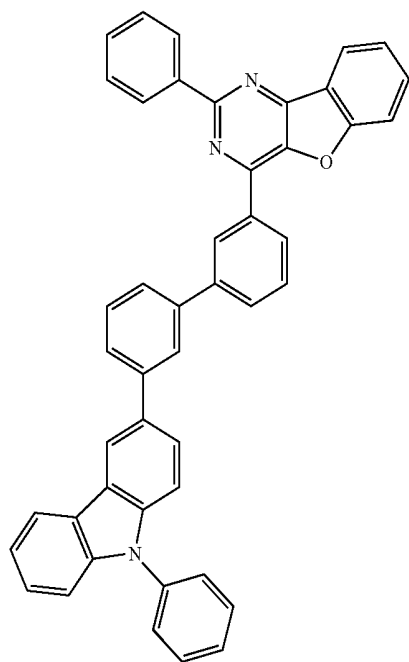
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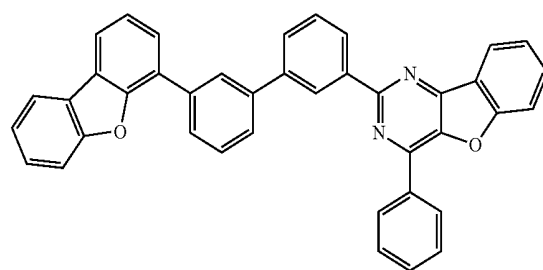
b-41



b-42

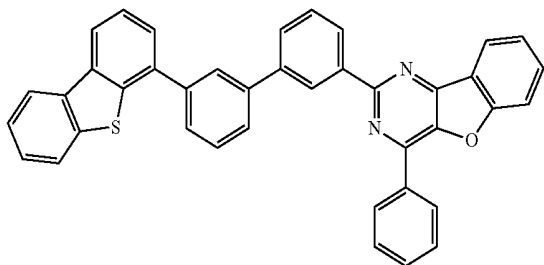


b-43



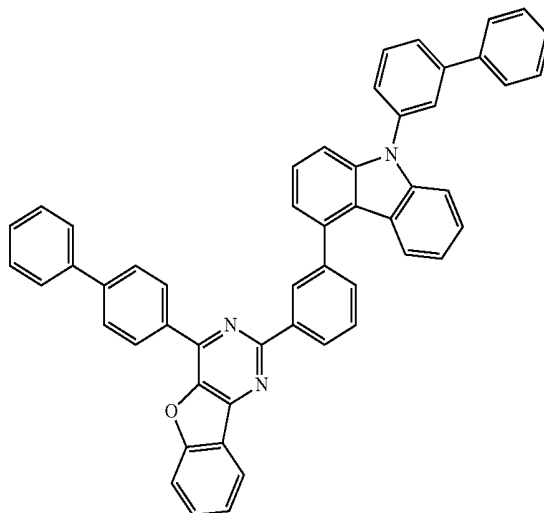
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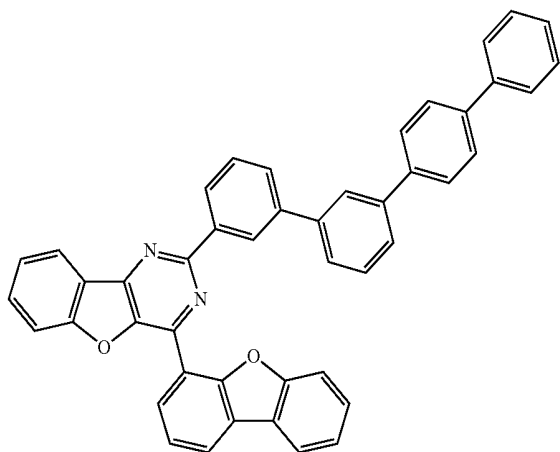


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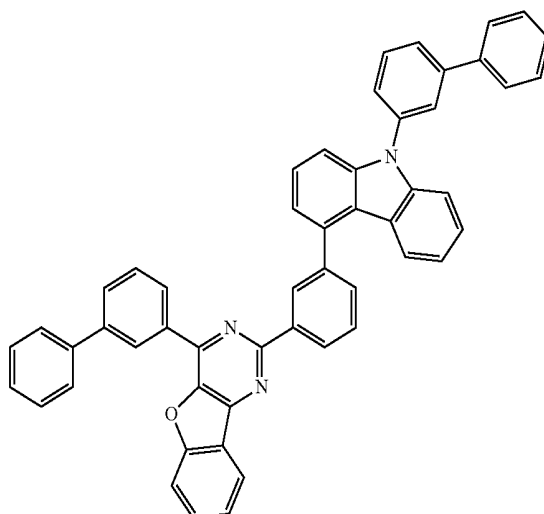
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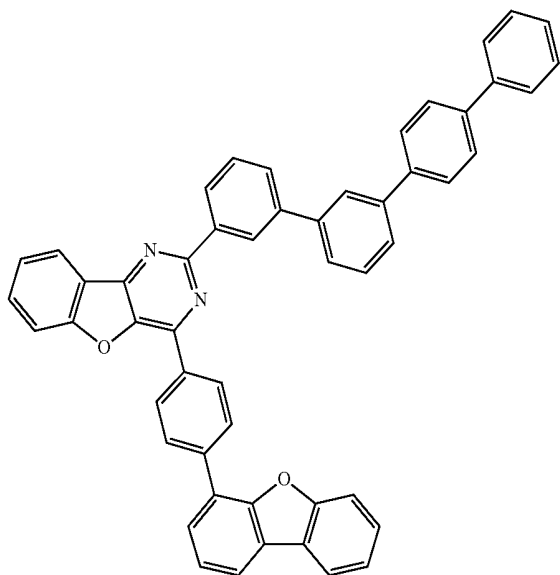
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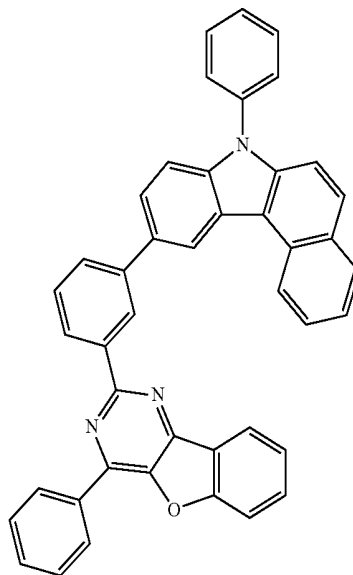
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b-46

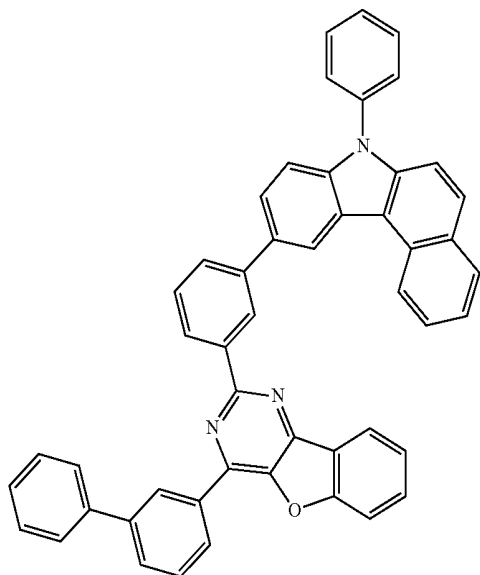


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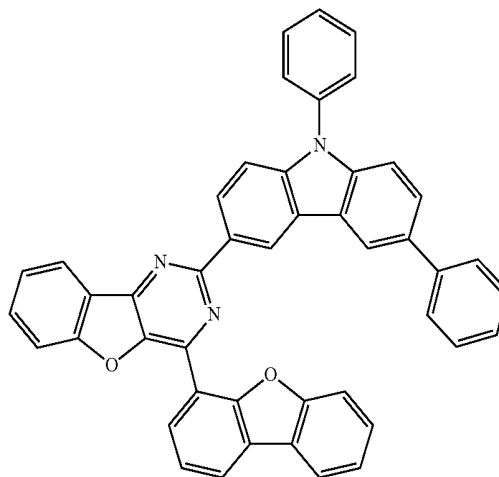
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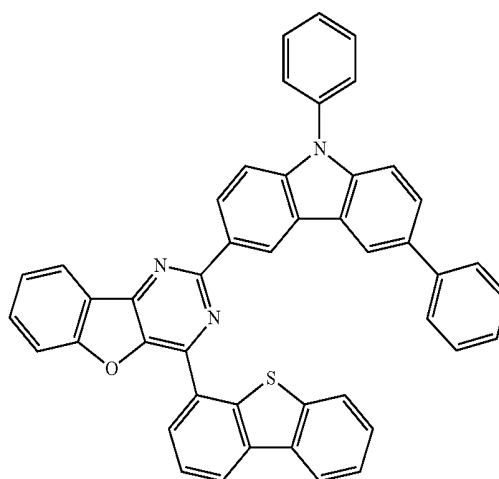
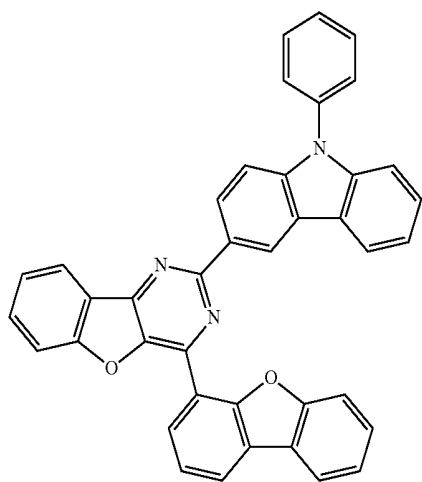
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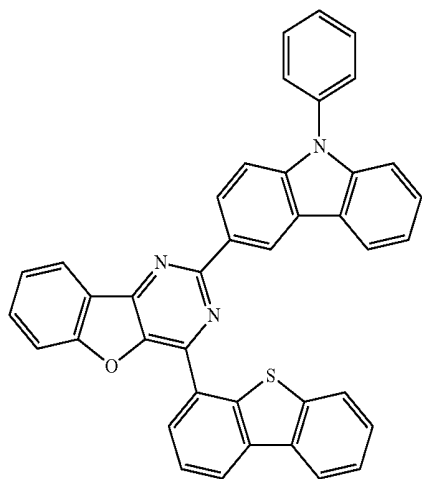


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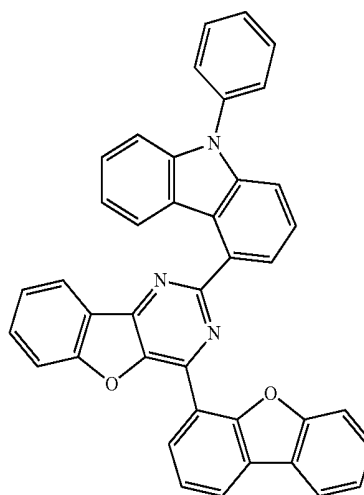
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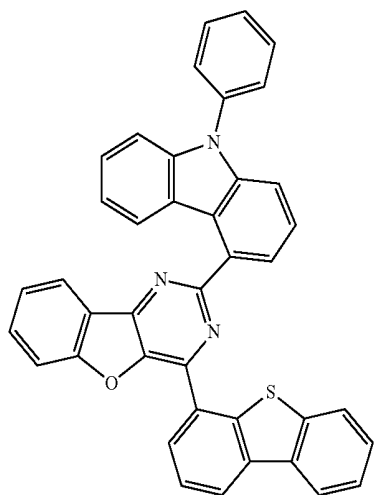
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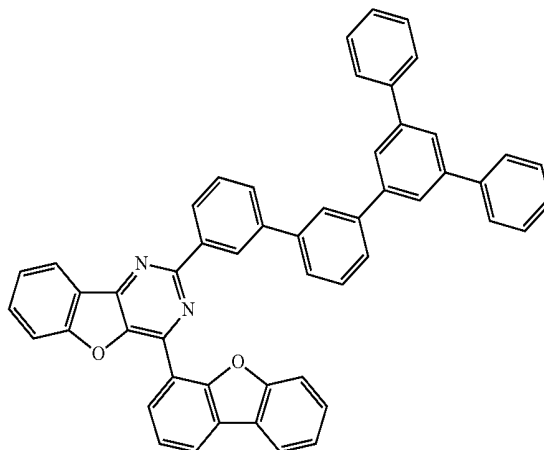


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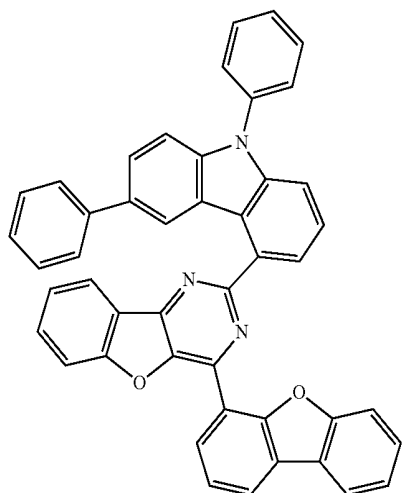


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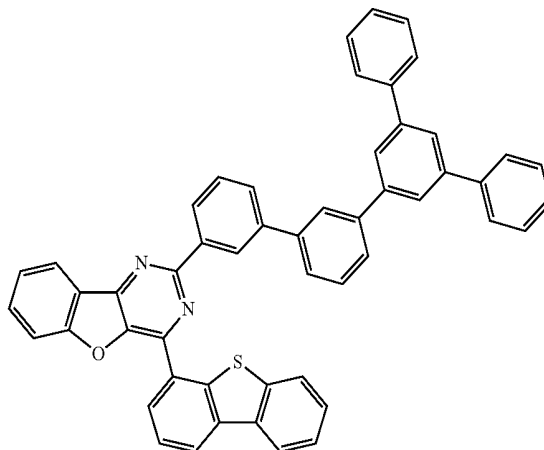
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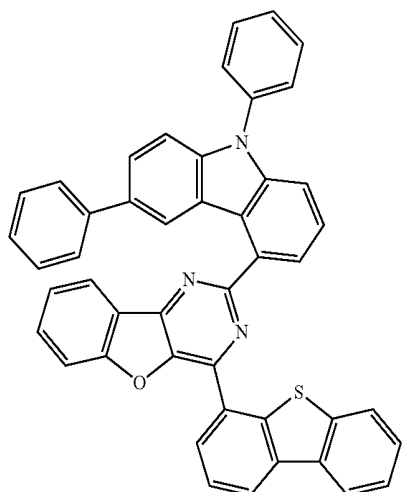
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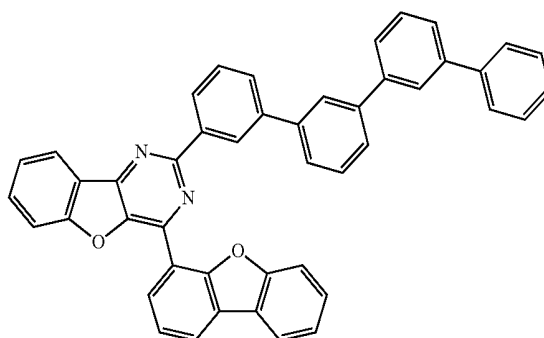
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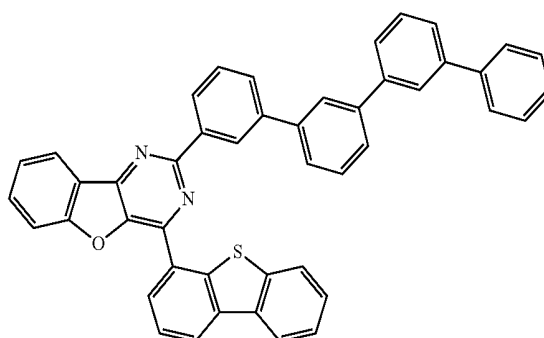
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b-58



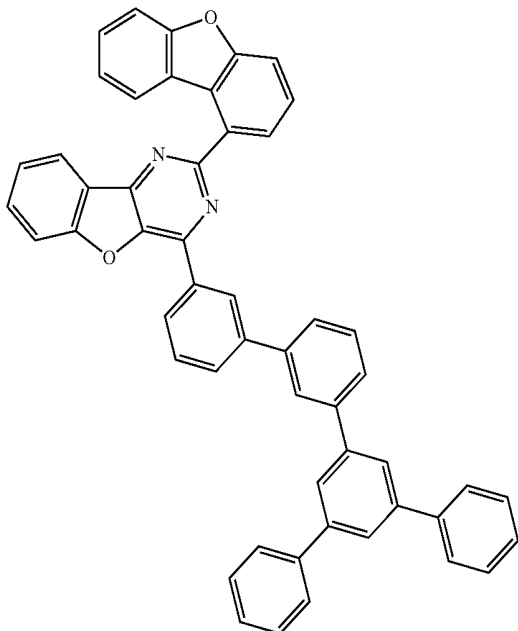
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b-62

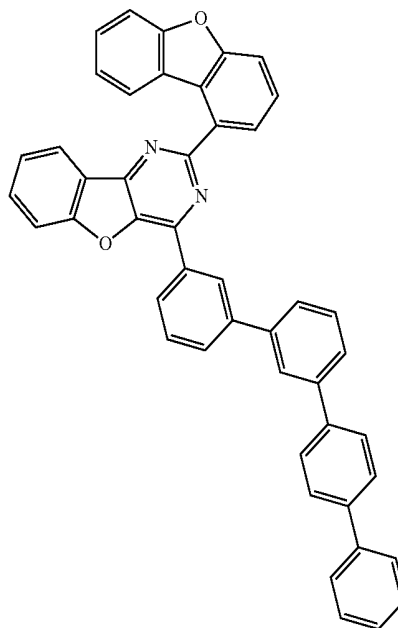
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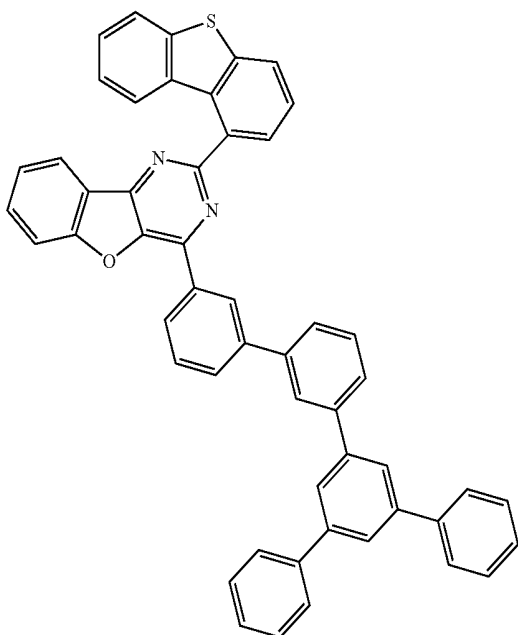
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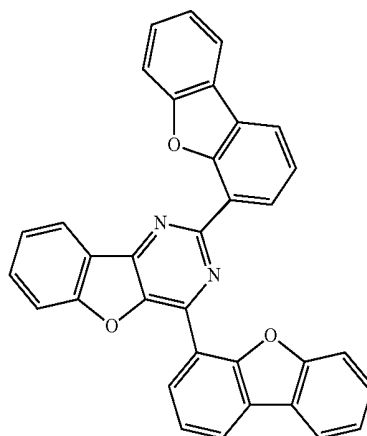


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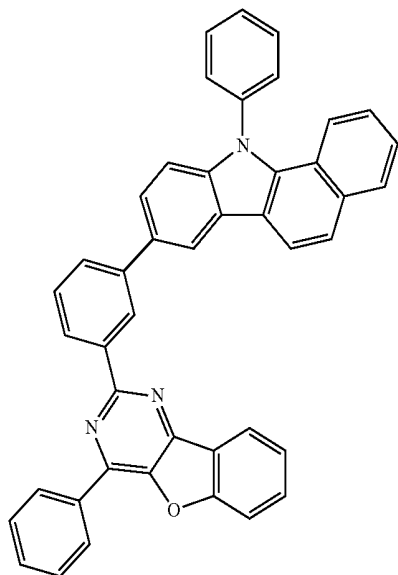
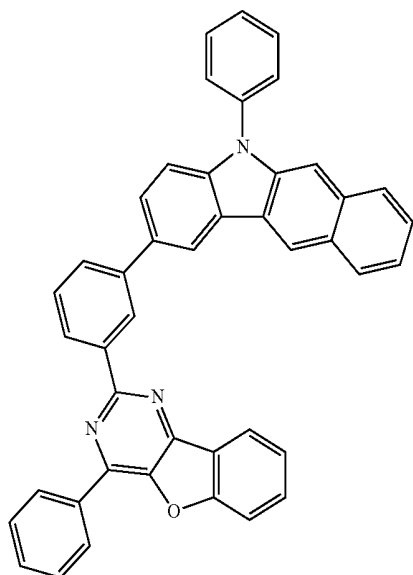
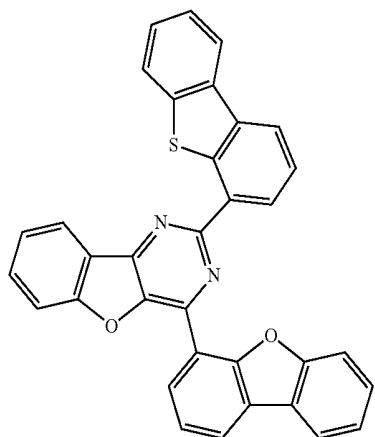
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b-67



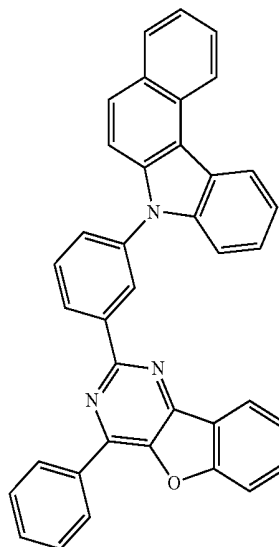
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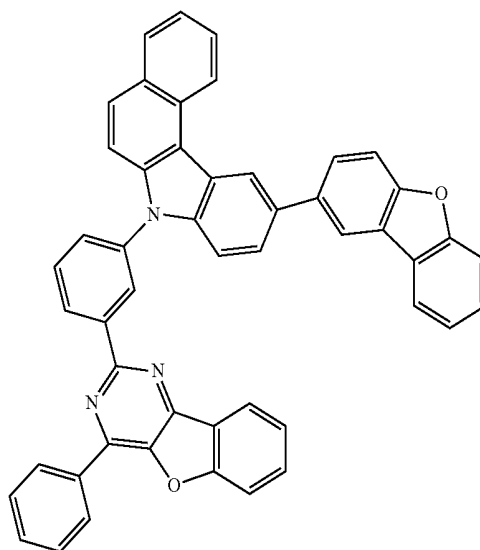
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b-71



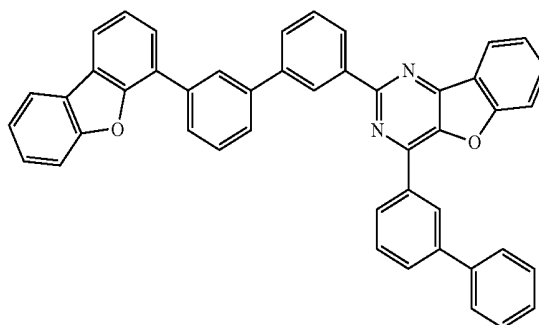
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b-72



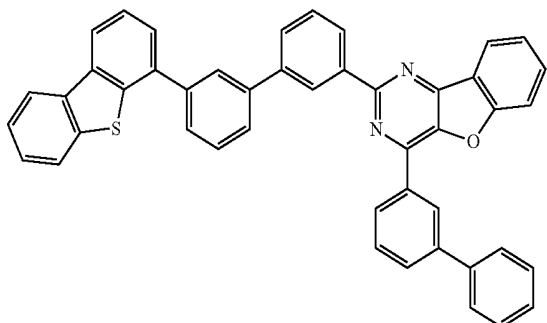
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b-73

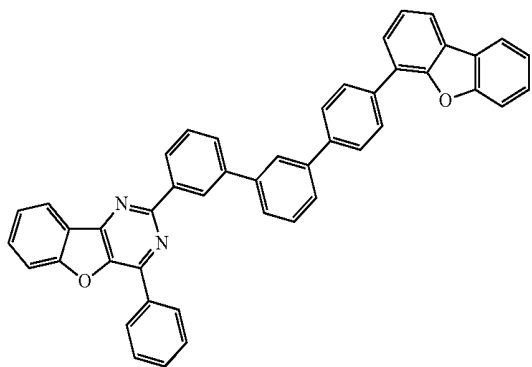


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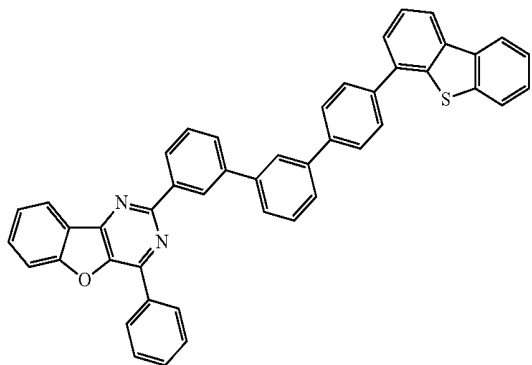
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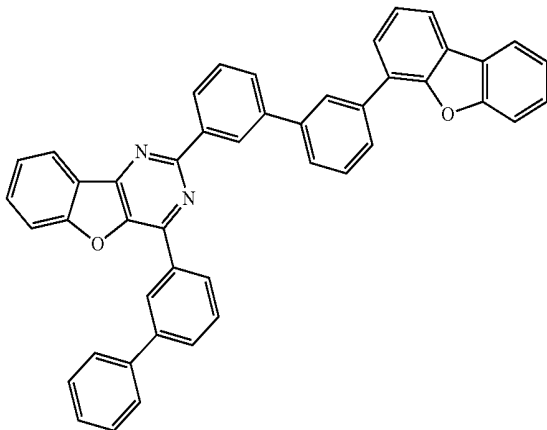
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b-76

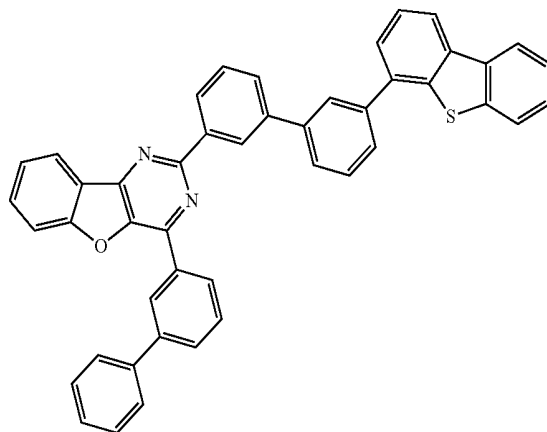


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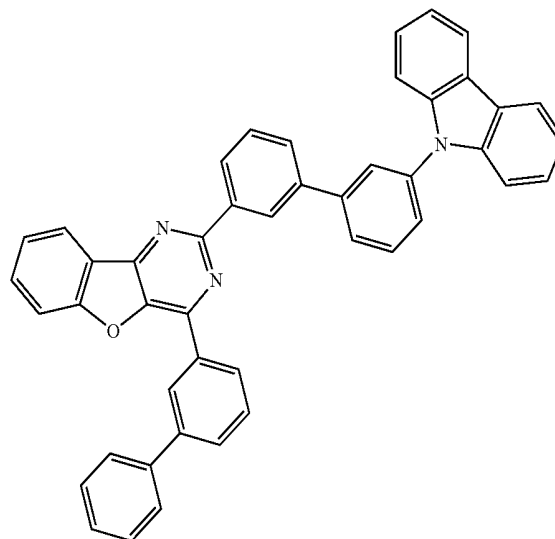


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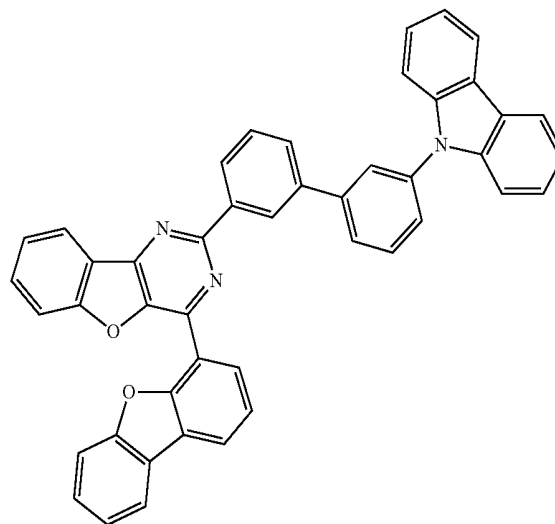
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b-79

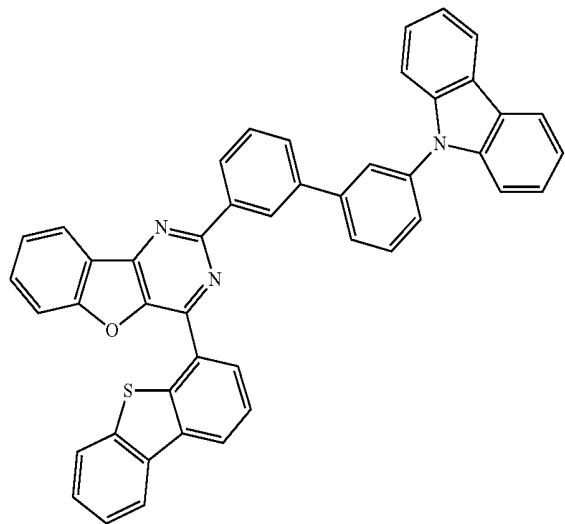


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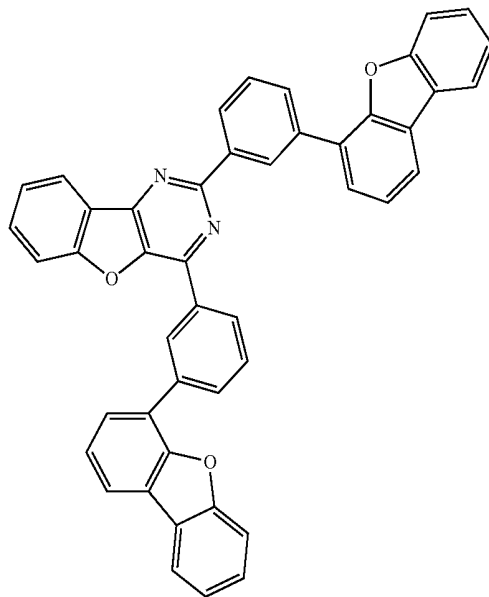
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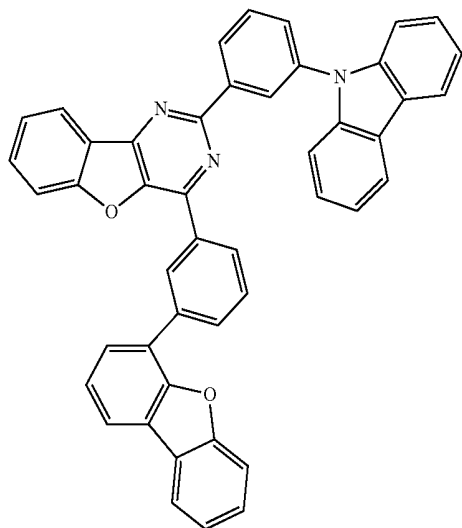


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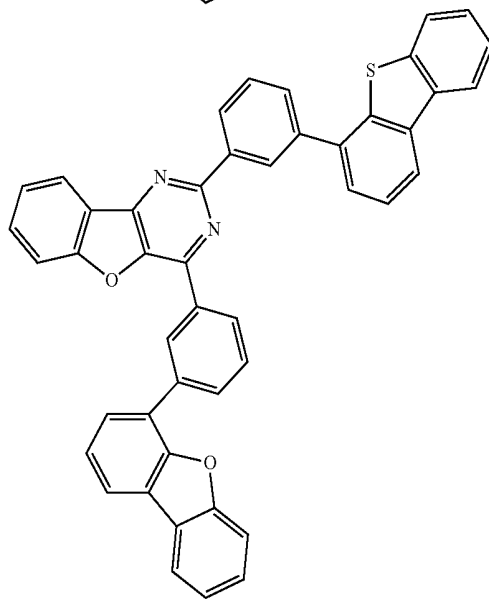
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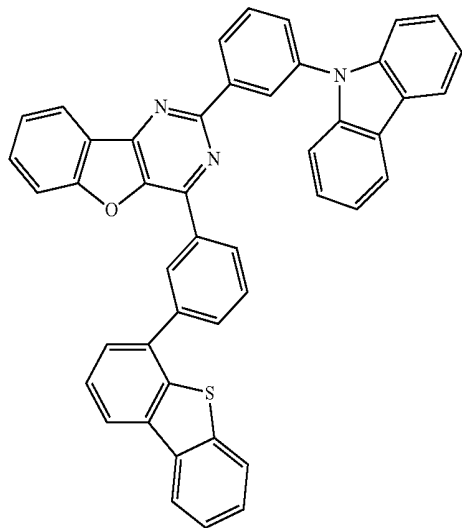
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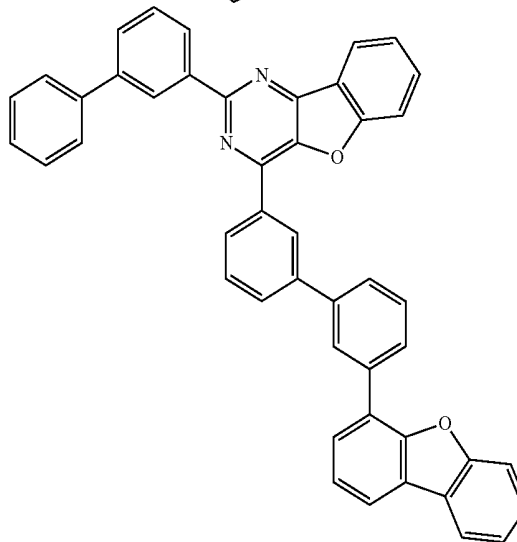
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b-83

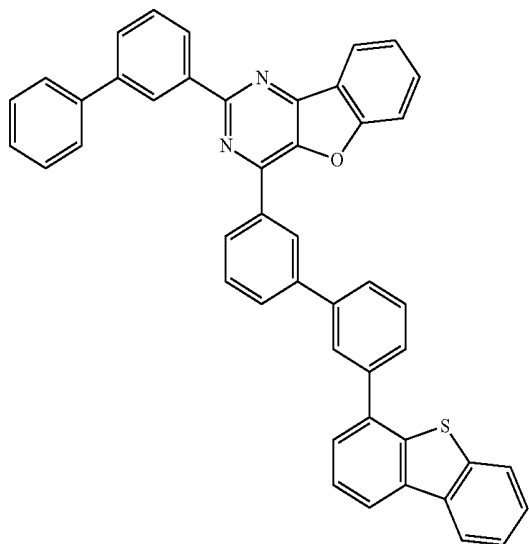


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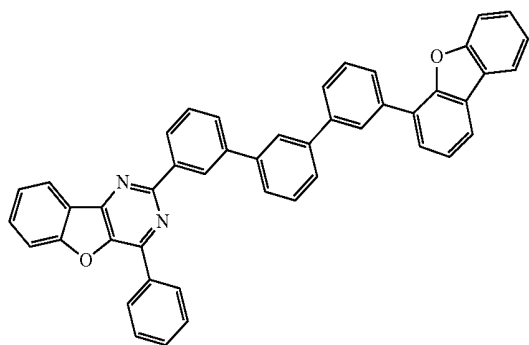


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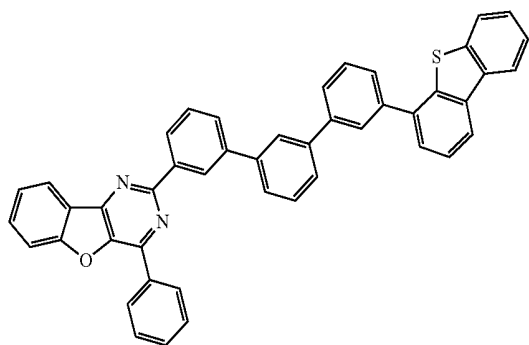
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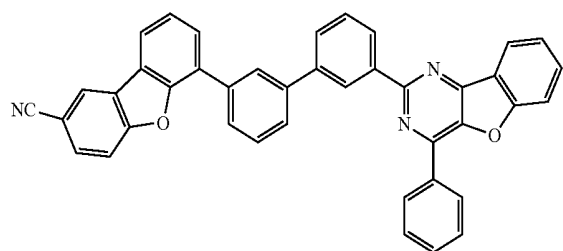
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b-89

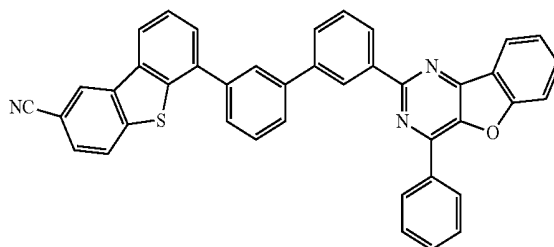


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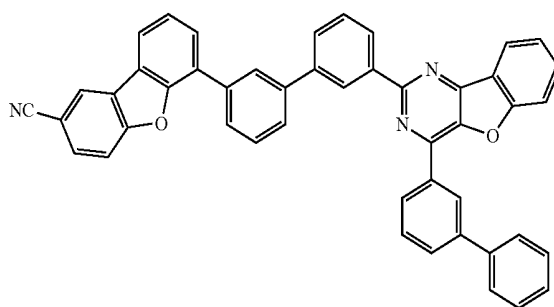


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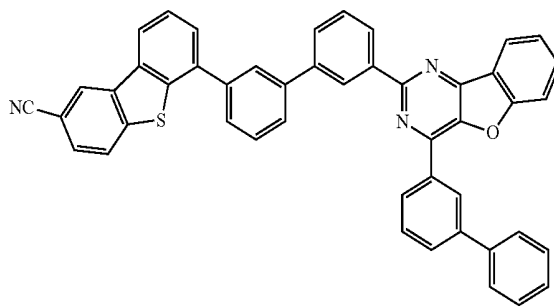
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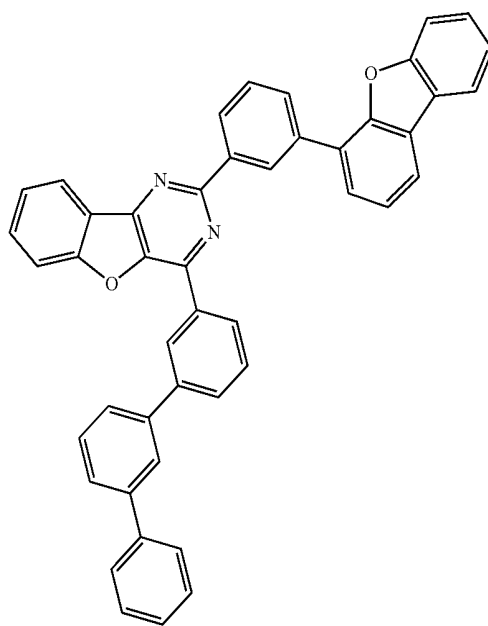
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b-93

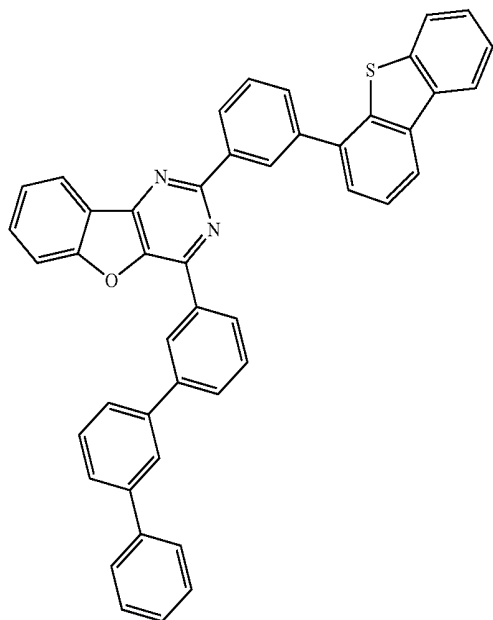


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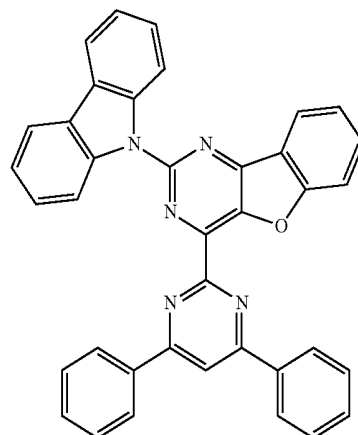
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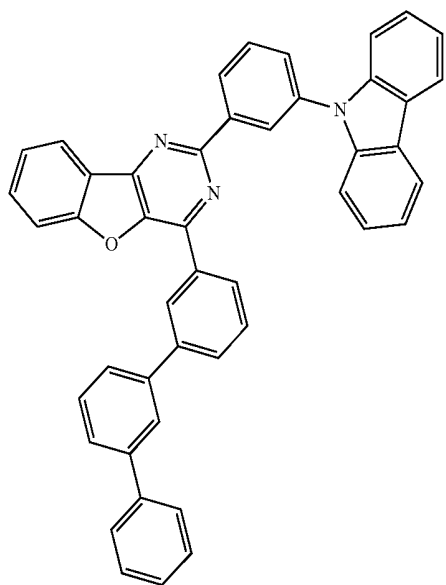
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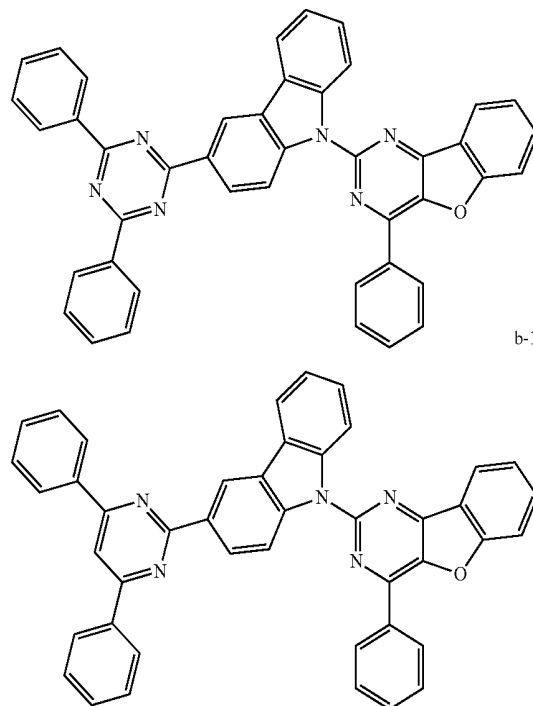


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b-96

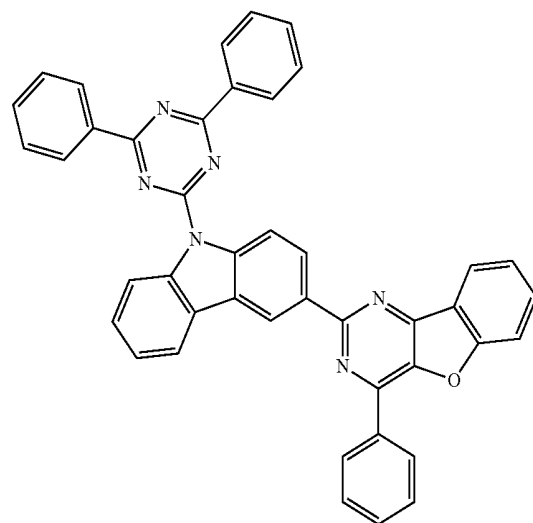
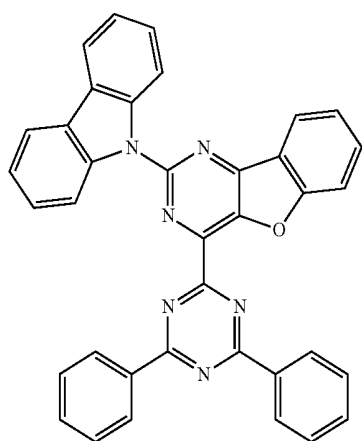


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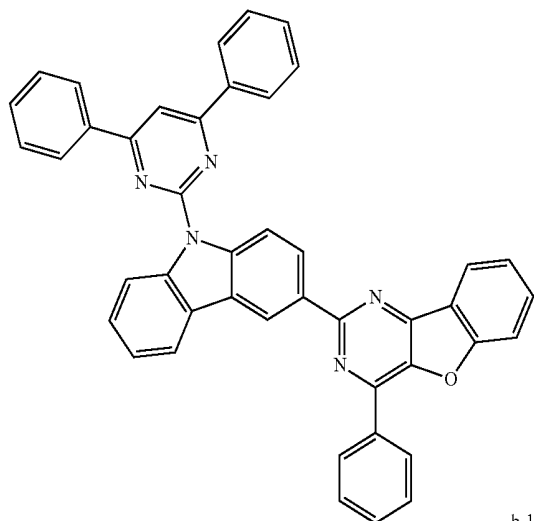
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b-97

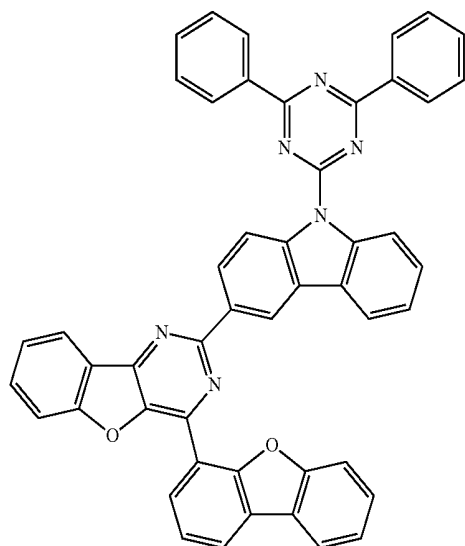


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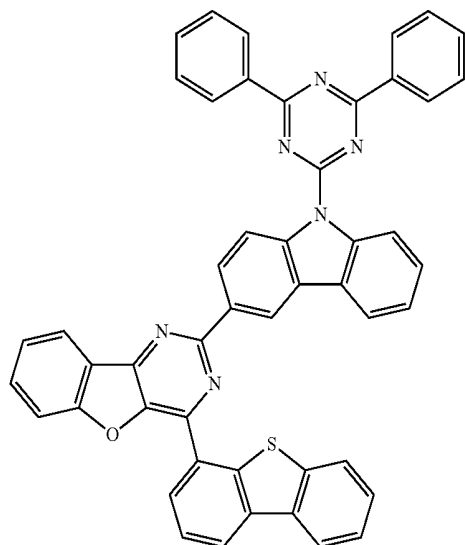
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b-103

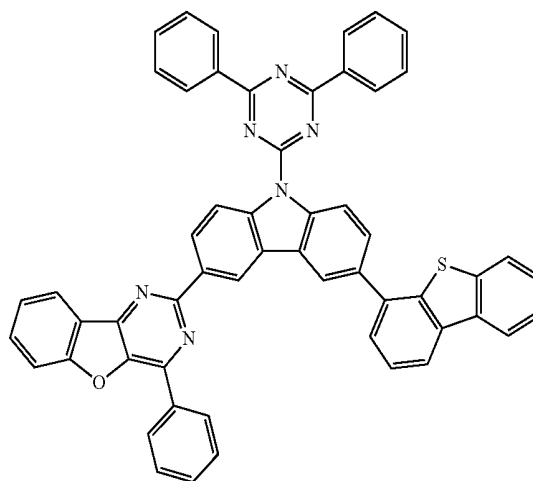


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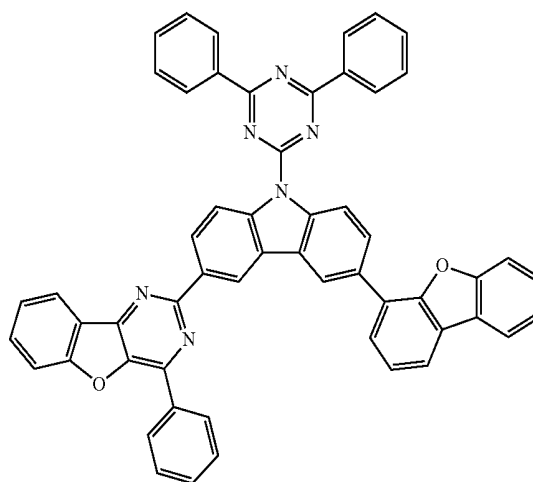


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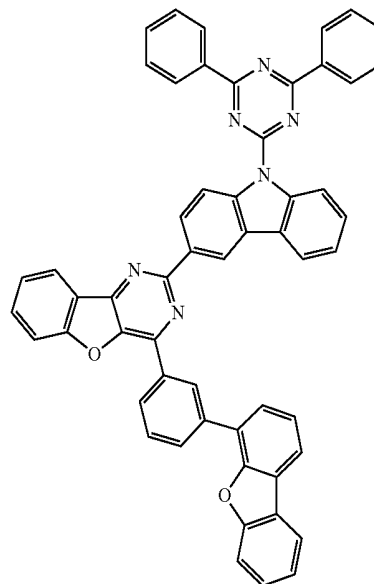
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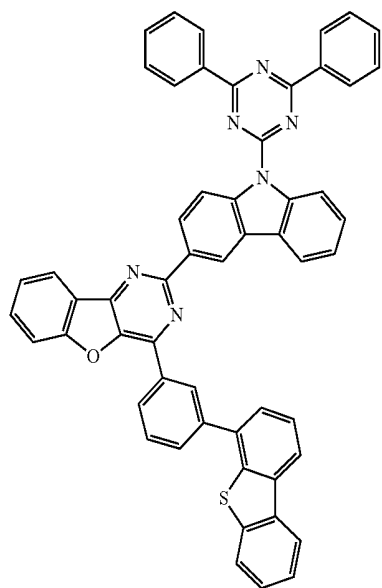
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b-107

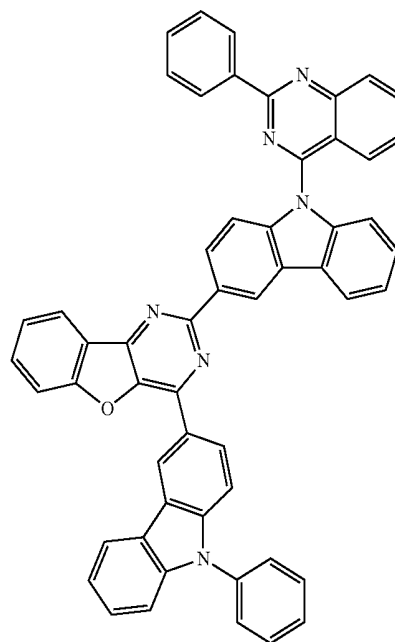


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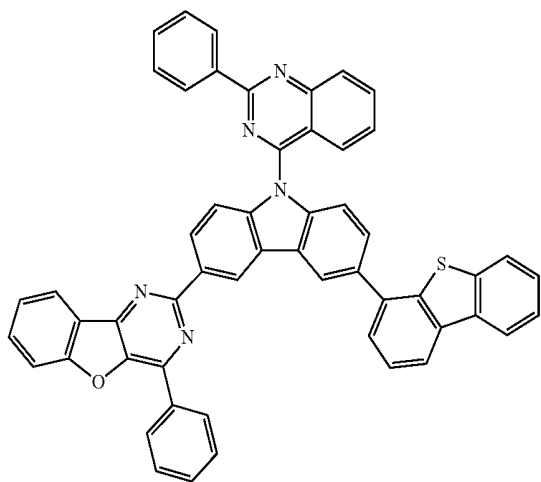


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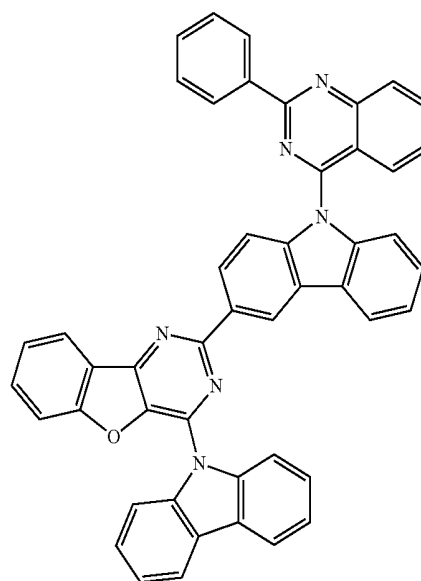
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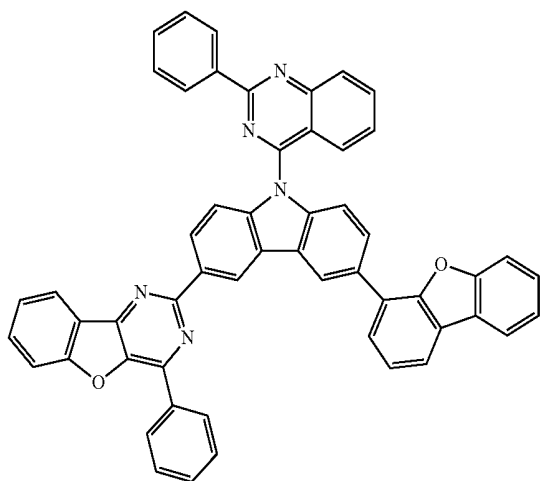
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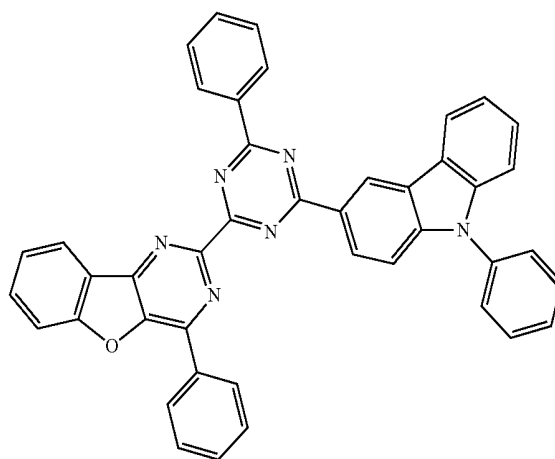
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b-112



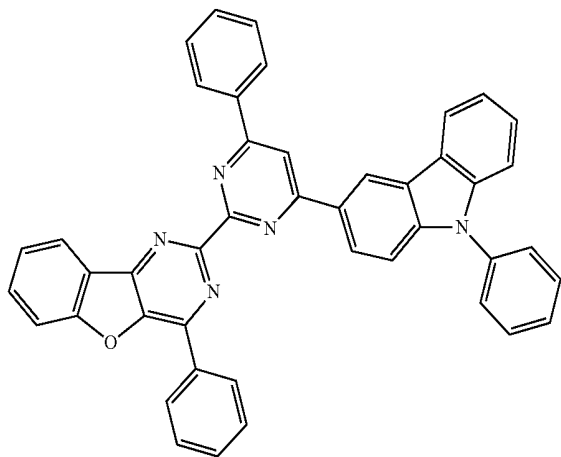
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b-113

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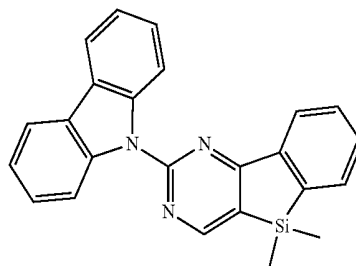
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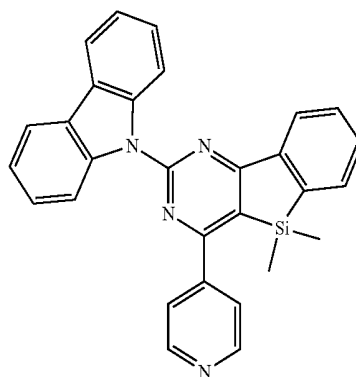
[0156] Group of X1=Si(R<sub>4</sub>)(R<sub>5</sub>) in Formula 1-1

[0157] (R<sub>4</sub> and R<sub>5</sub> are Described in the Above Specification)

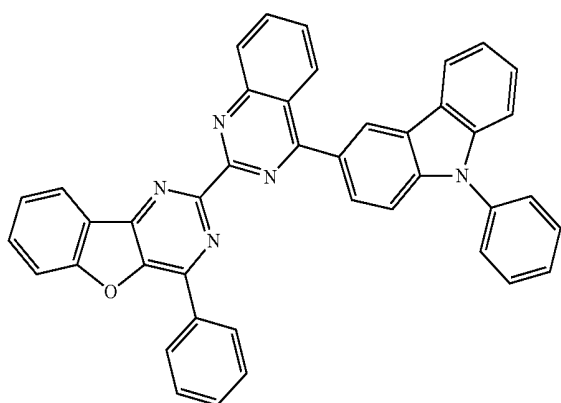
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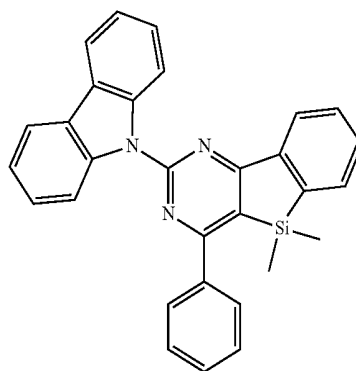
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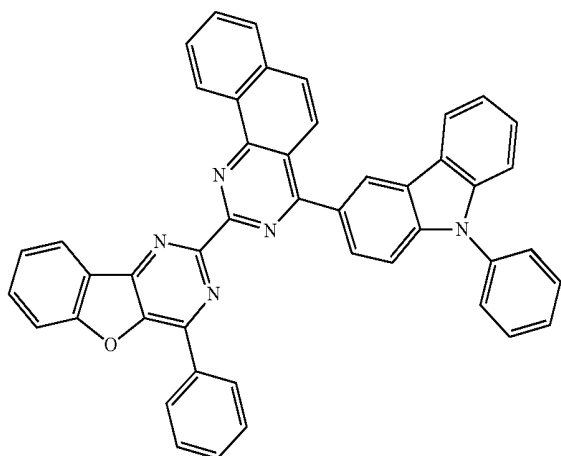
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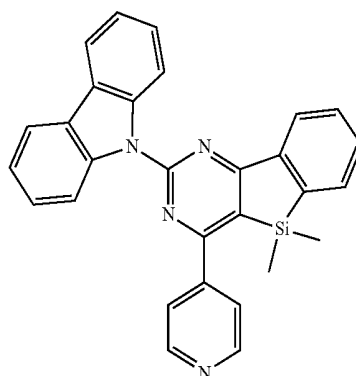
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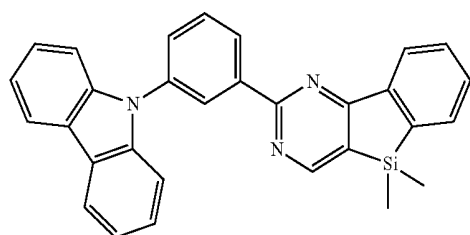
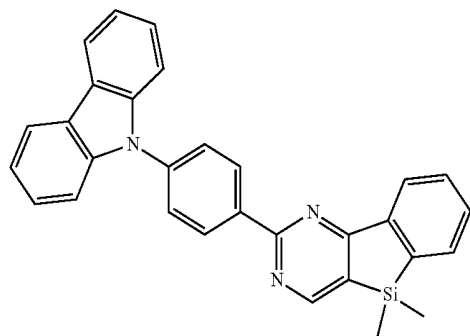
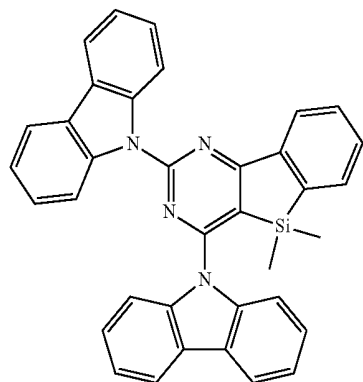
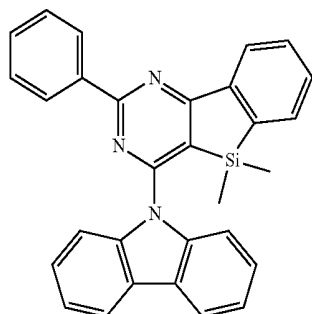
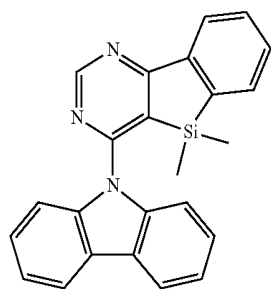
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70



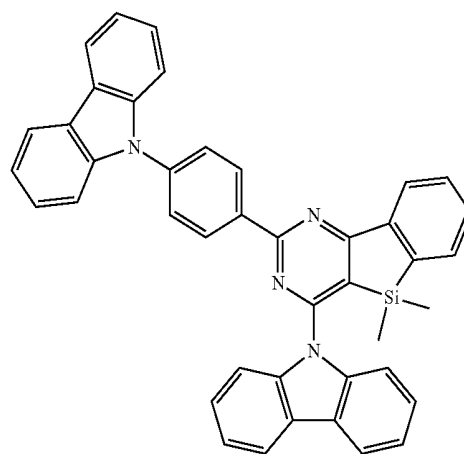
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71

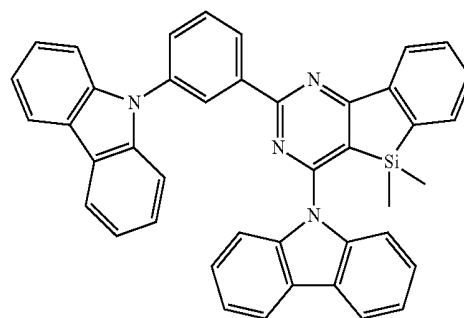
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72

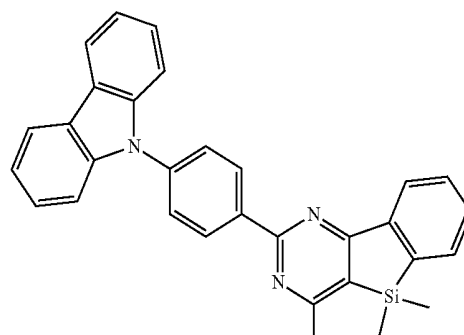
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77

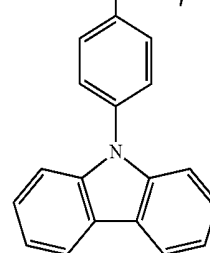


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78

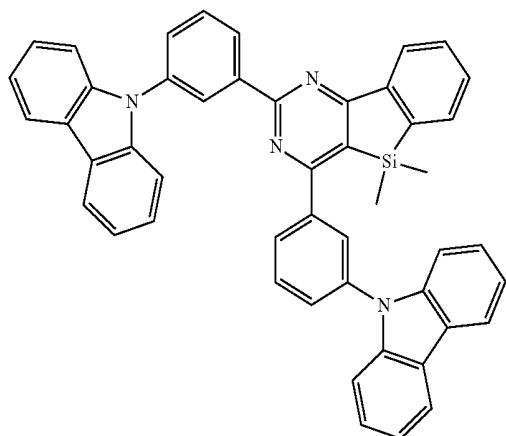


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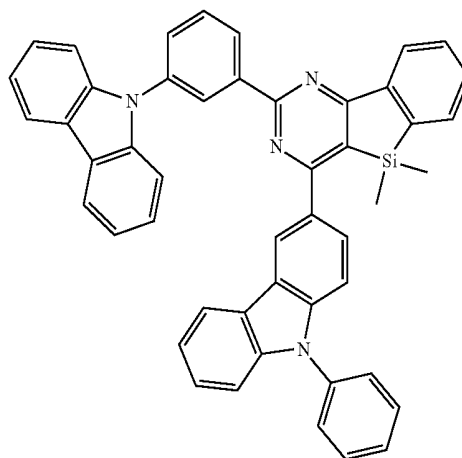
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79



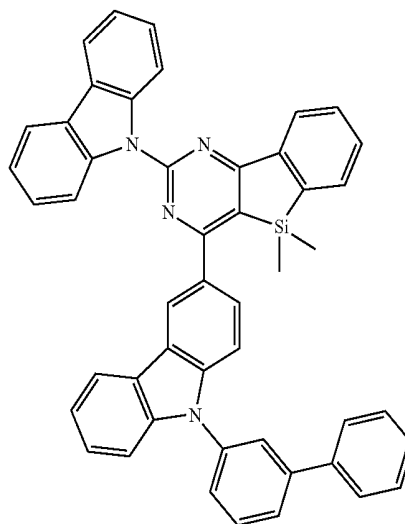
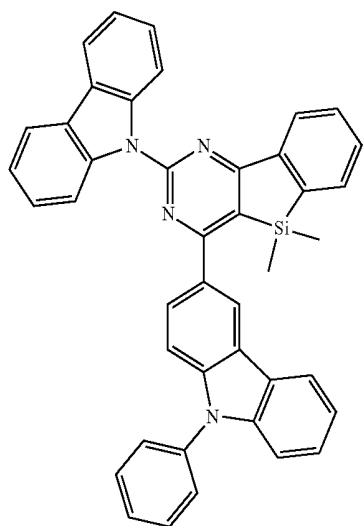
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82



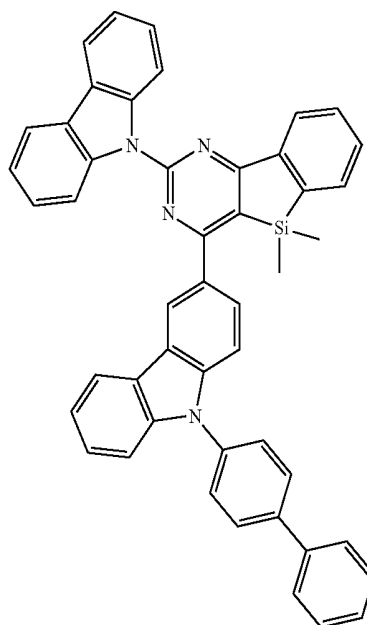
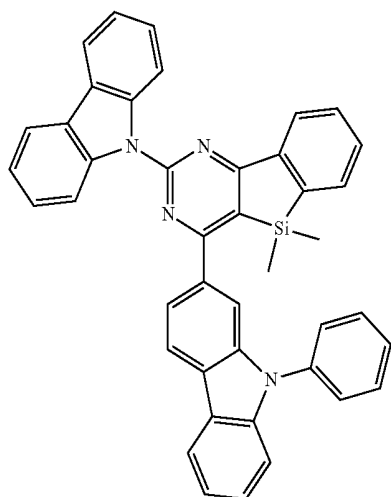
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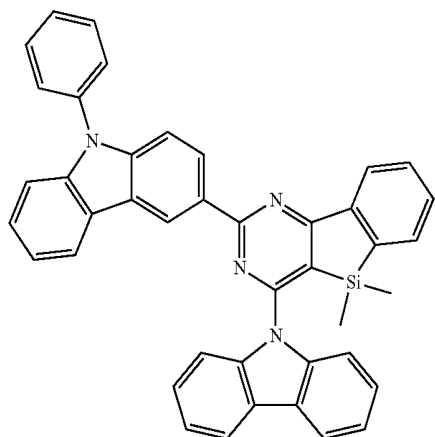


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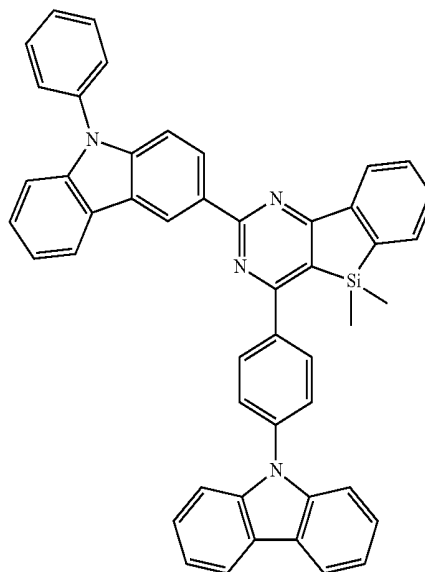


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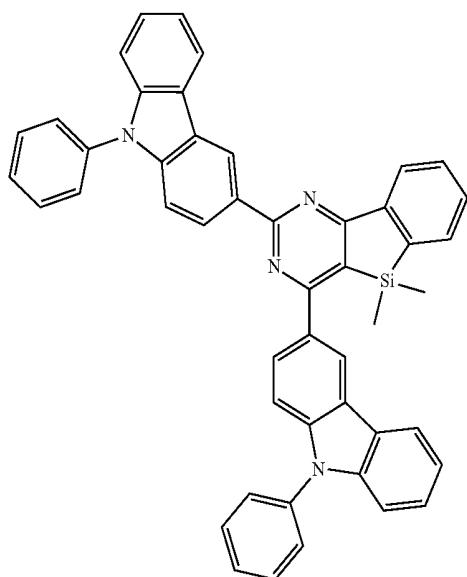
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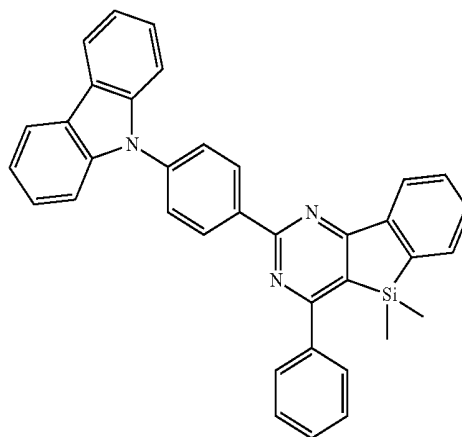


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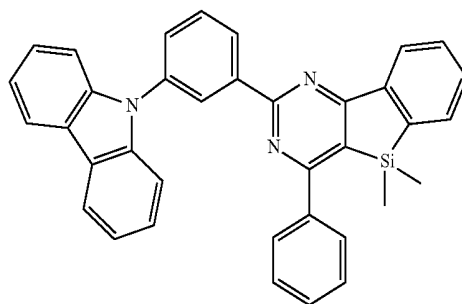
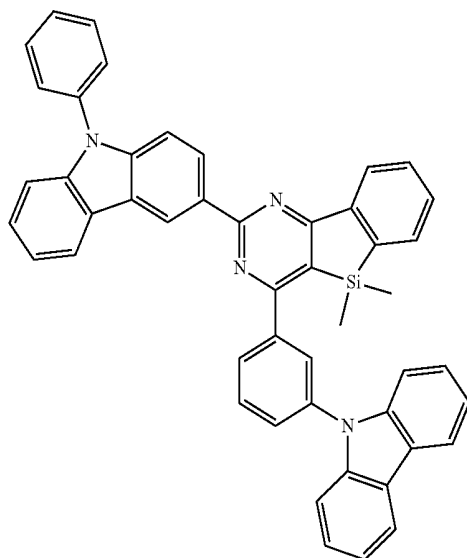
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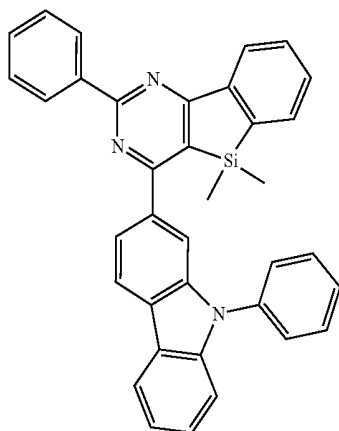


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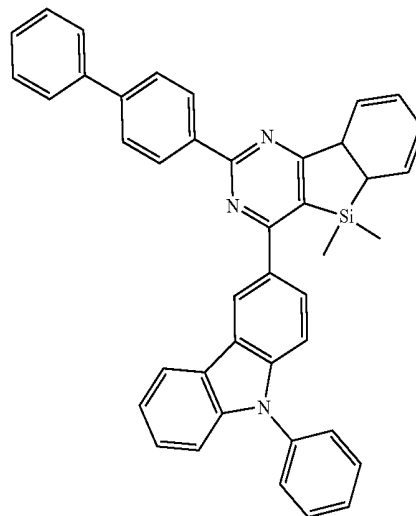
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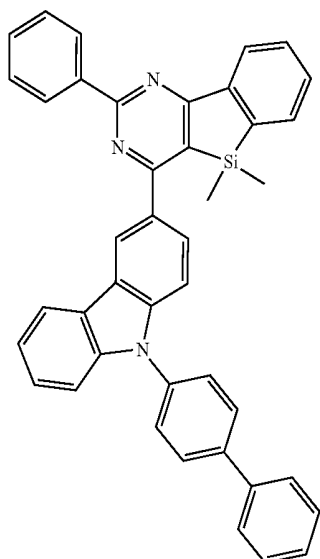


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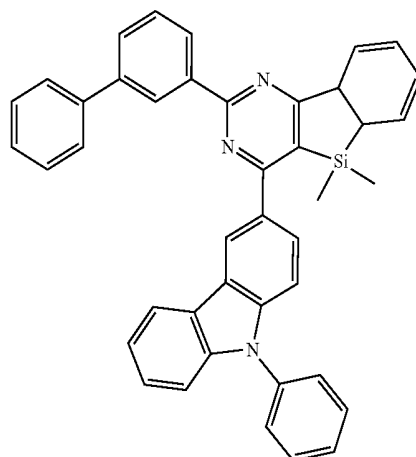
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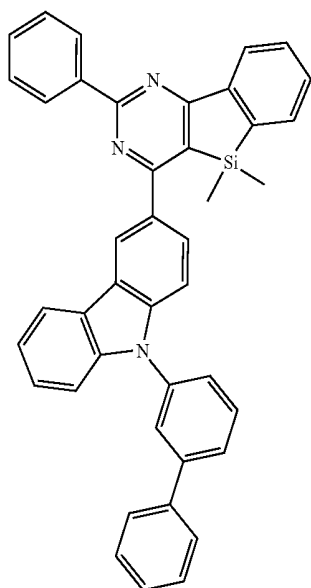
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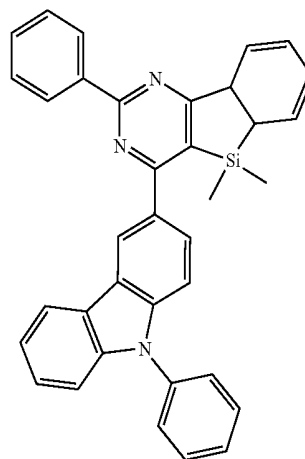
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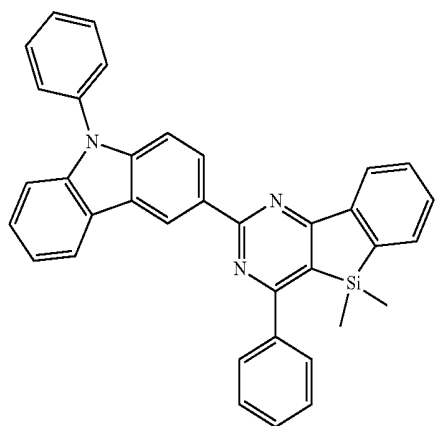


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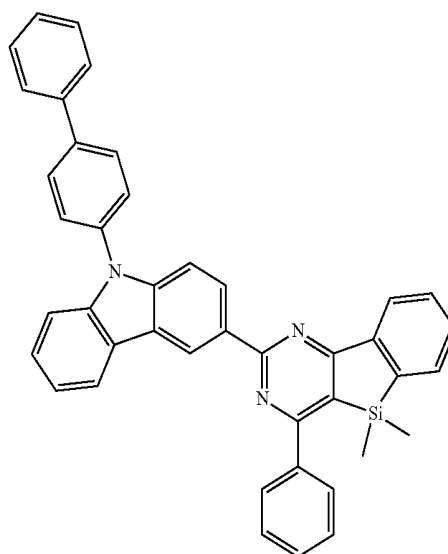
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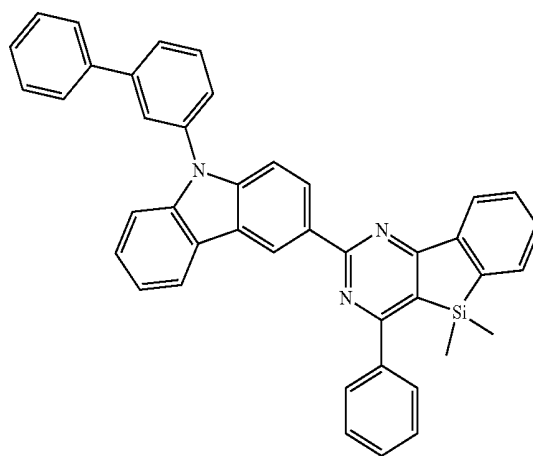
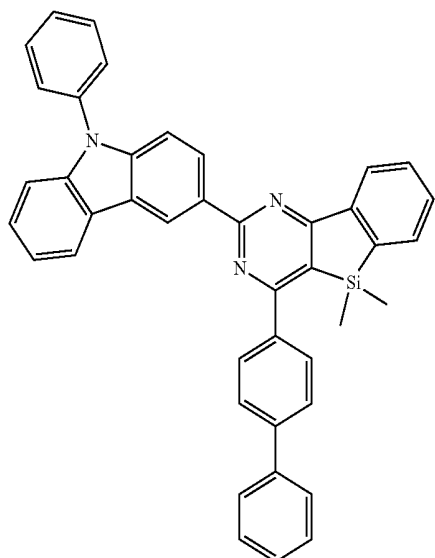
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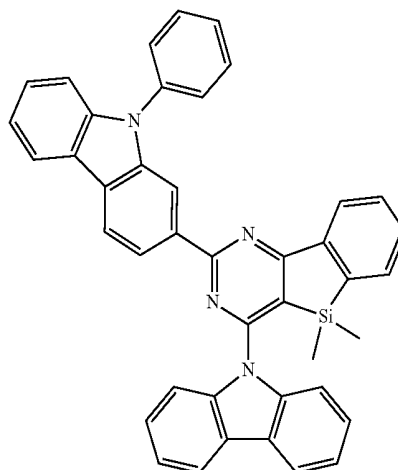
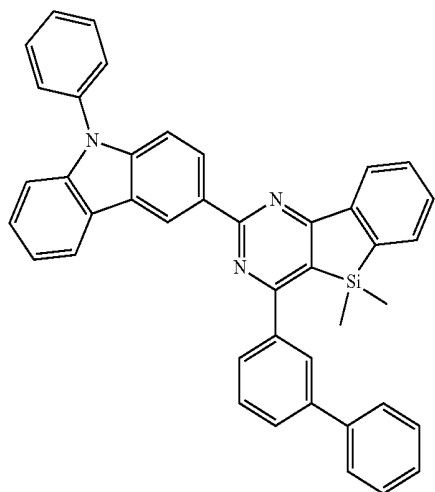
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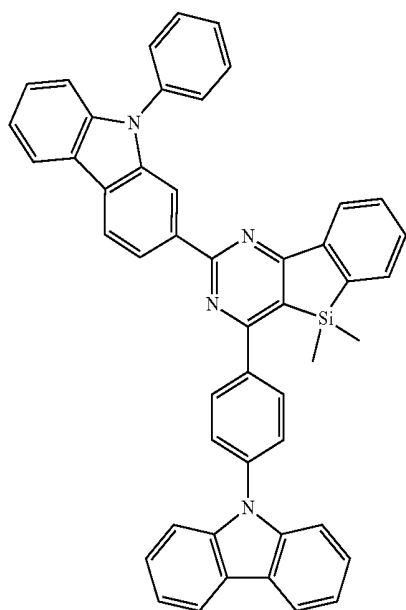
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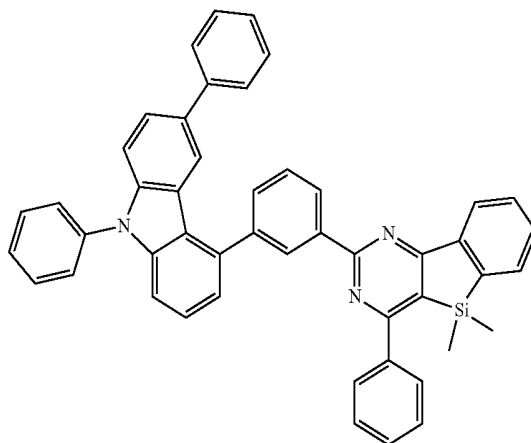
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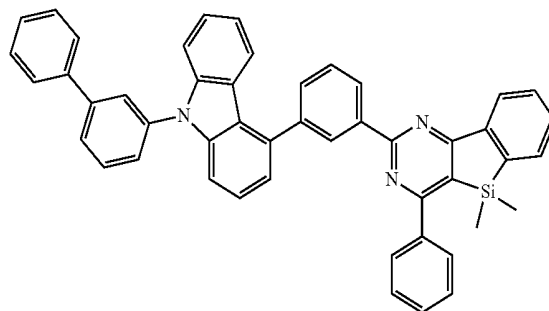
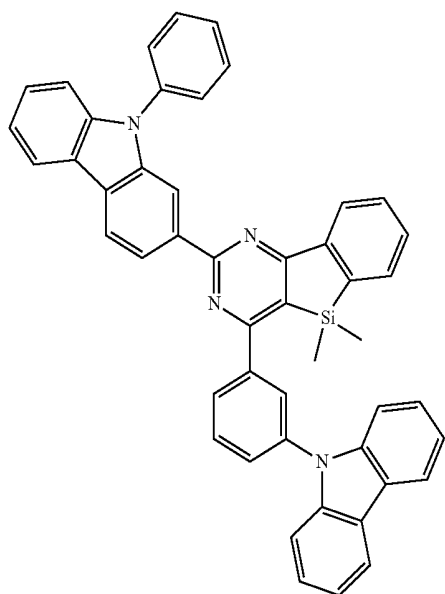
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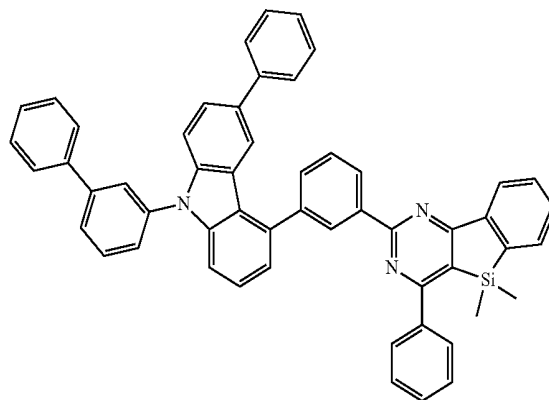
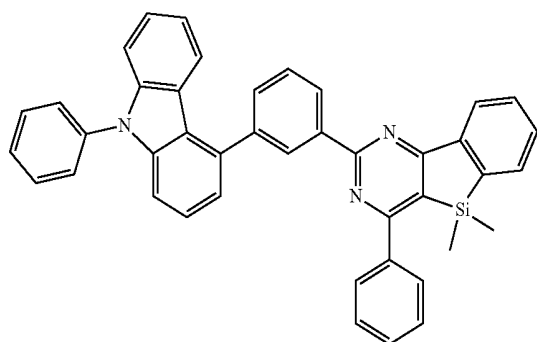
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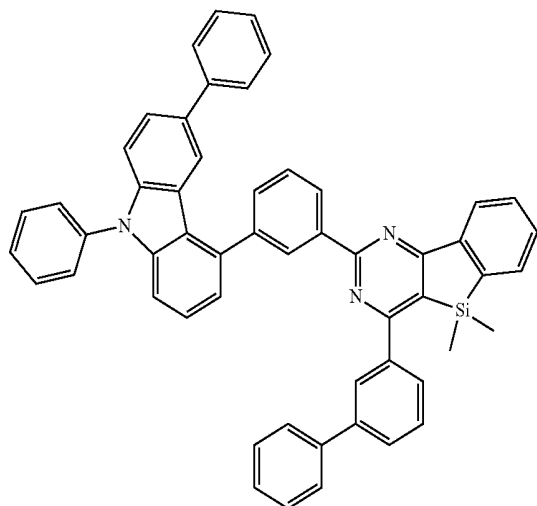
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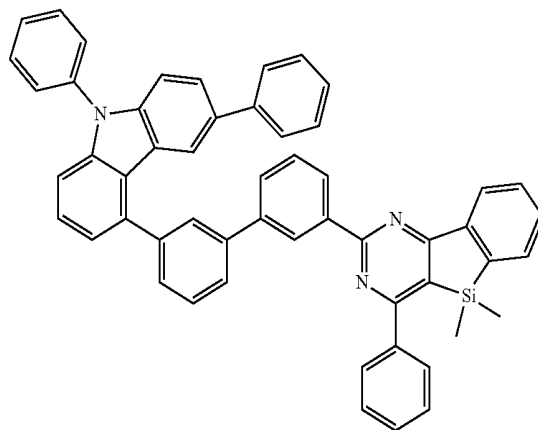
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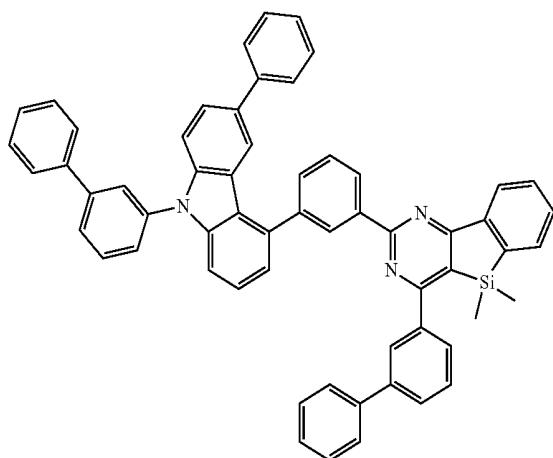


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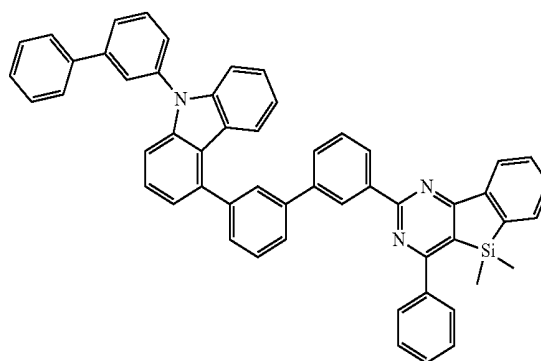
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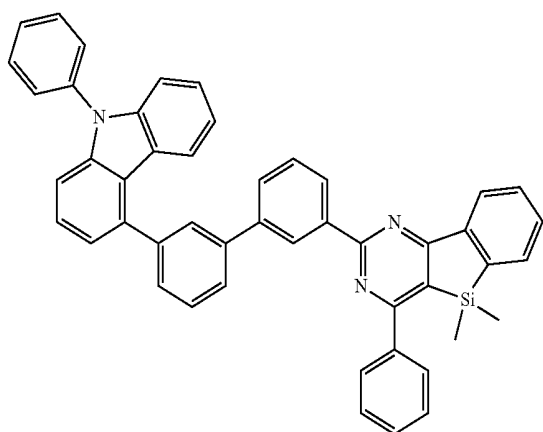
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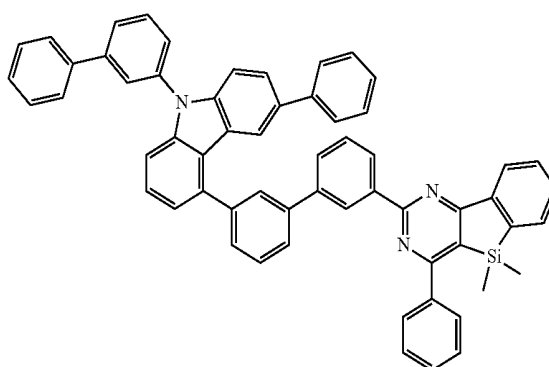
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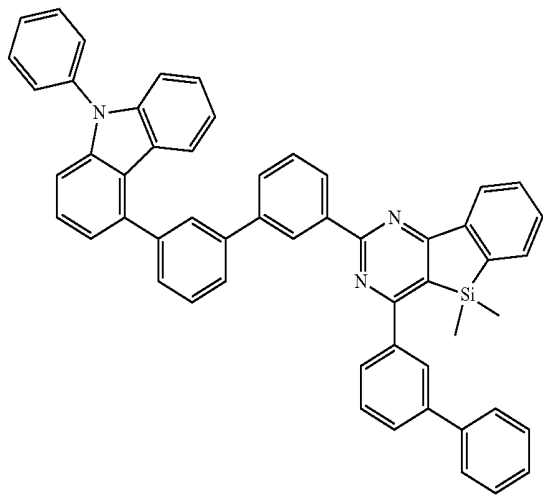


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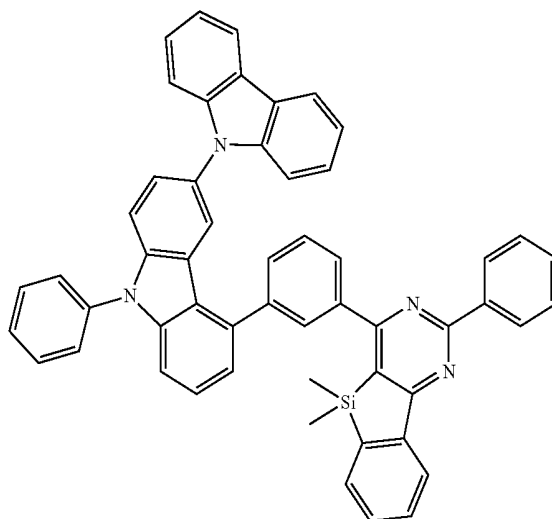
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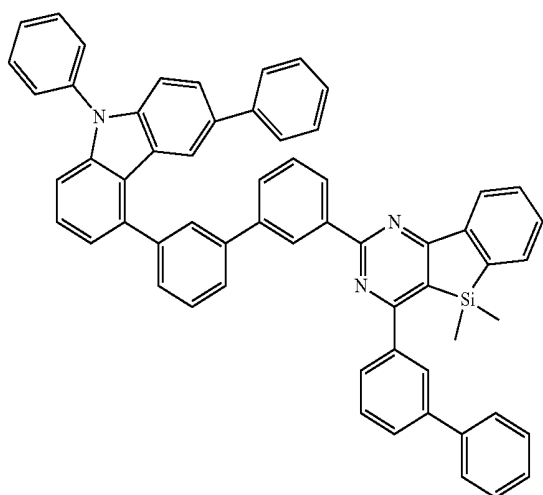


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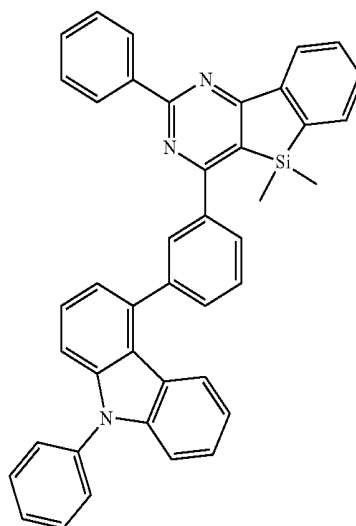
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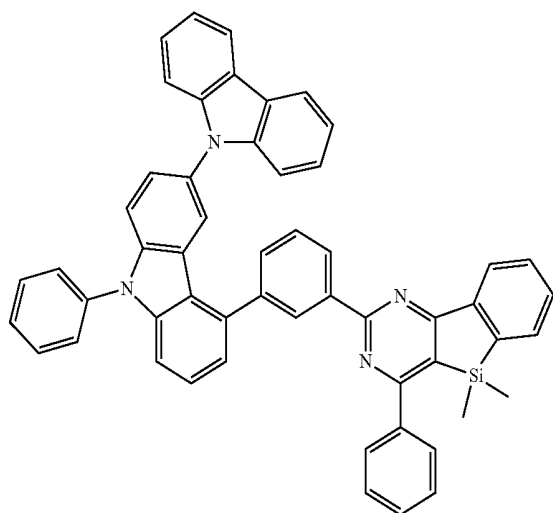
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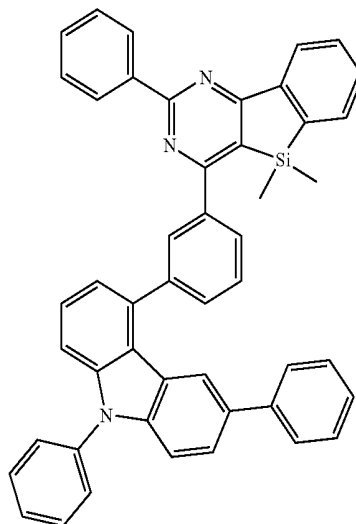
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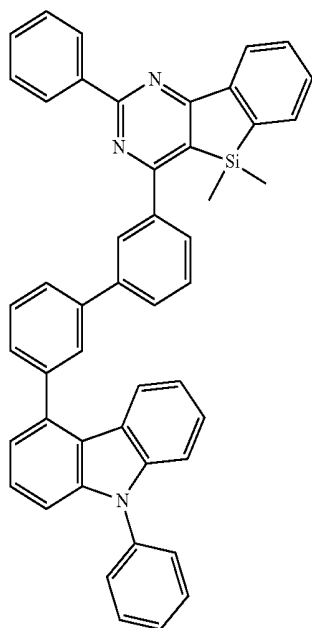
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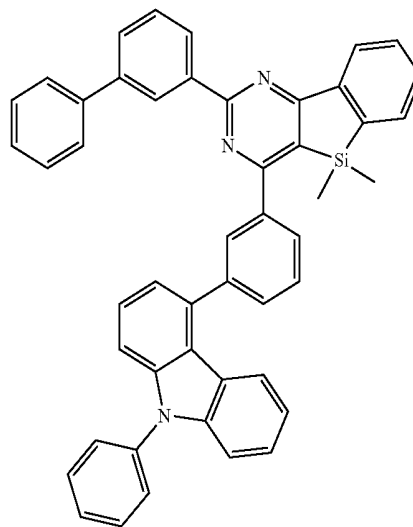


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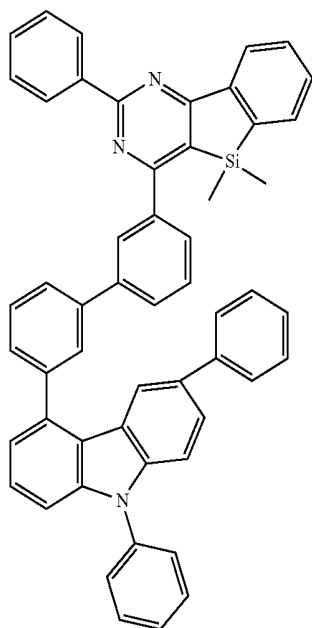


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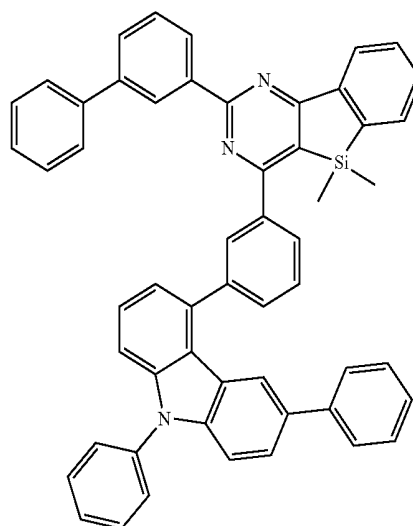
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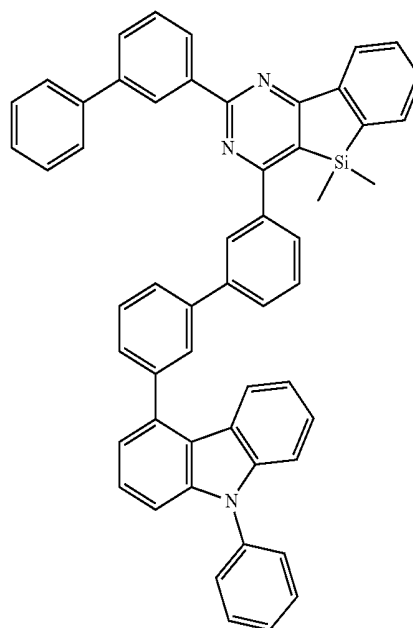
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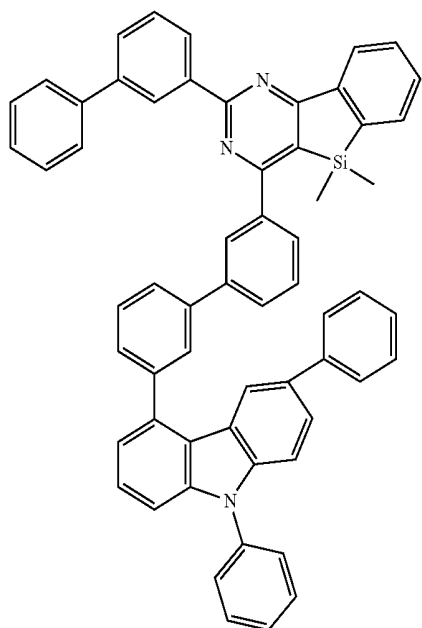


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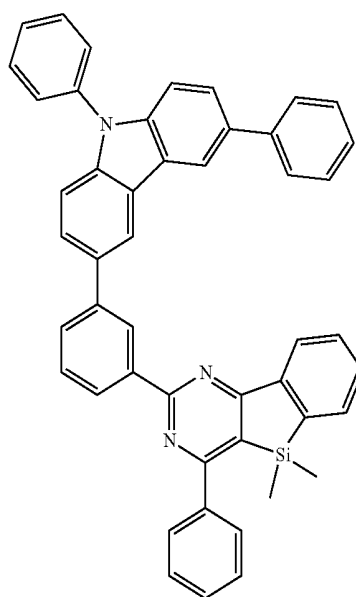
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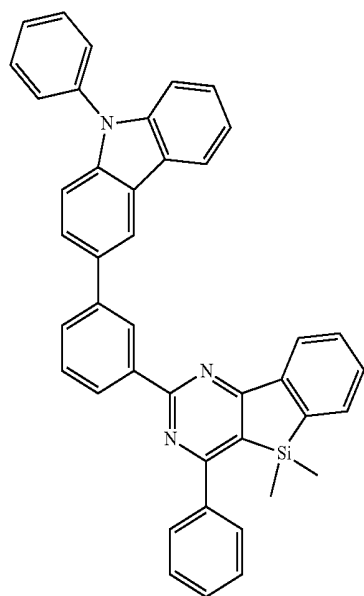


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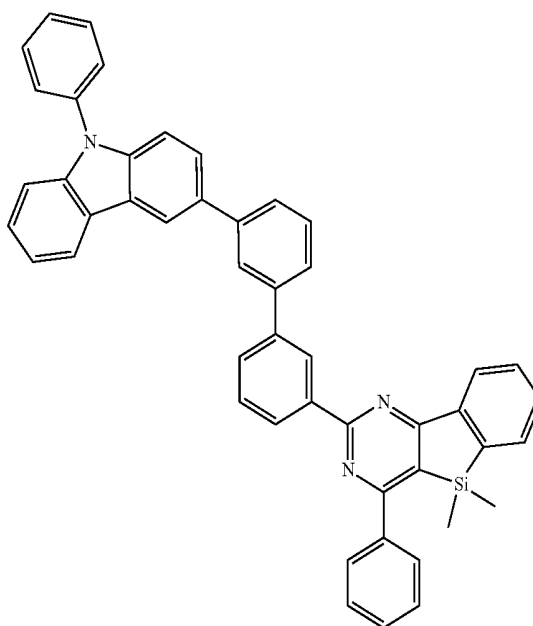


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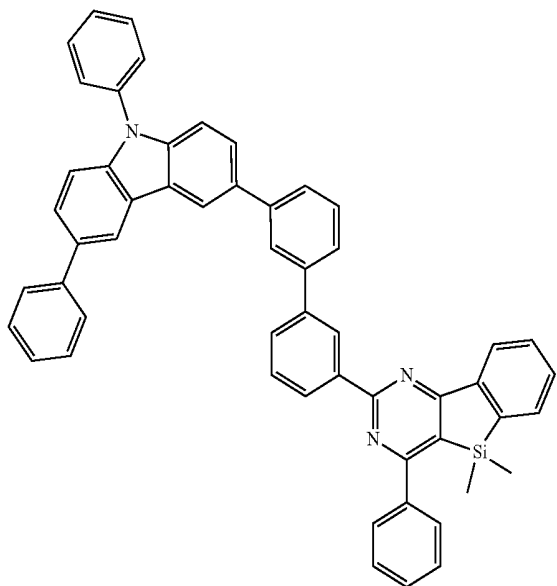
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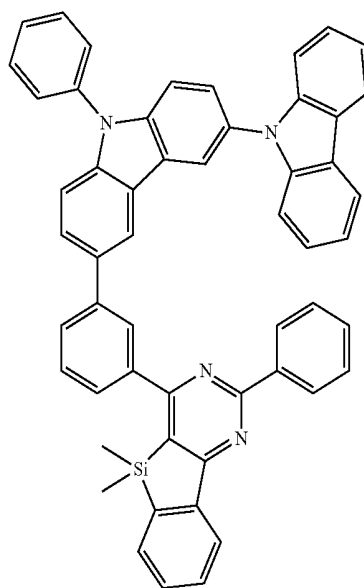
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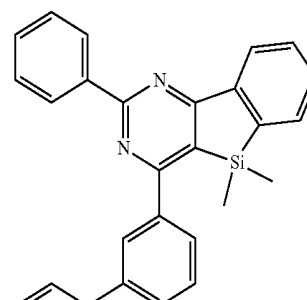


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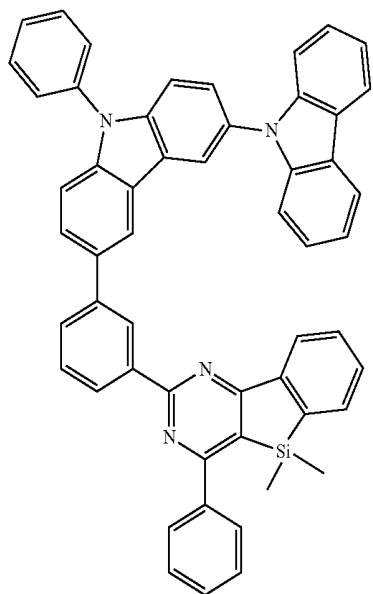
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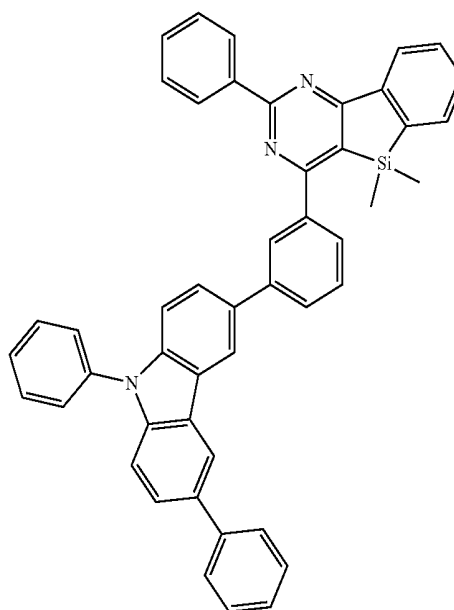
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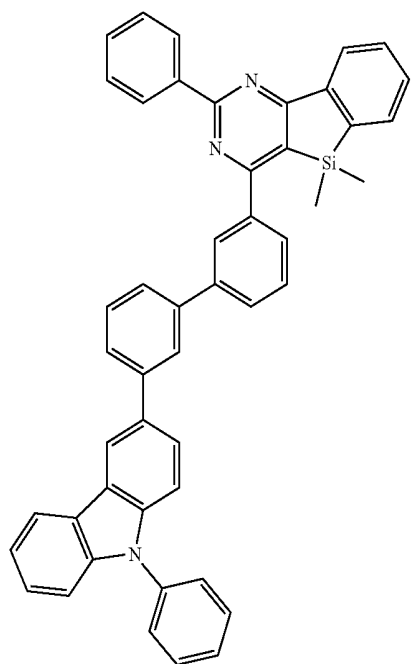
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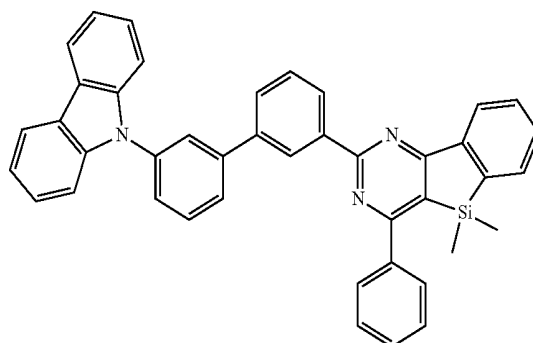
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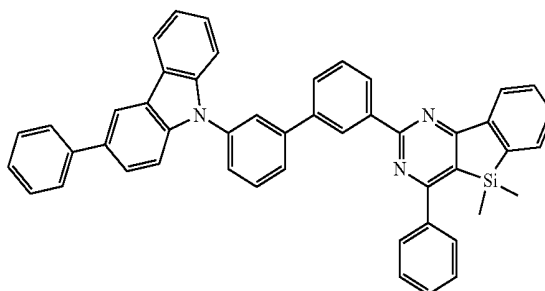


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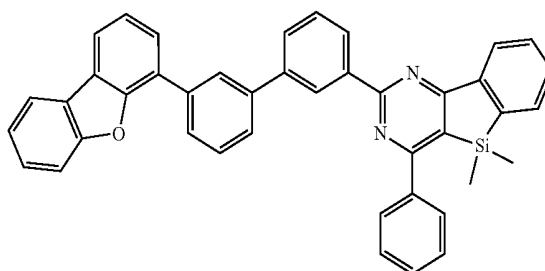


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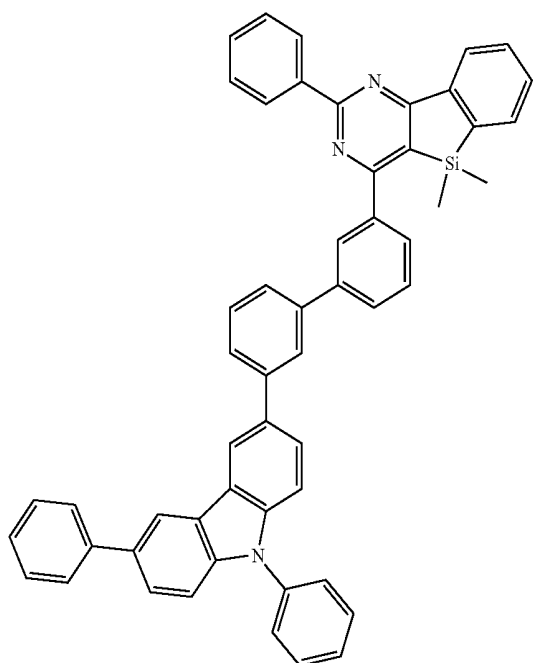
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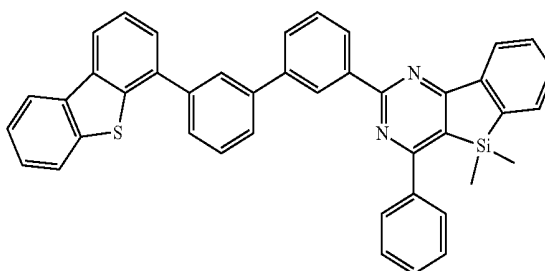
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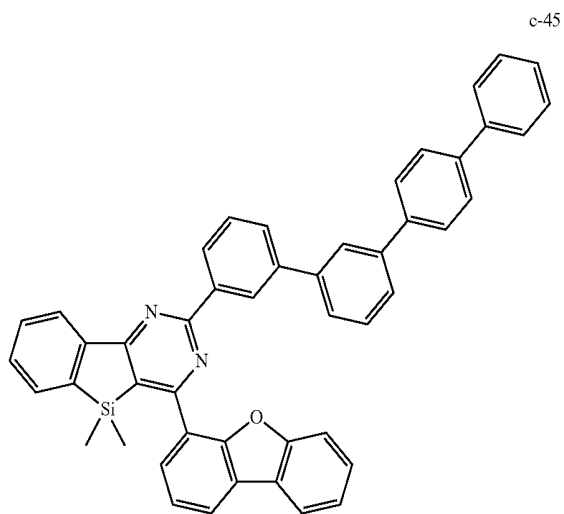
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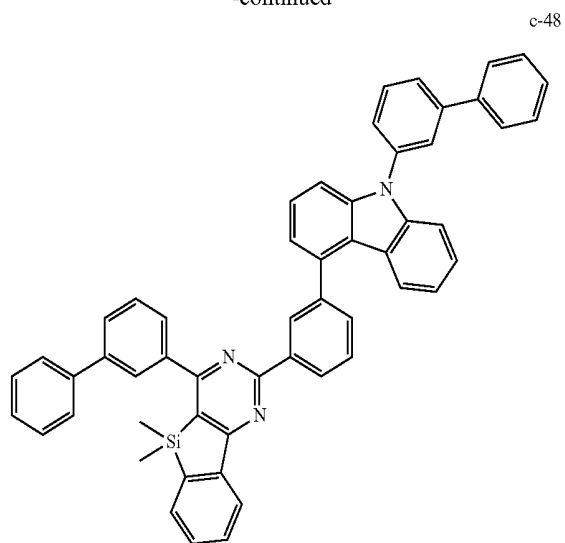
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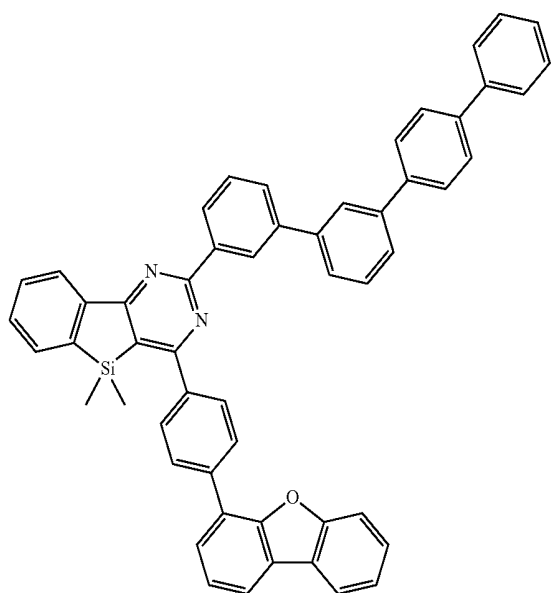
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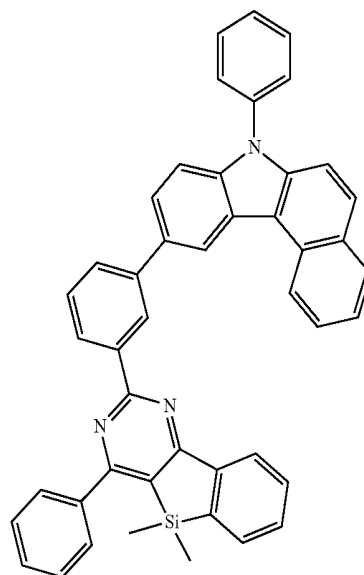
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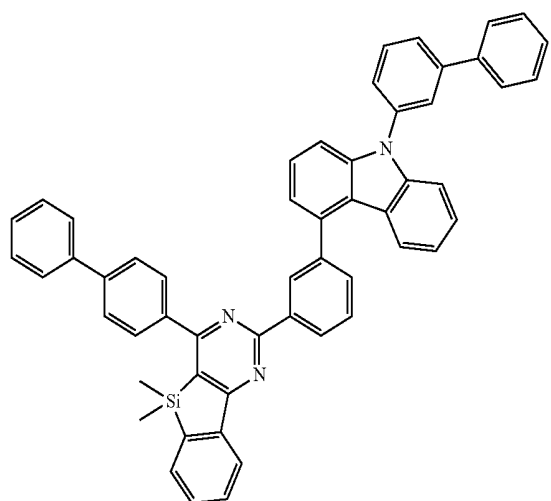
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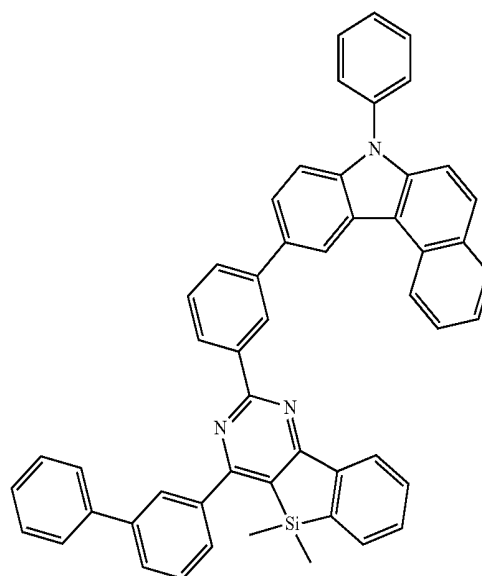
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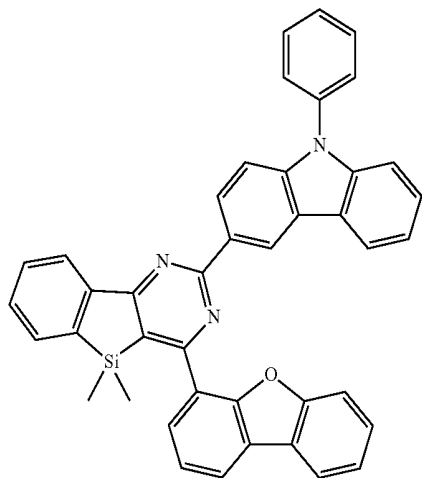


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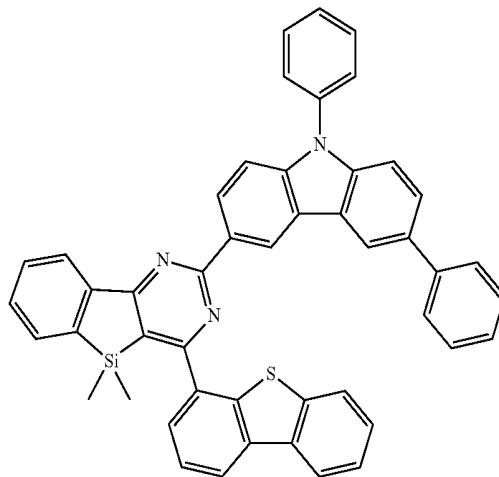
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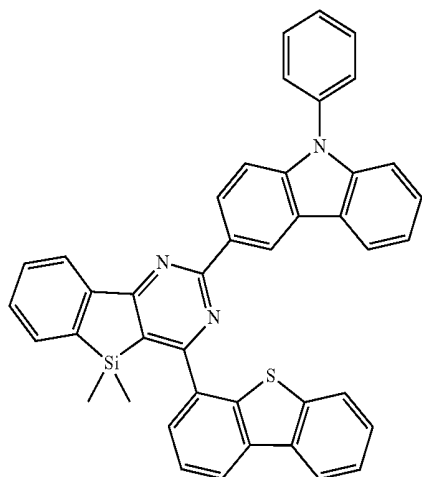


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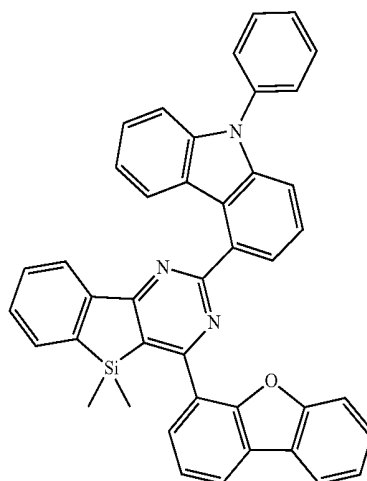
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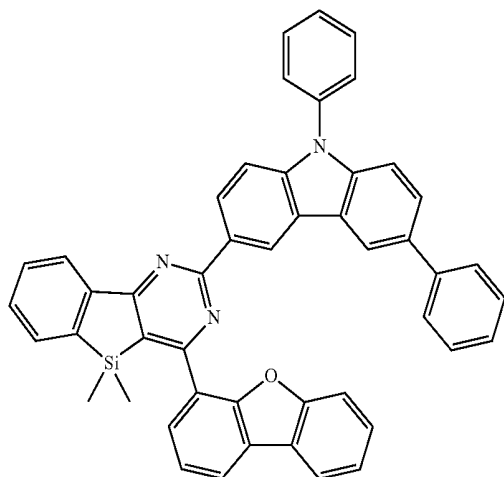
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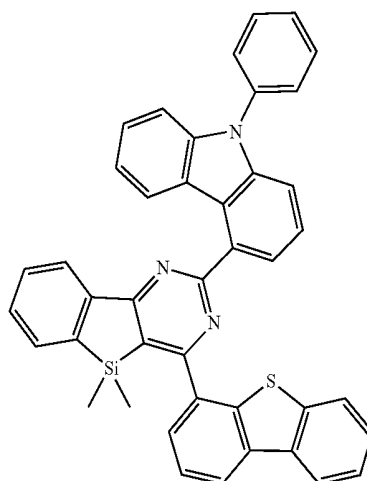
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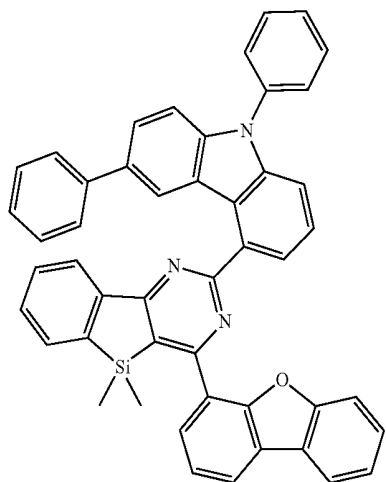
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c-56

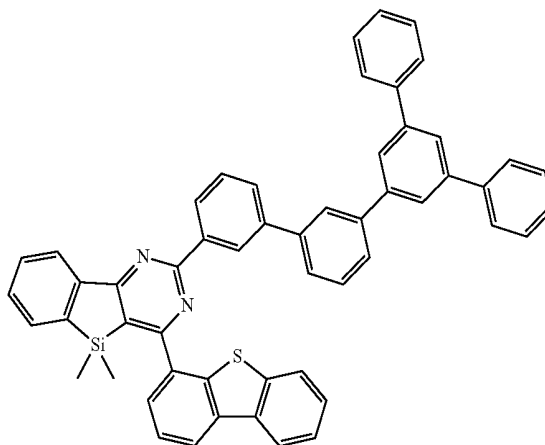


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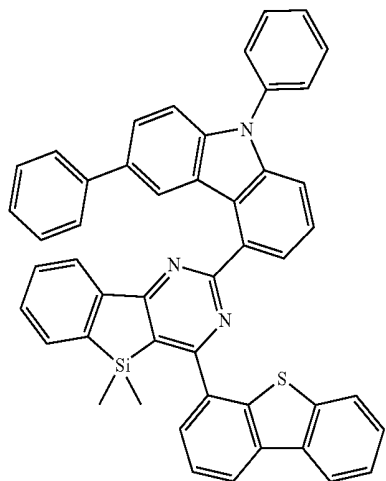
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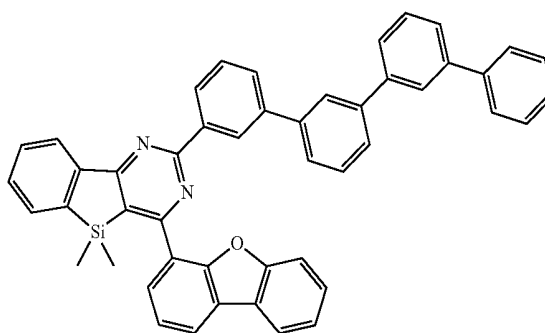


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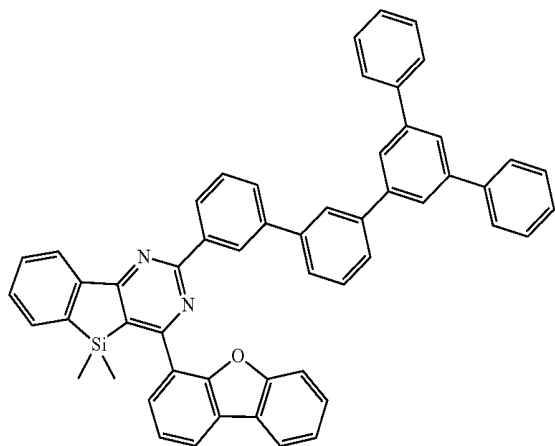
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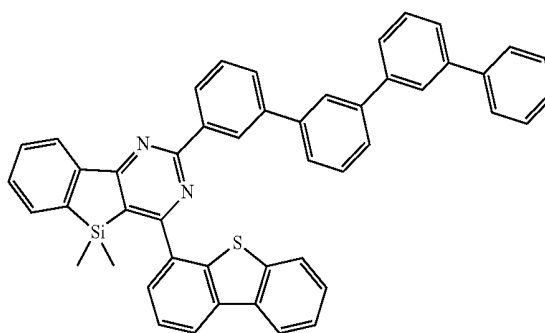
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c-59

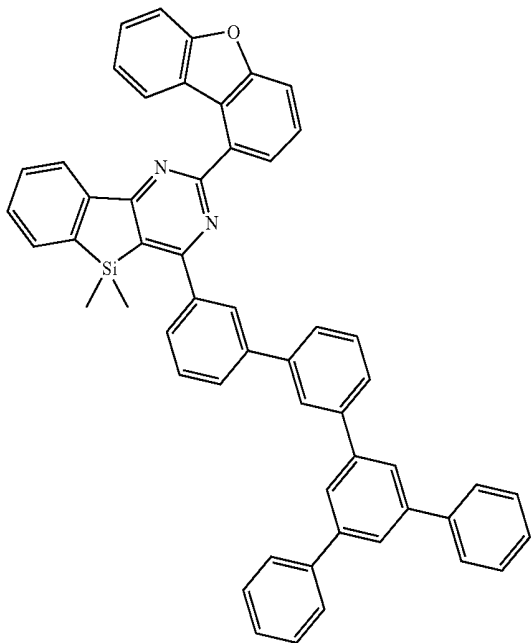


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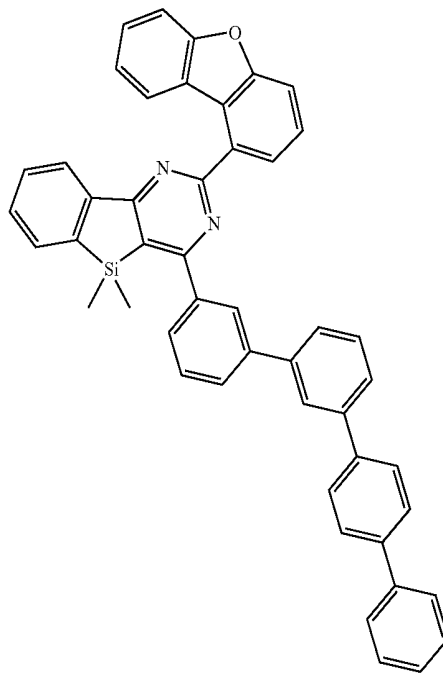
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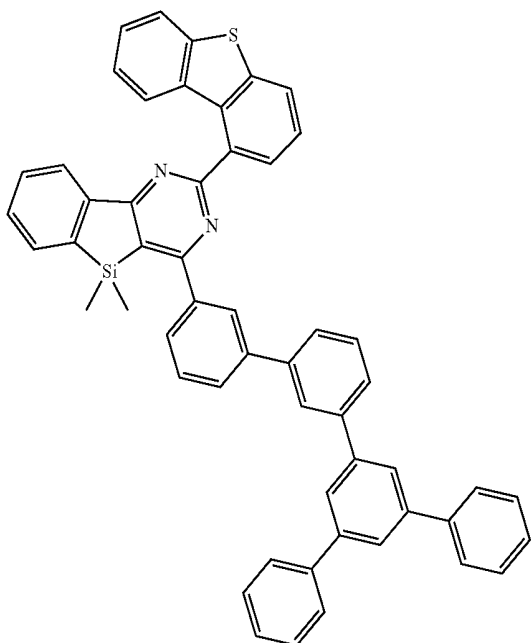


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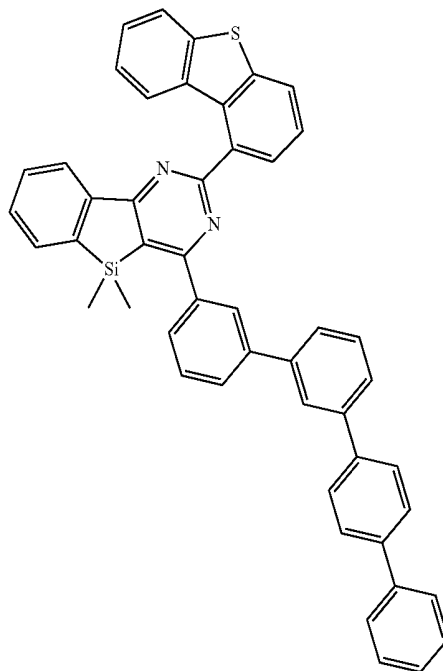
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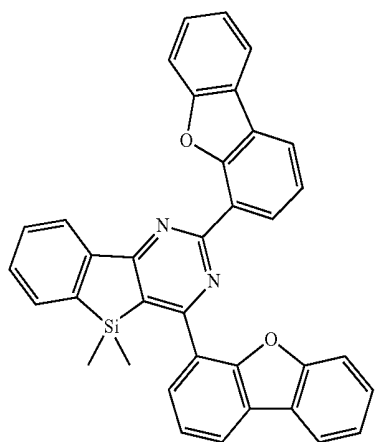
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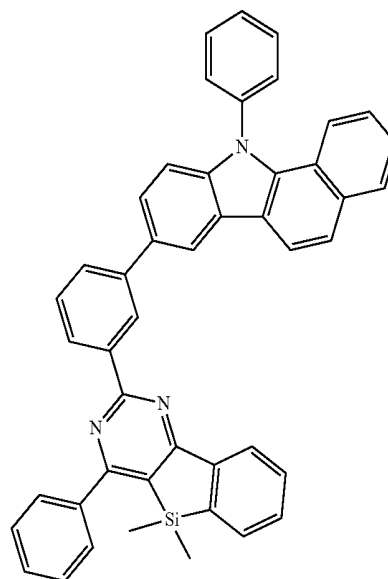


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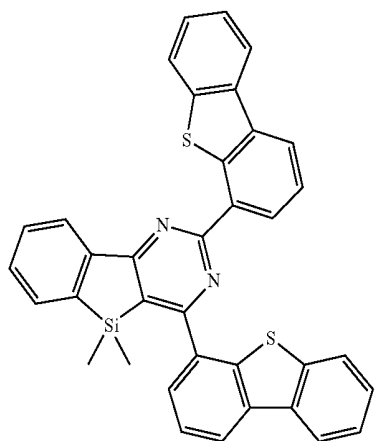
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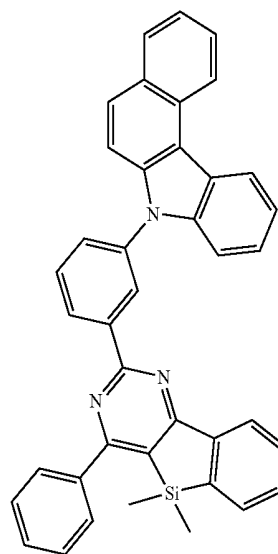


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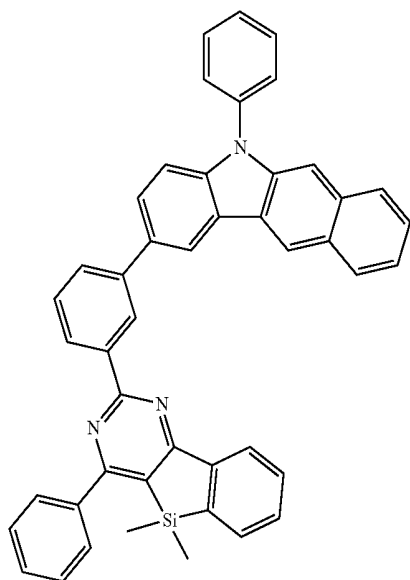
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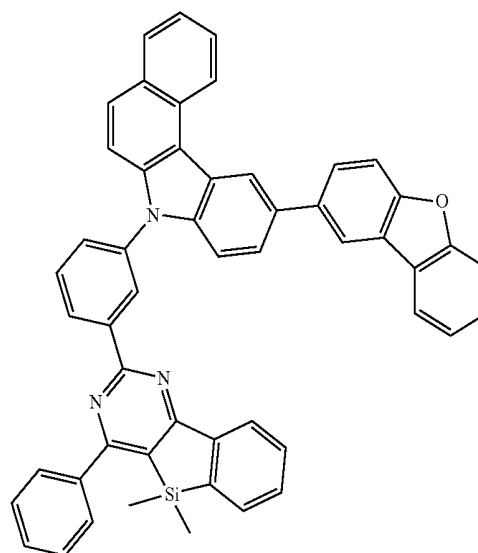
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c-69

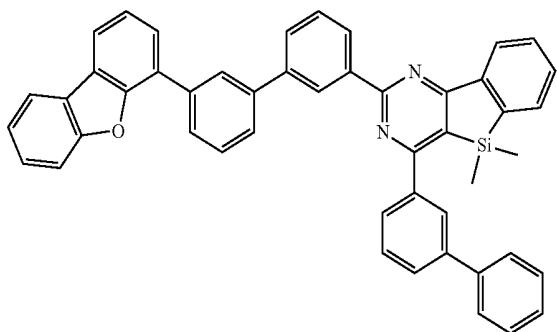


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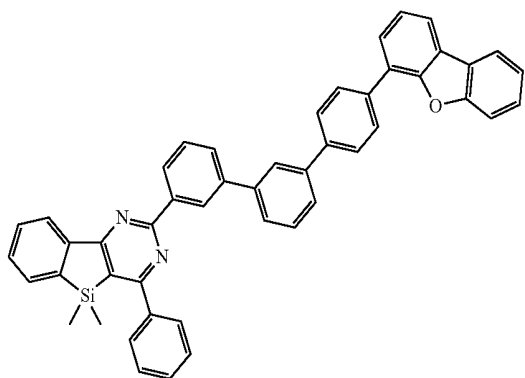
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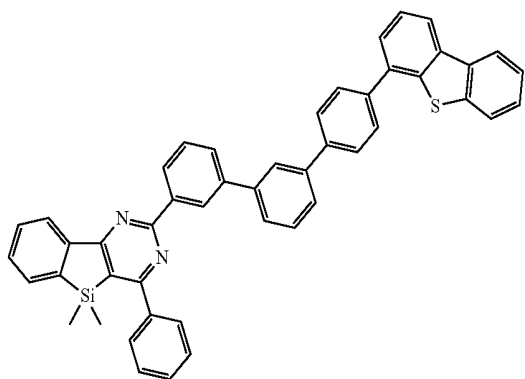
c-74



c-75

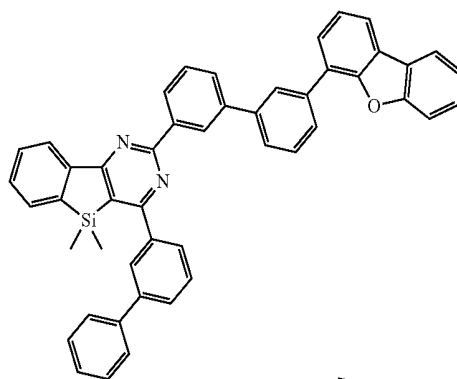


c-76

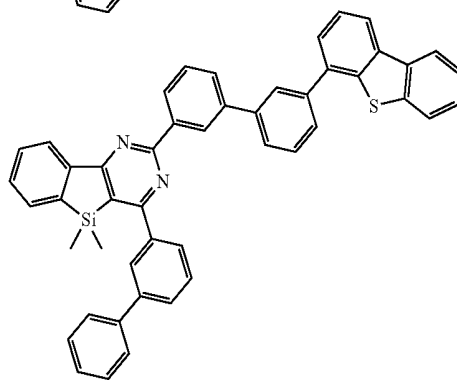


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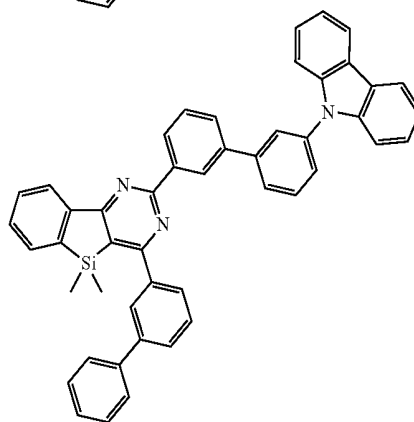
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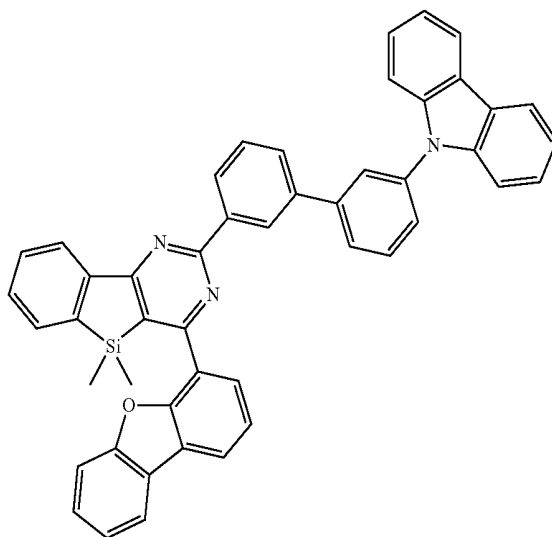
c-78



c-79

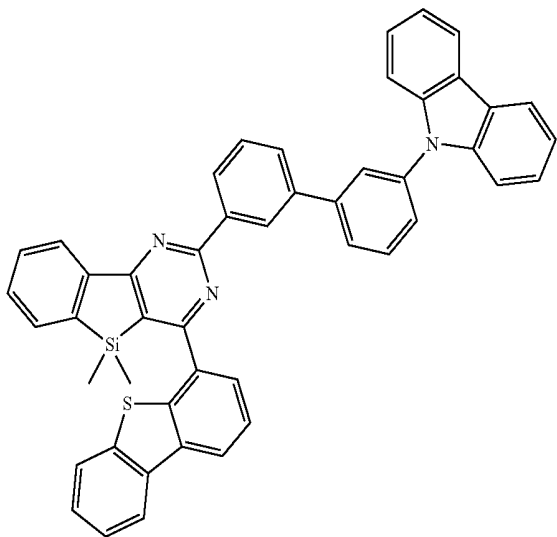


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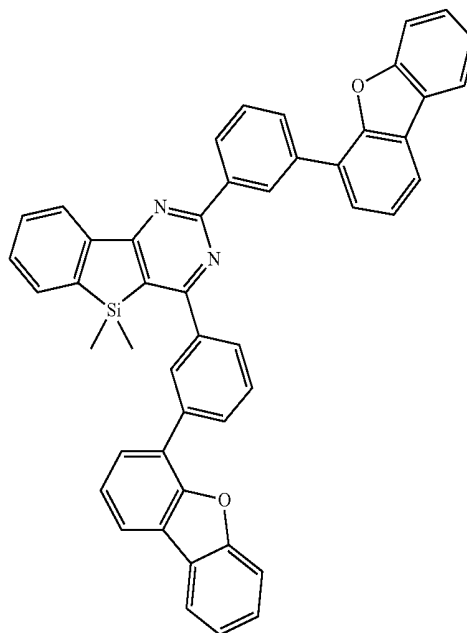
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c-81

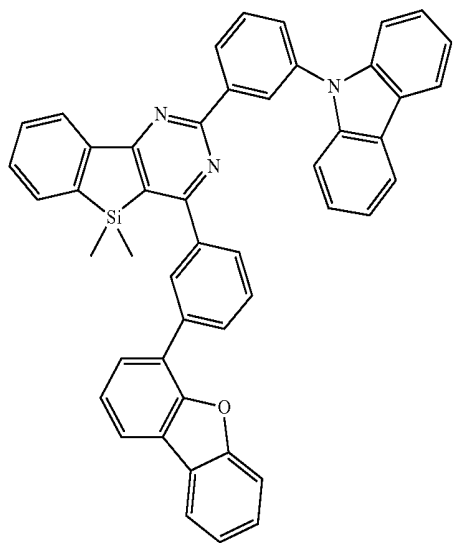


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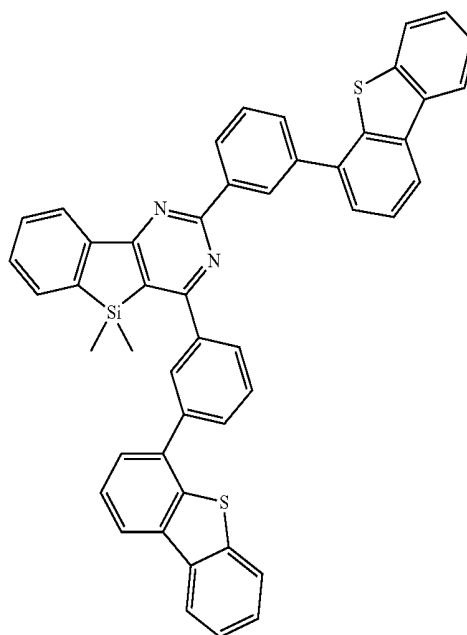
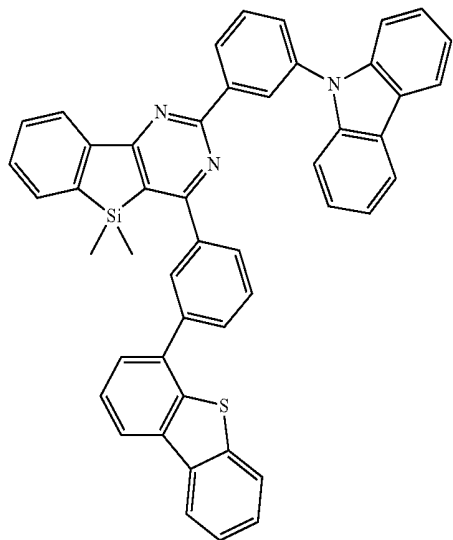


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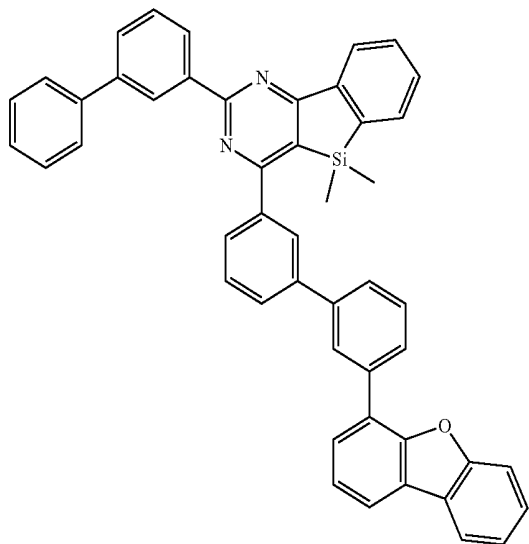
c-85

c-83



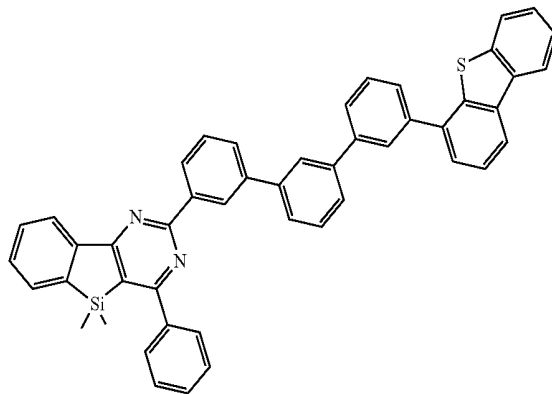
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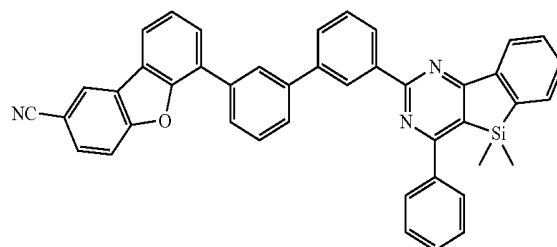


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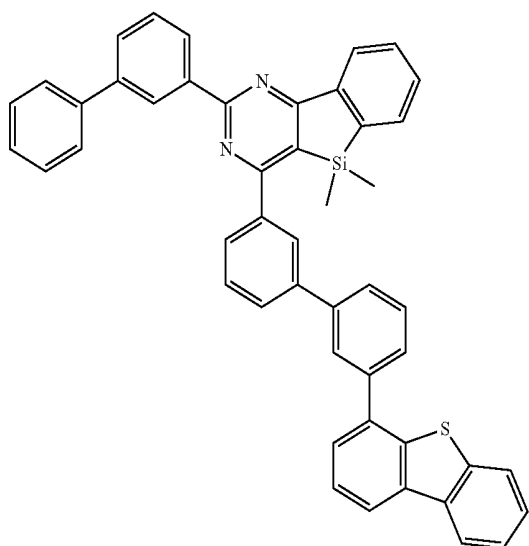
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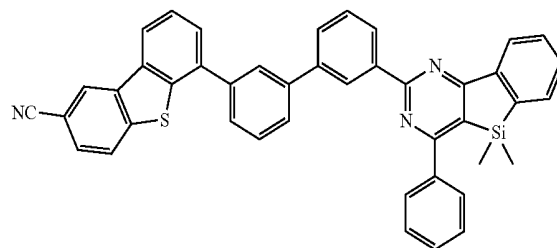
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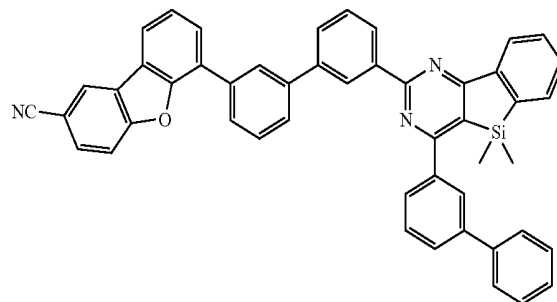
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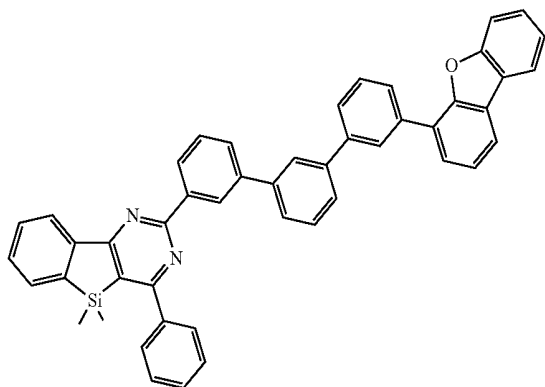
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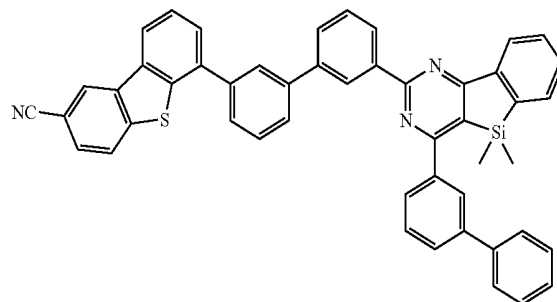
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c-88

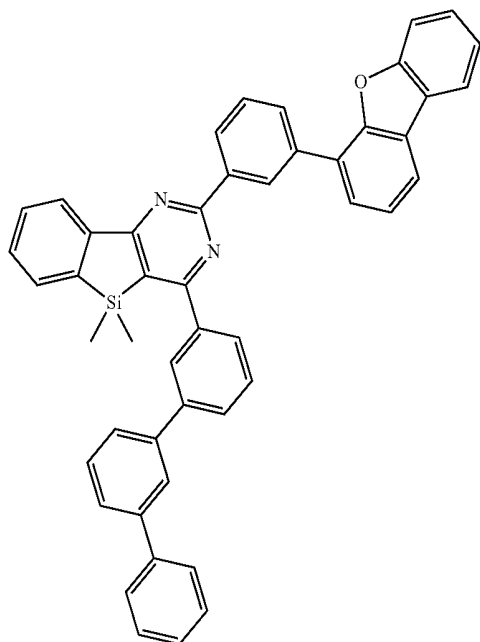


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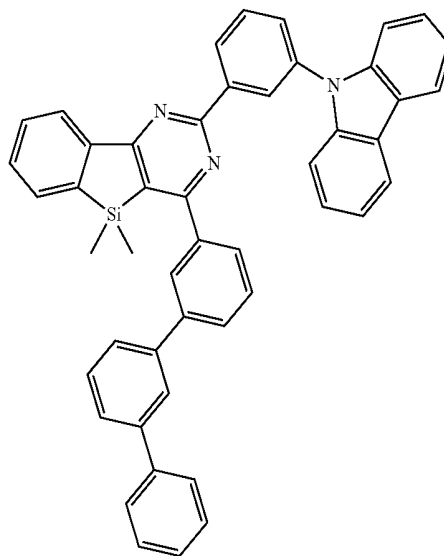
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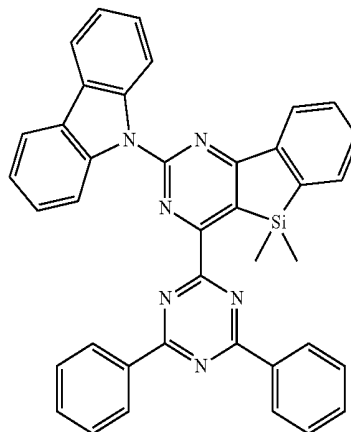


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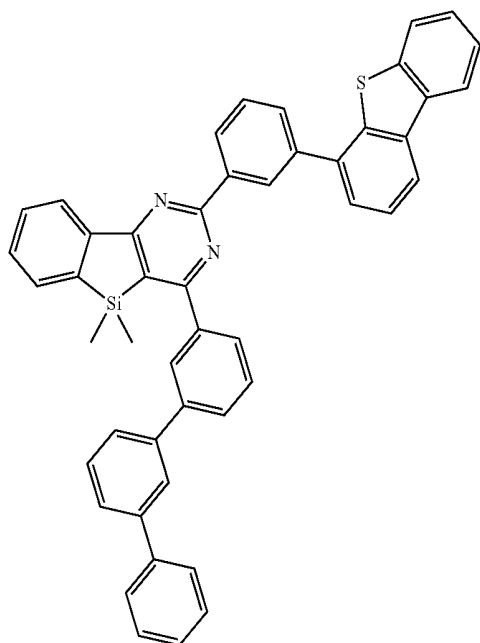
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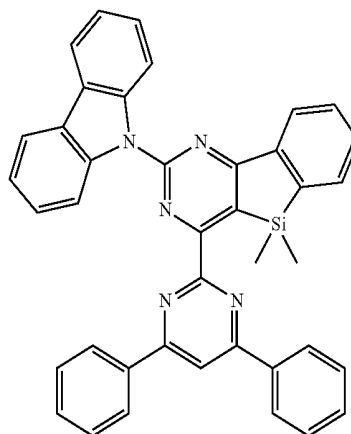
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c-95

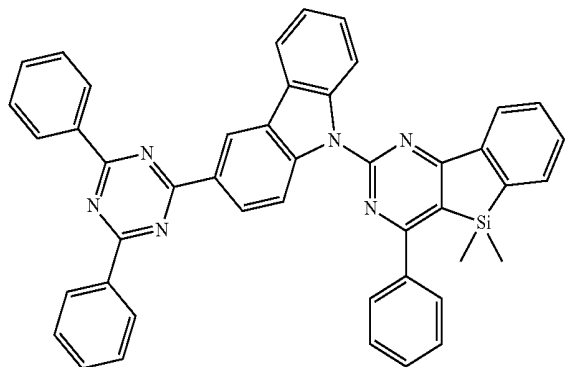


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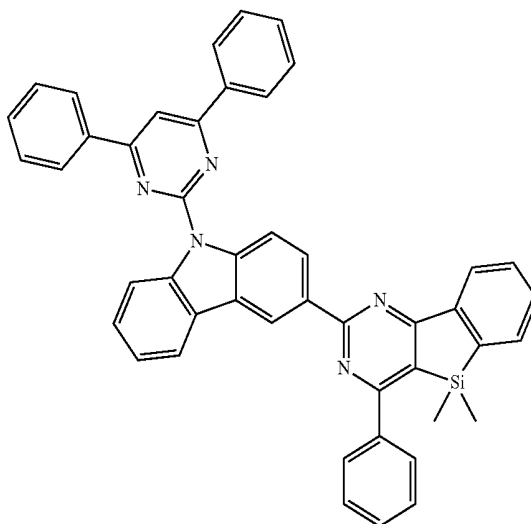
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c-99



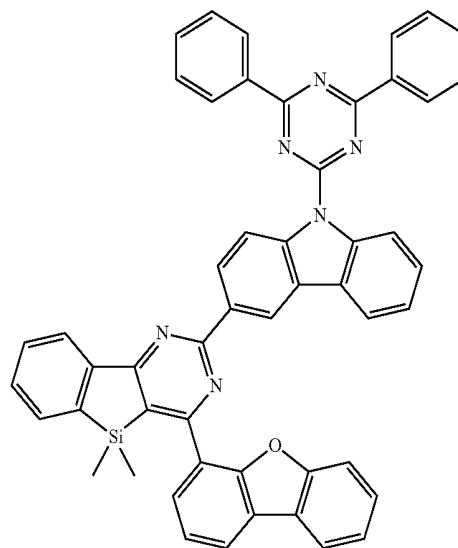
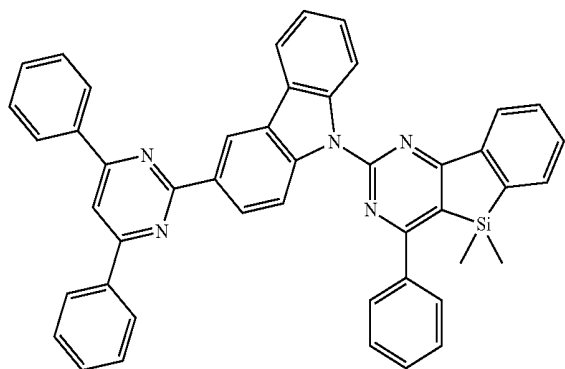
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c-102



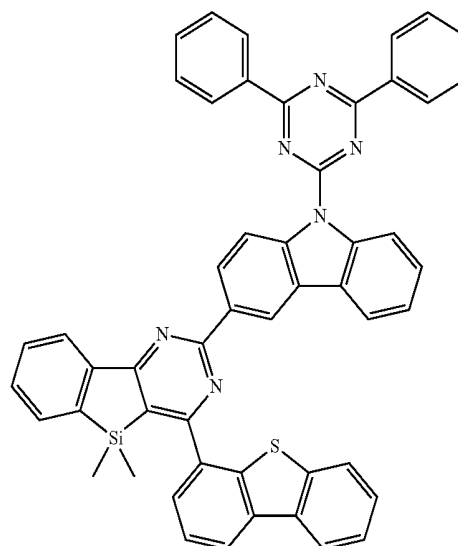
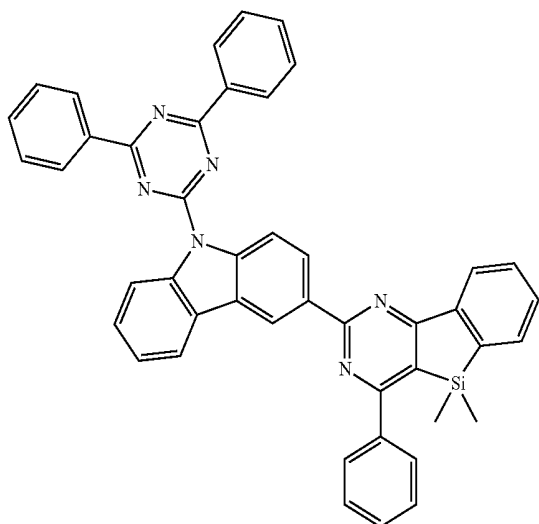
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c-103



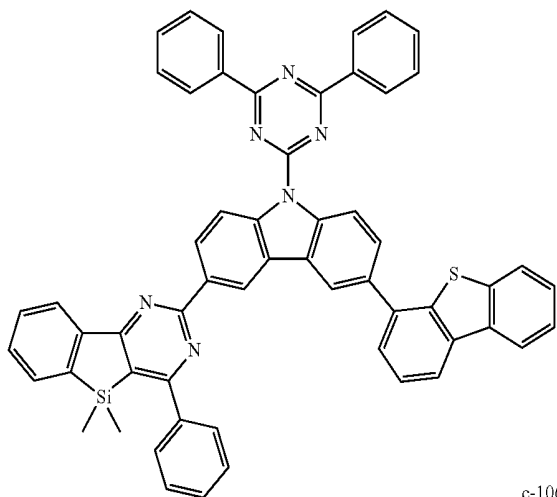
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c-104

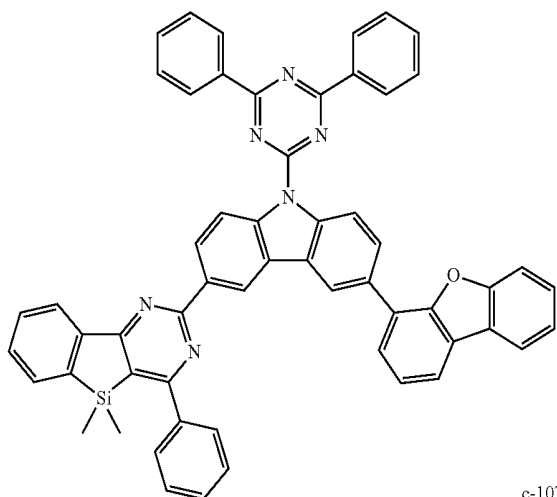


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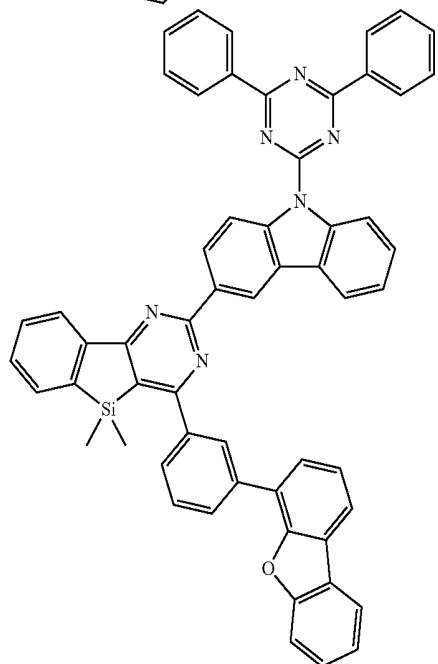
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c-106

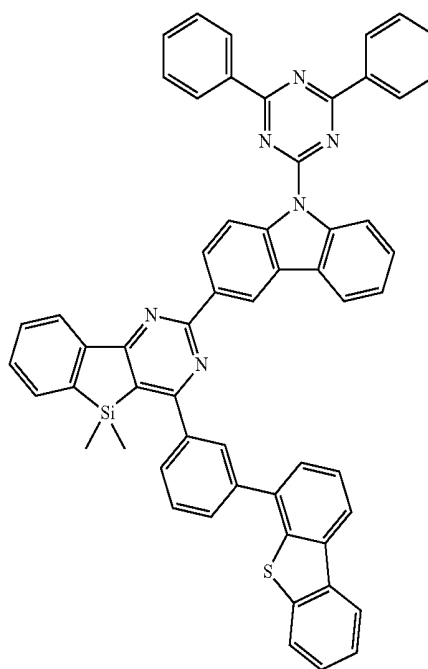


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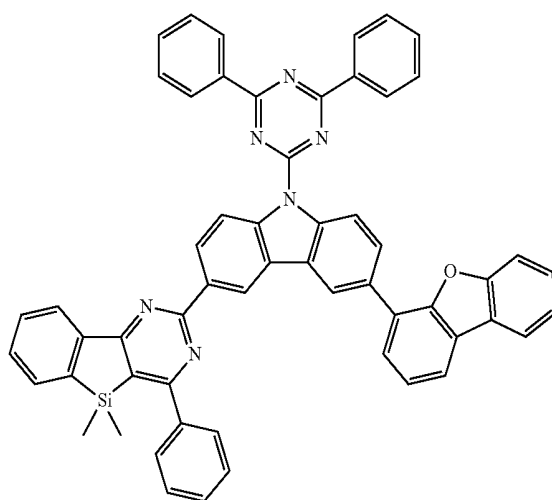


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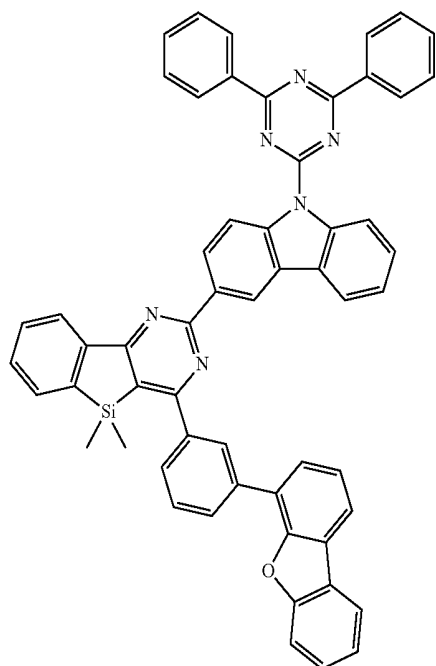
c-108



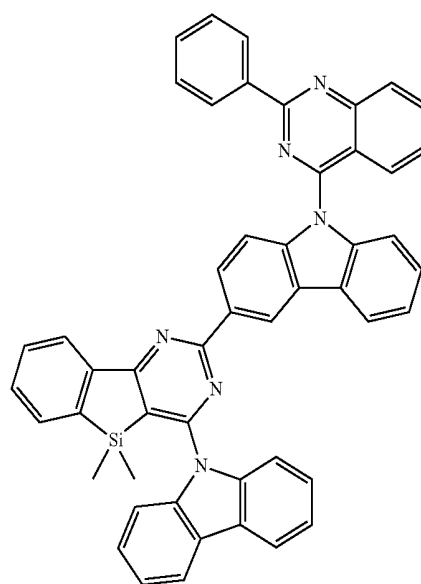
c-109



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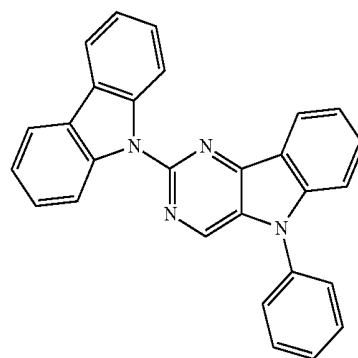
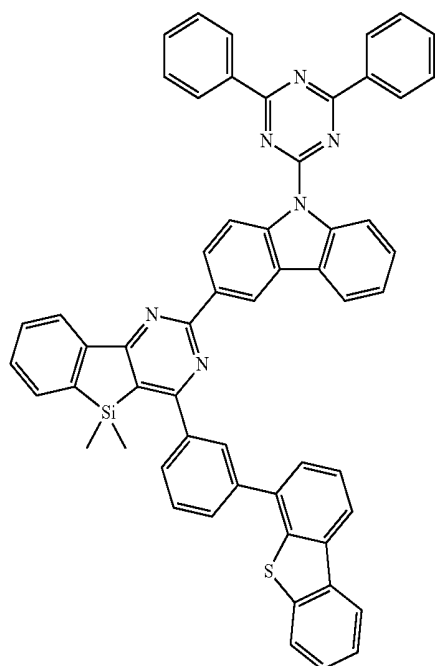


[0158] Group of  $X1=N-[(L_1)a1-(R_1)b1]$  in Formula 1-1

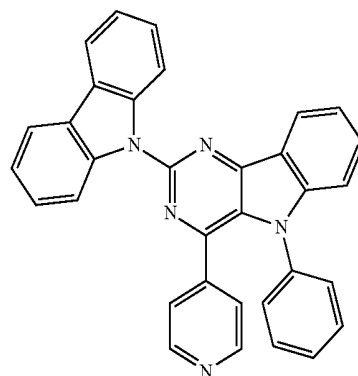
[0159] ( $L_1$ ,  $a1$ ,  $R_1$  and  $b1$  are Described in the Above Specification)

99

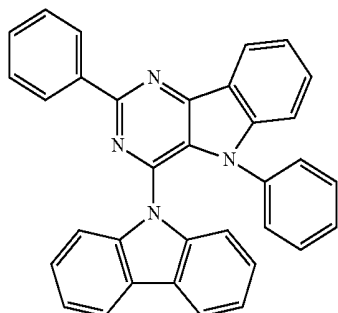
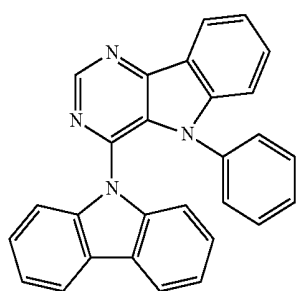
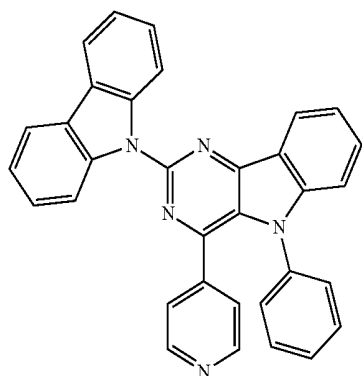
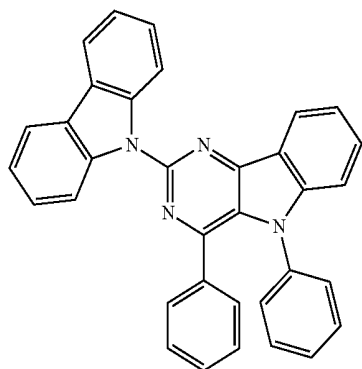
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100



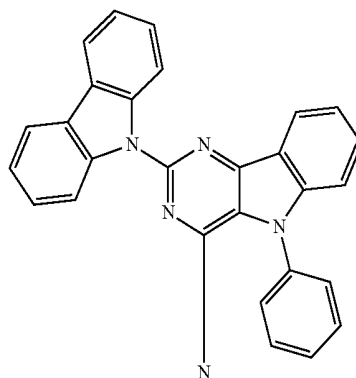
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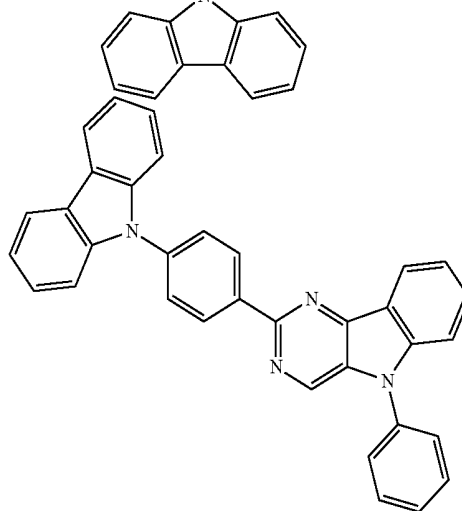
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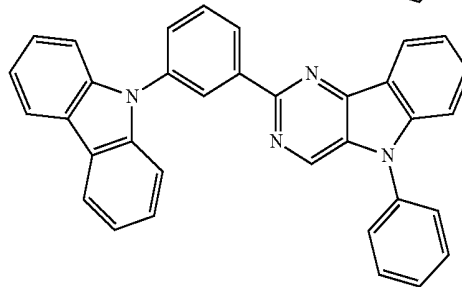
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106



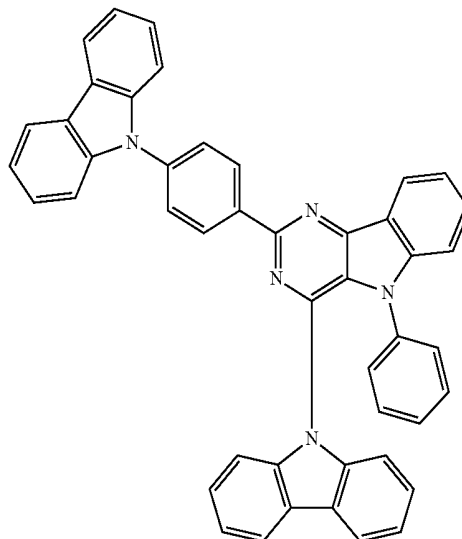
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107

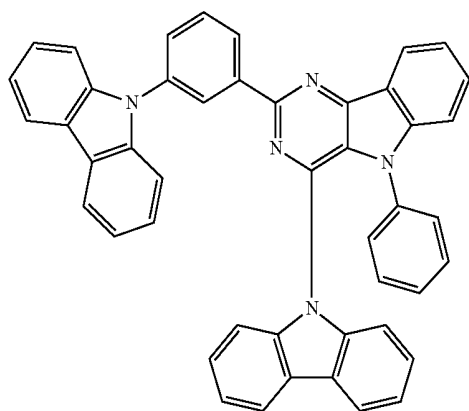


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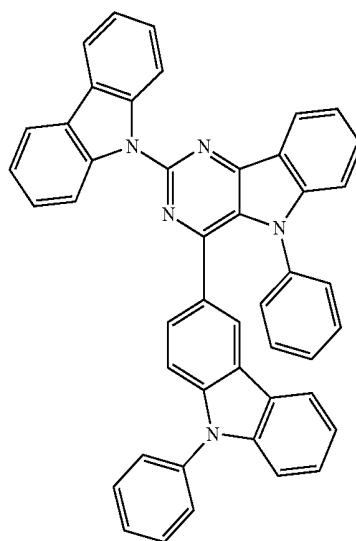


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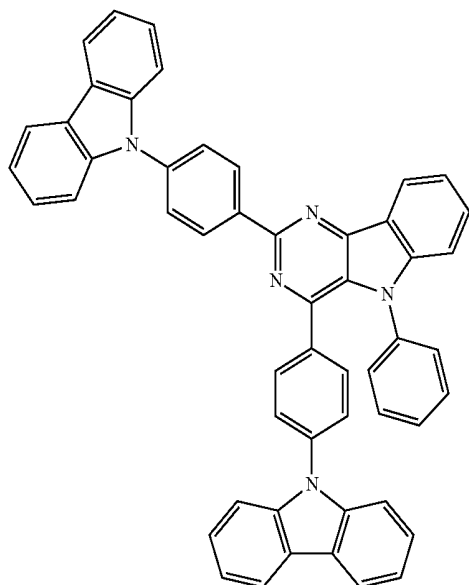


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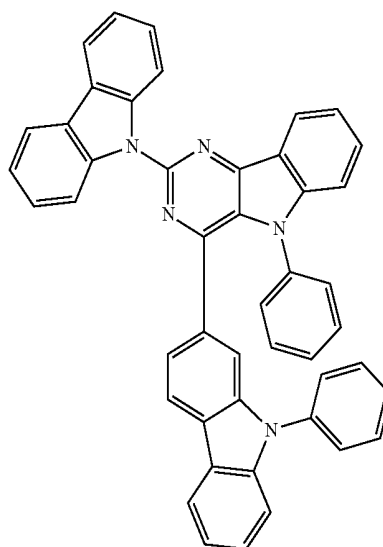
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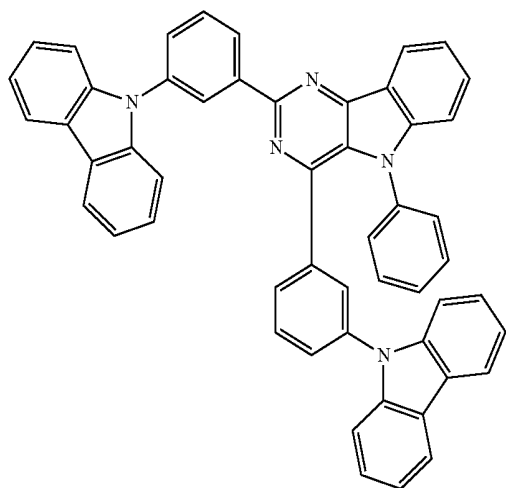
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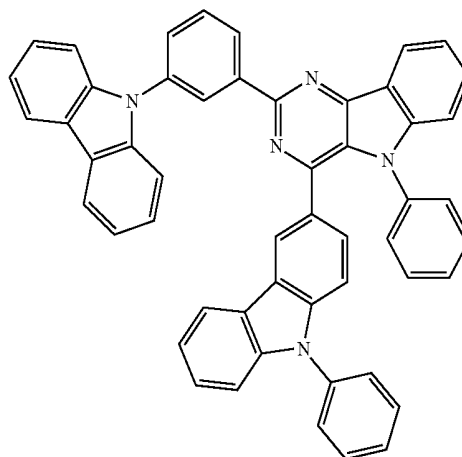
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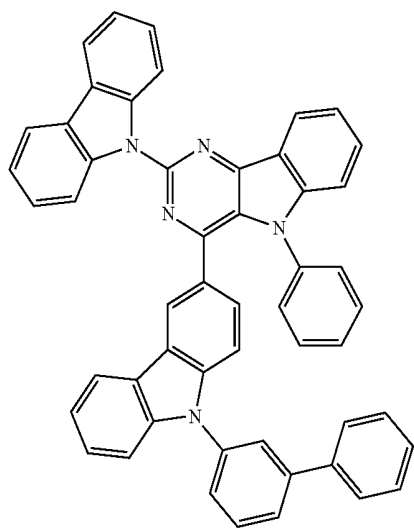


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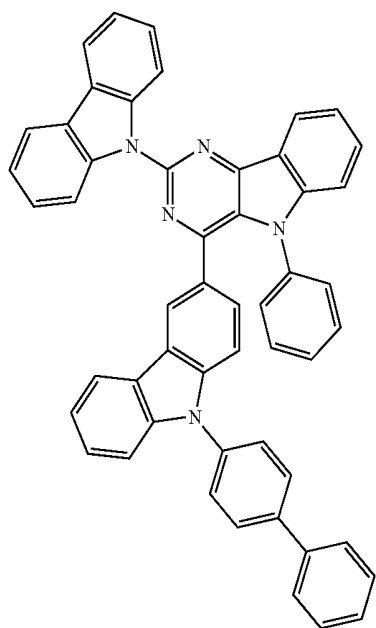


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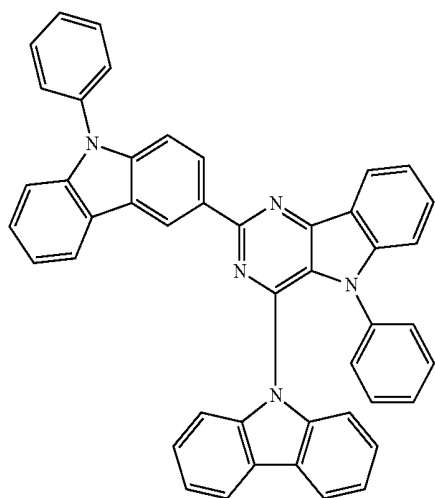
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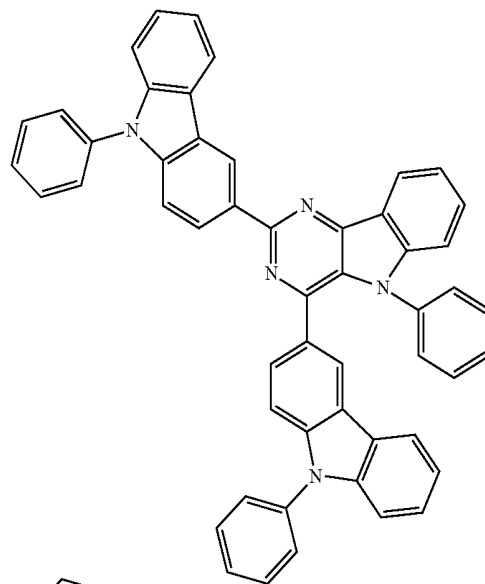


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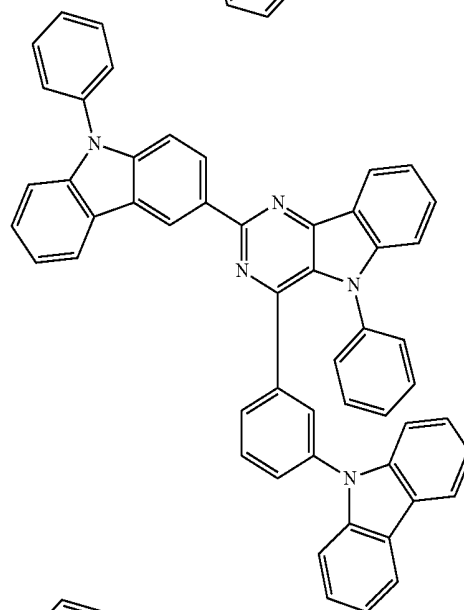


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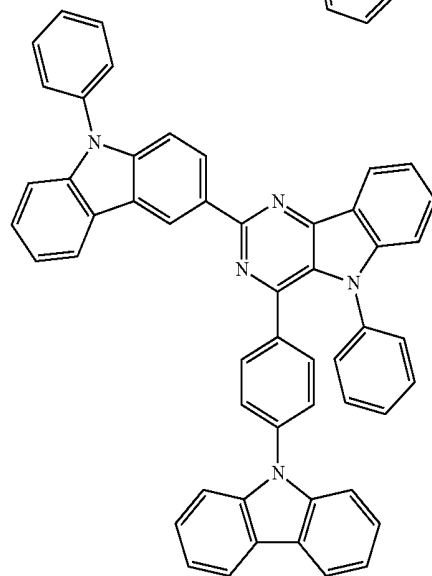
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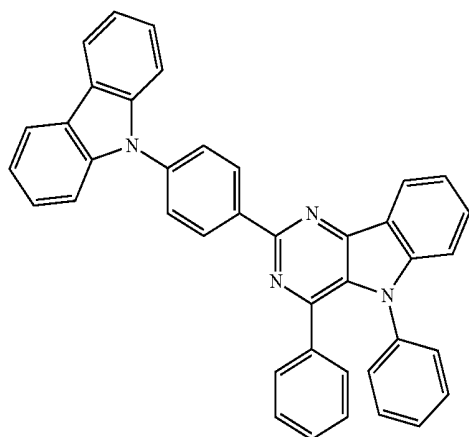
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120

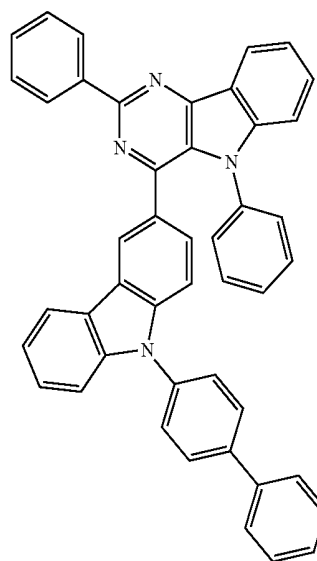
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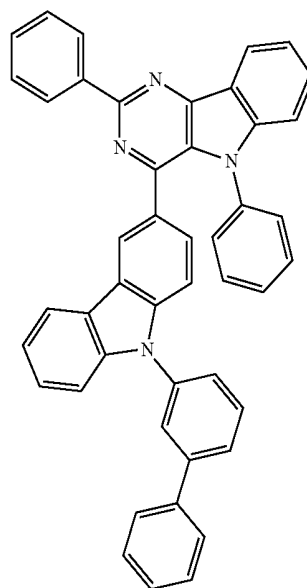
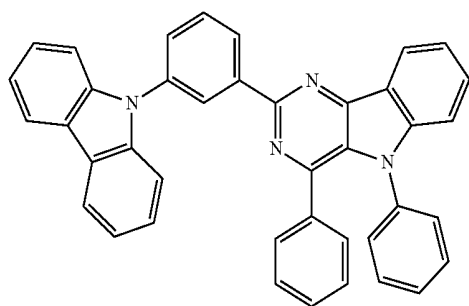
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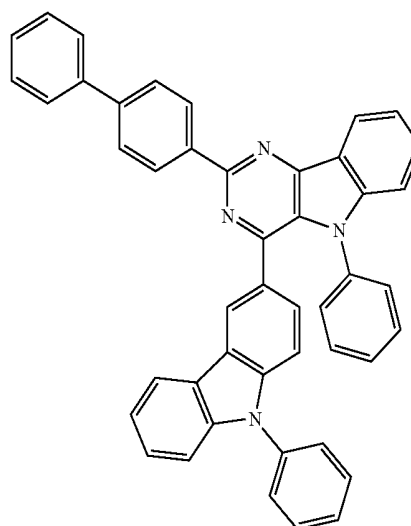
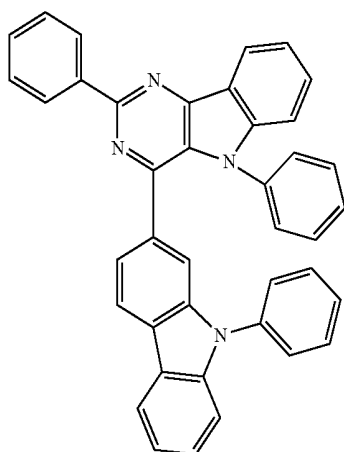
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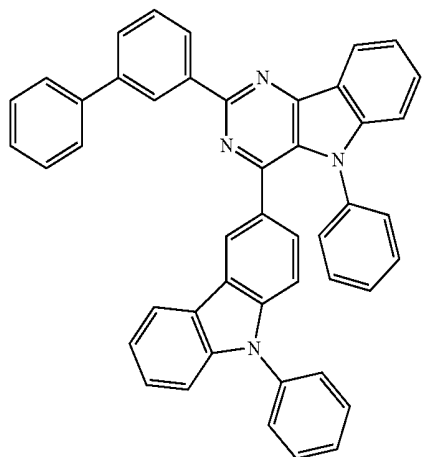


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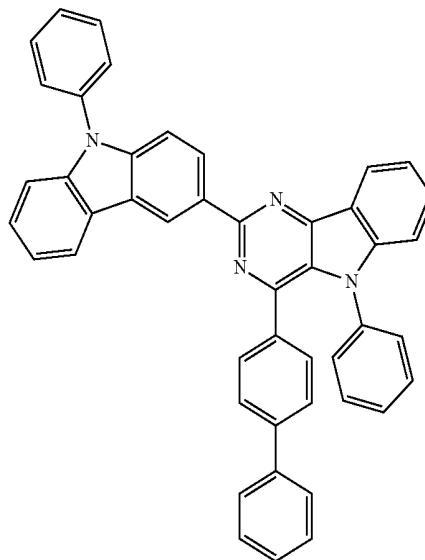


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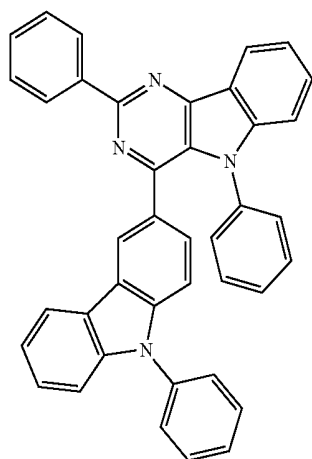


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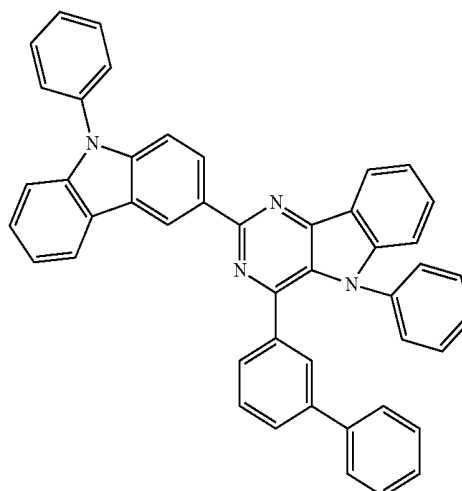
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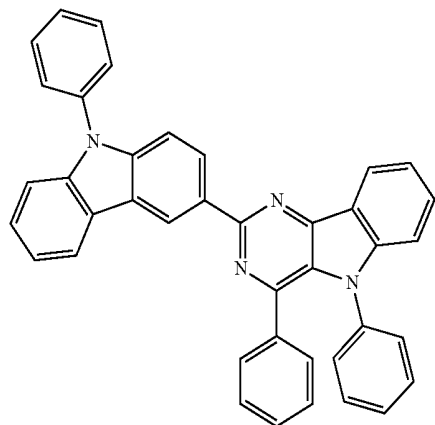
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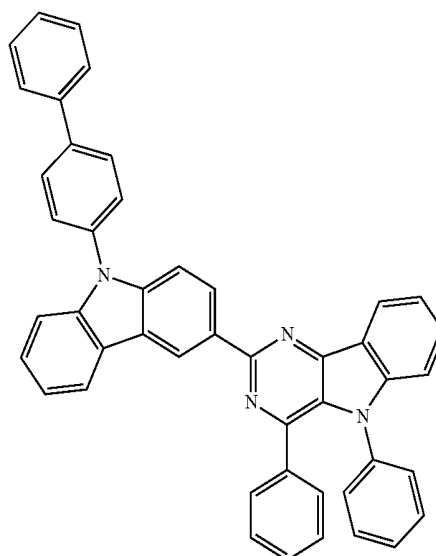
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d-3



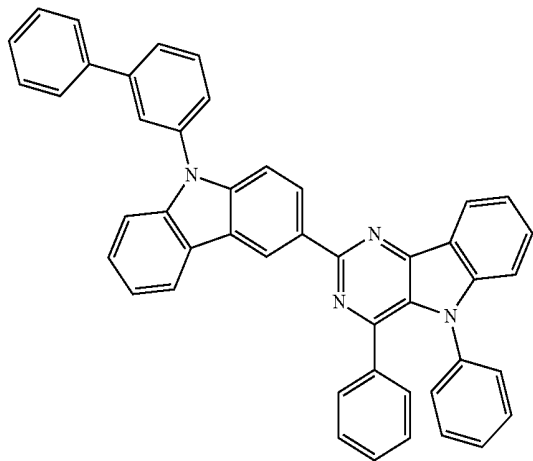
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d-4

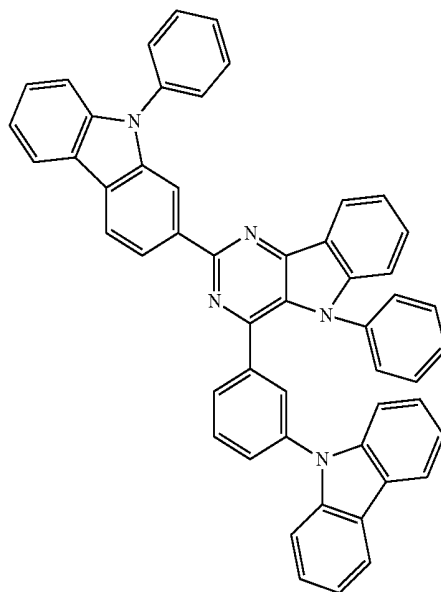
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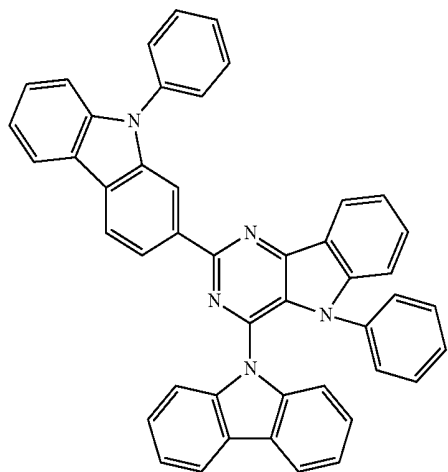


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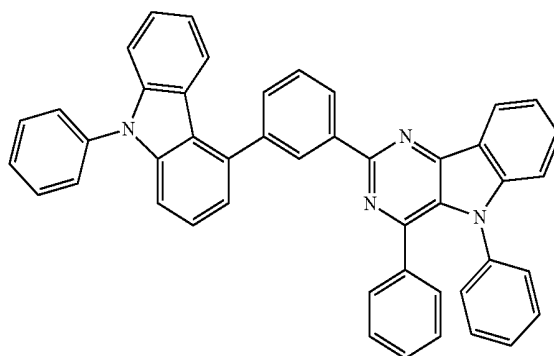
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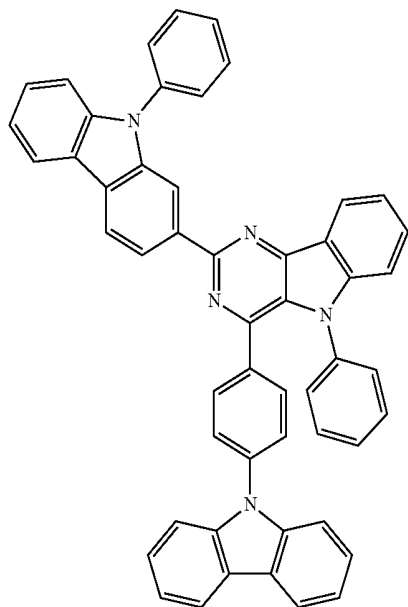
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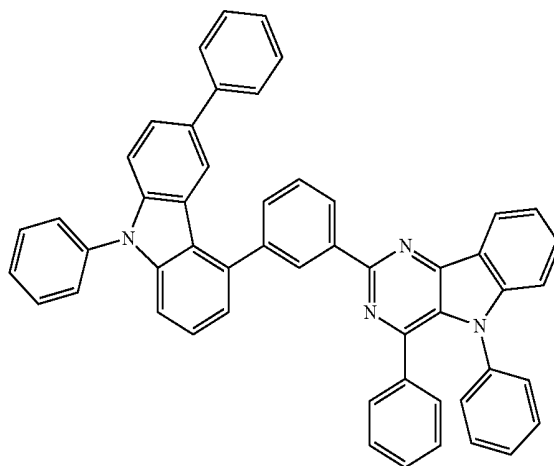
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d-7

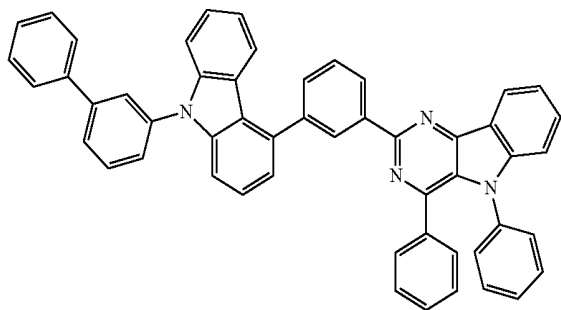


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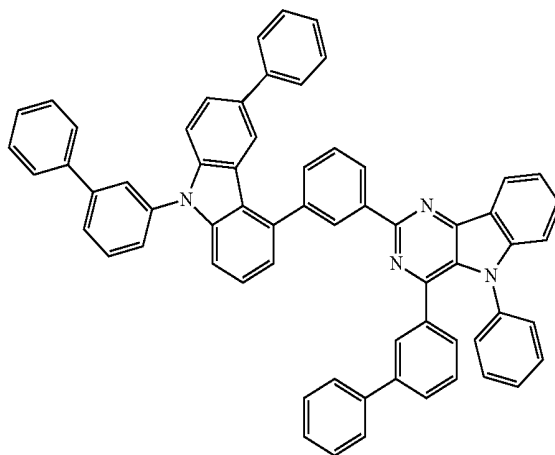
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d-11

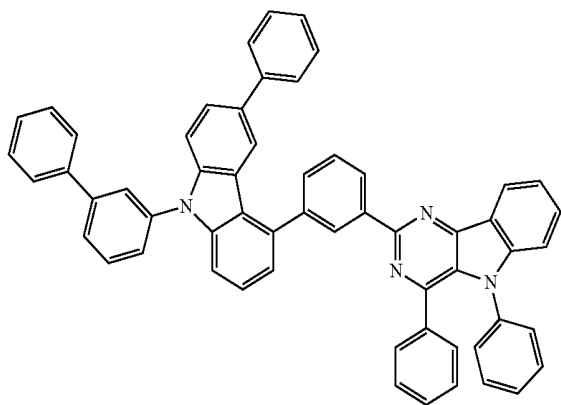


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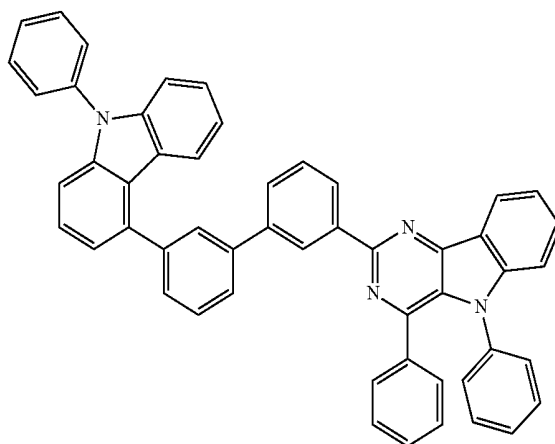
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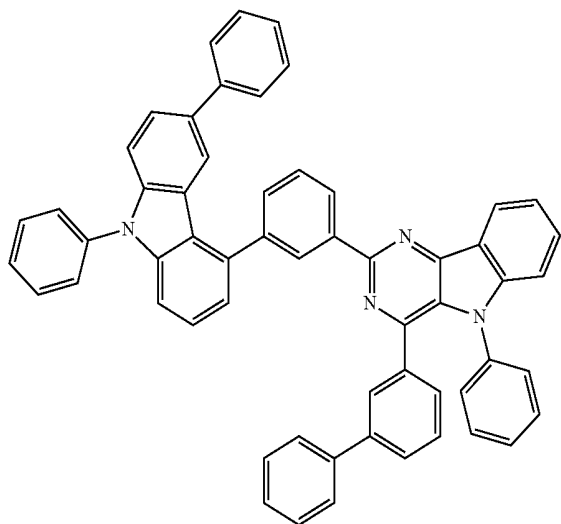
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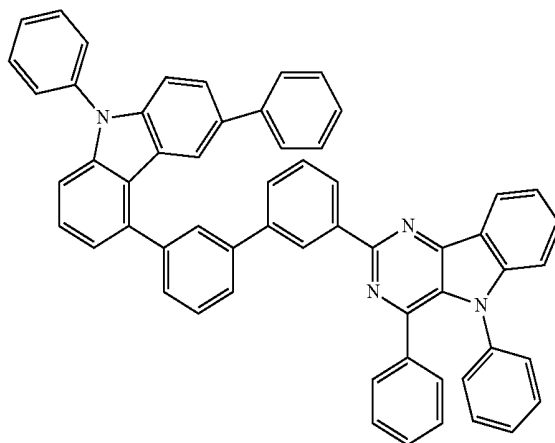
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d-13

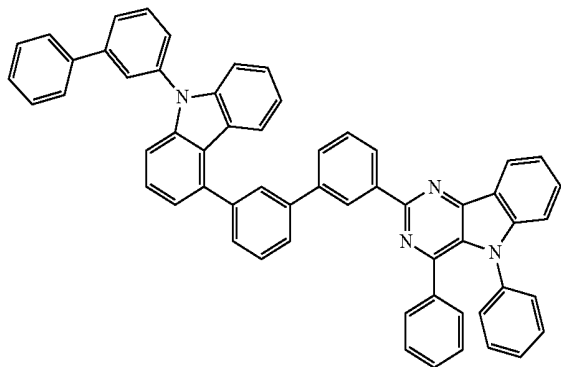


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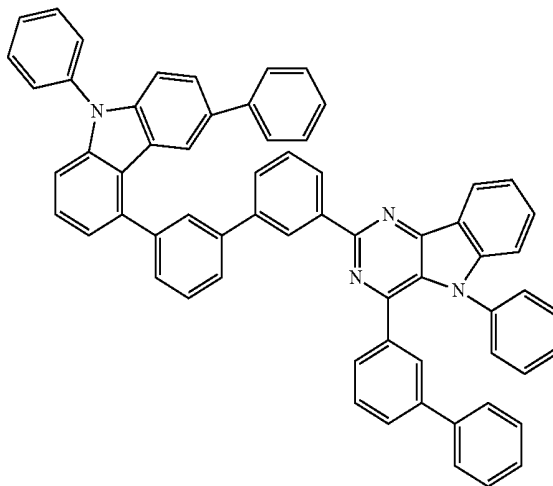
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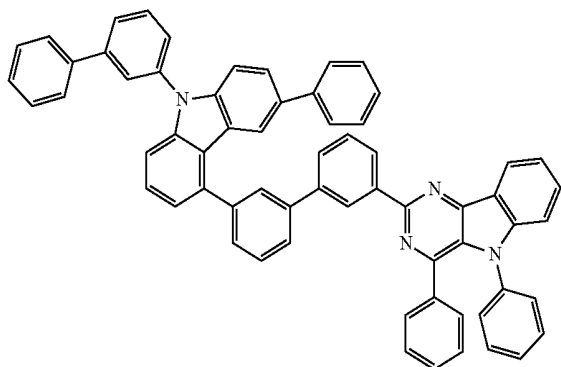


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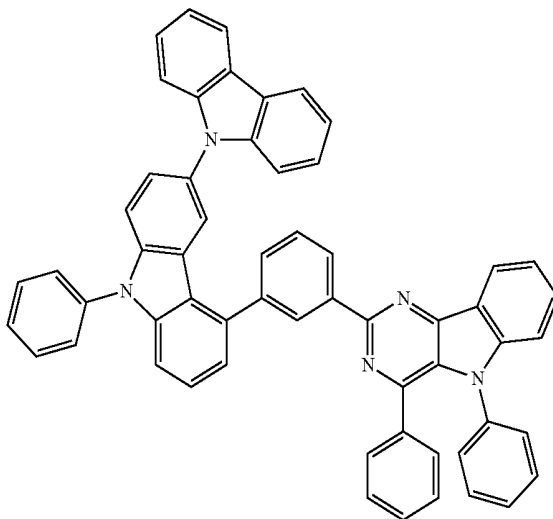
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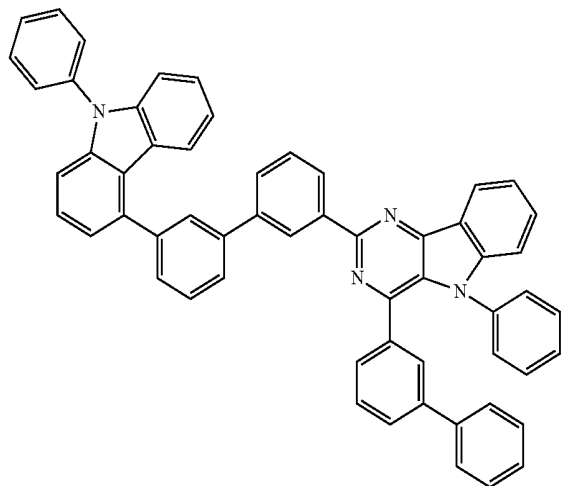
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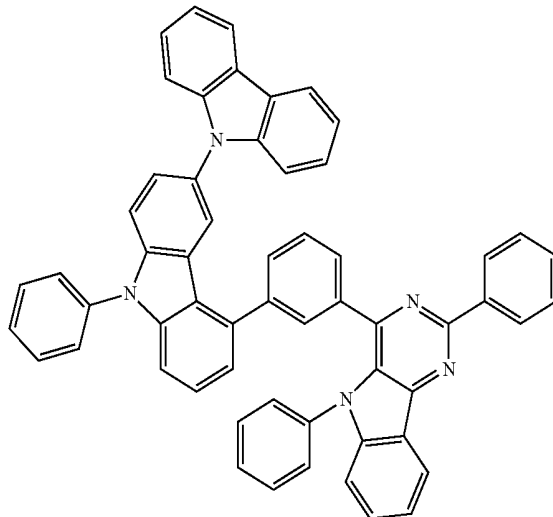
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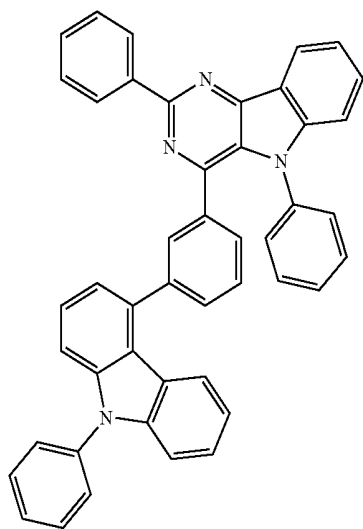
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d-22

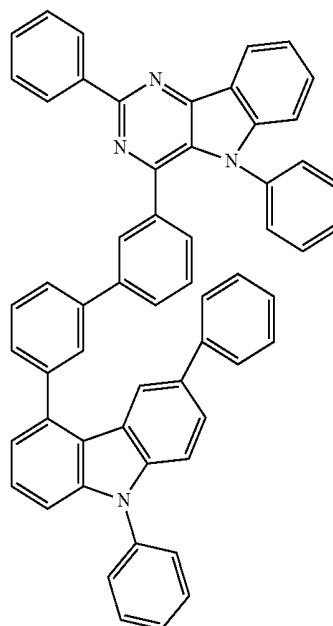


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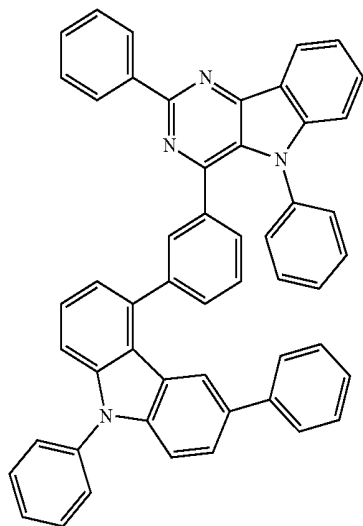
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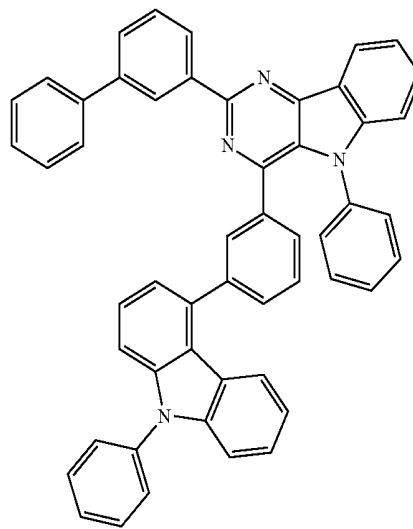


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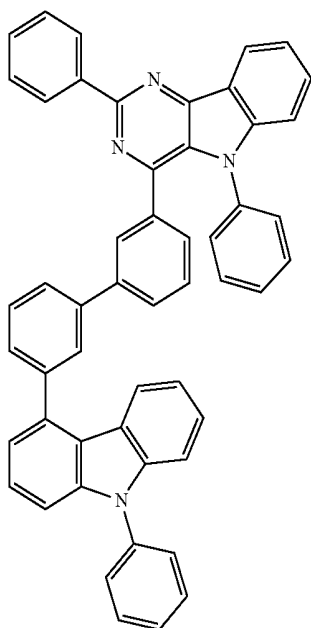
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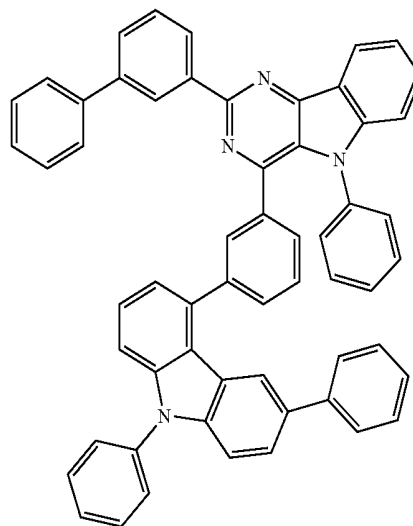
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d-27

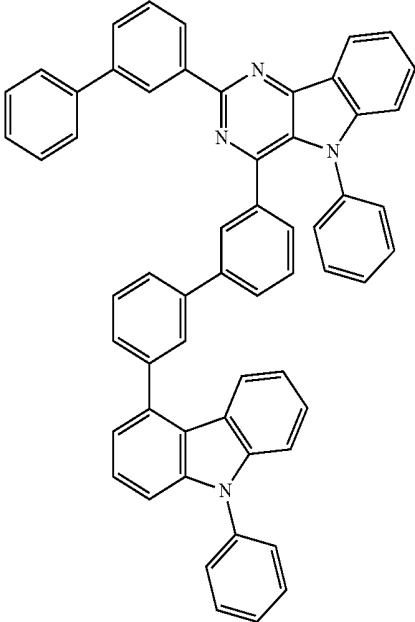


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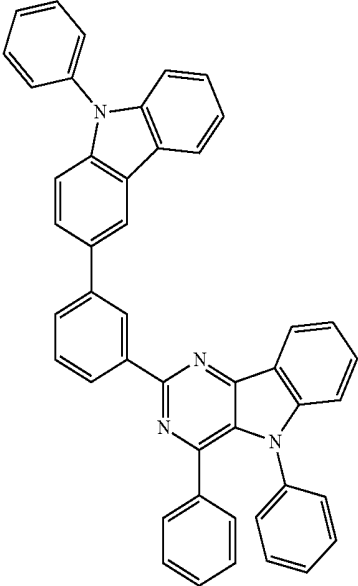
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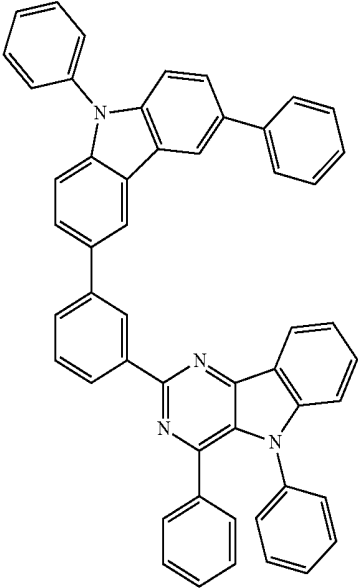
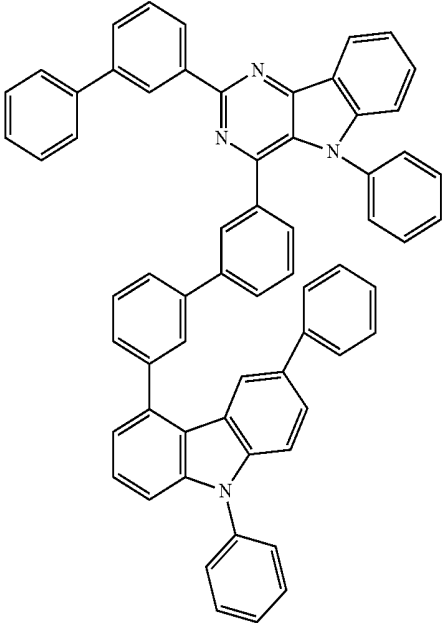
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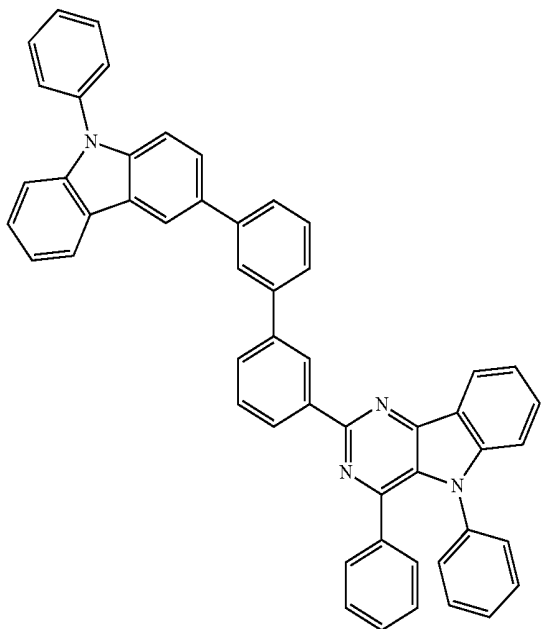
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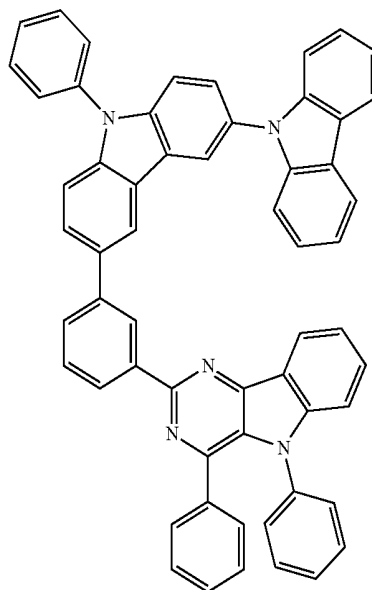
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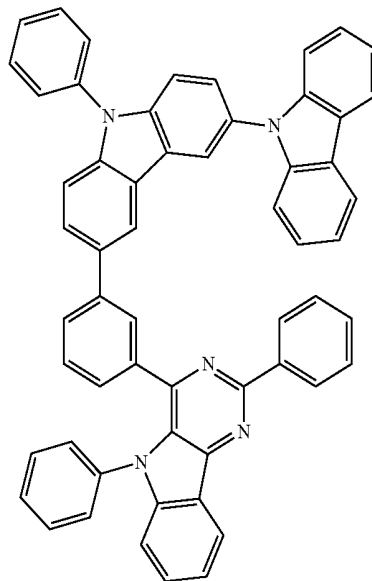


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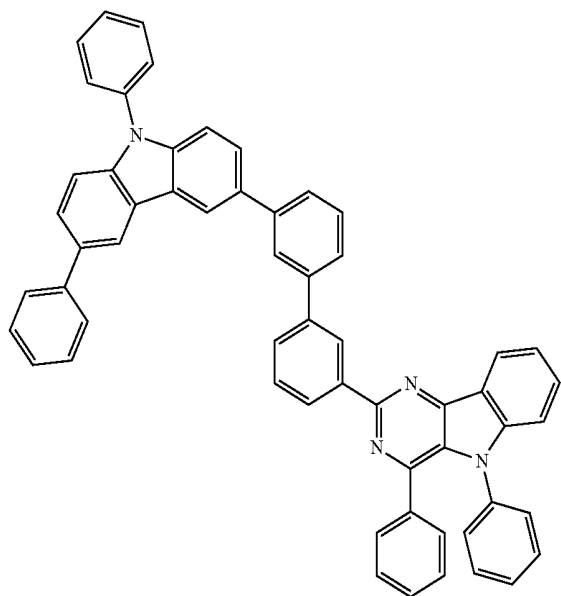
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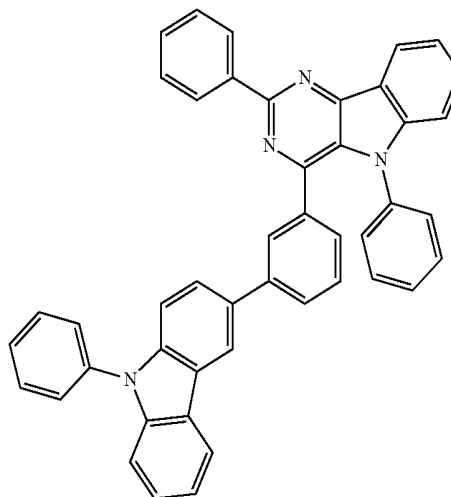
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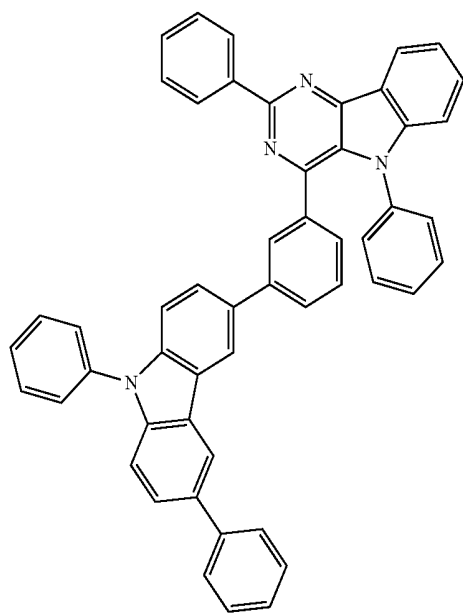
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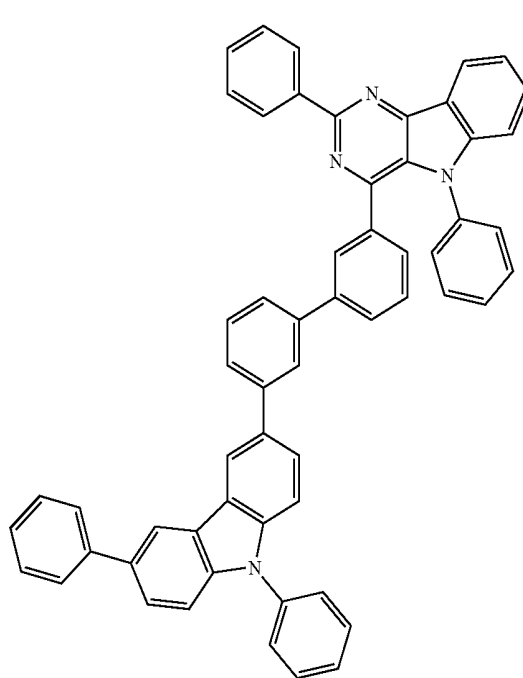
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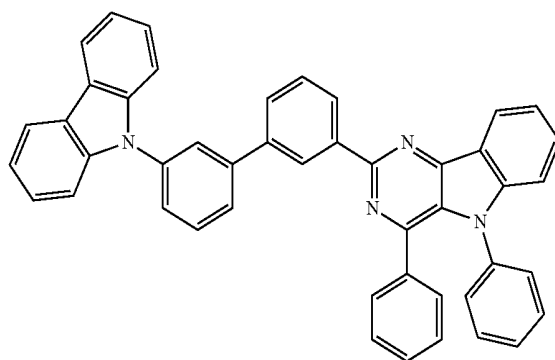


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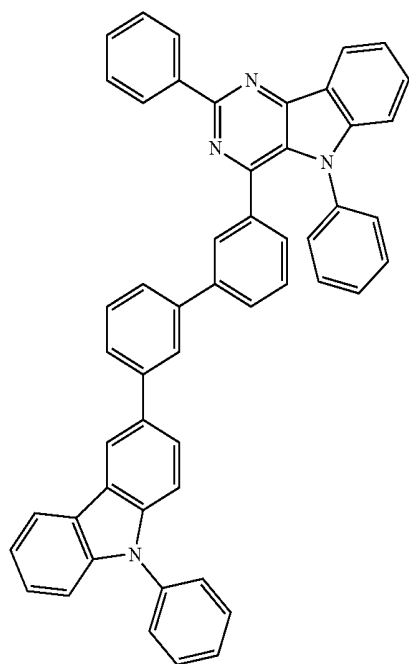


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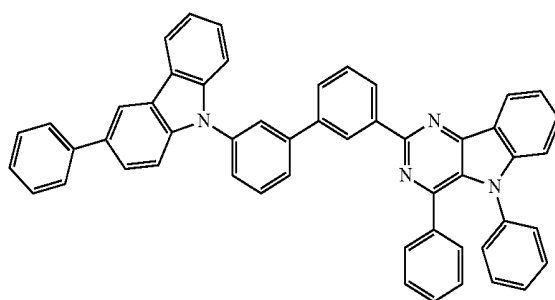
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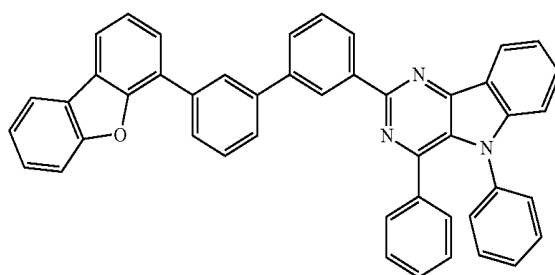
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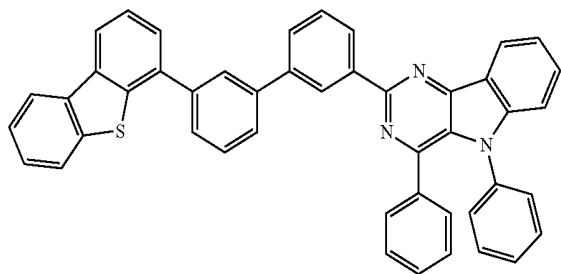


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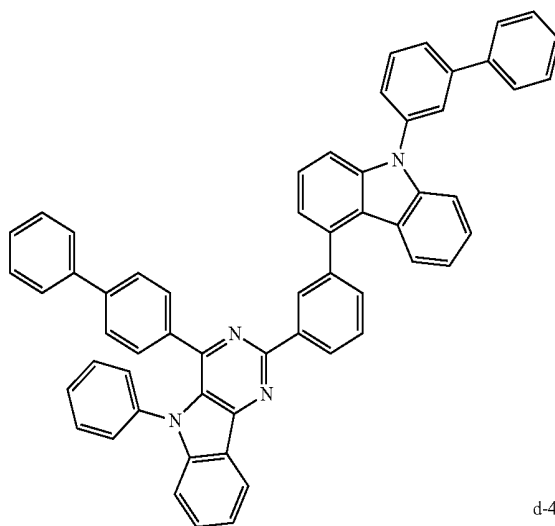
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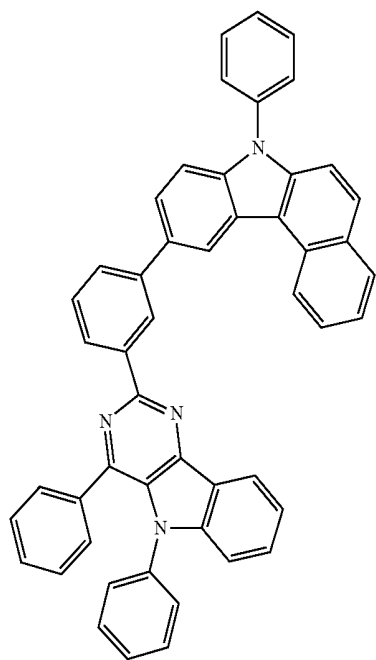


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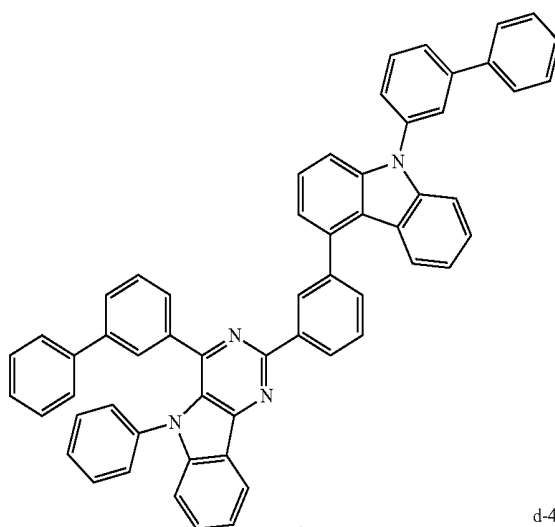
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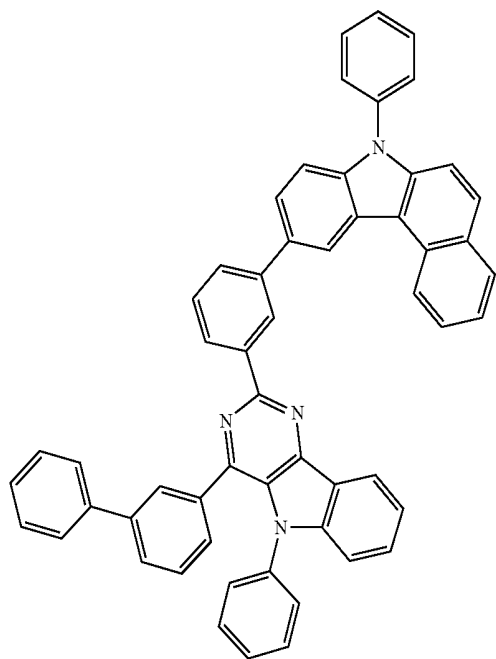
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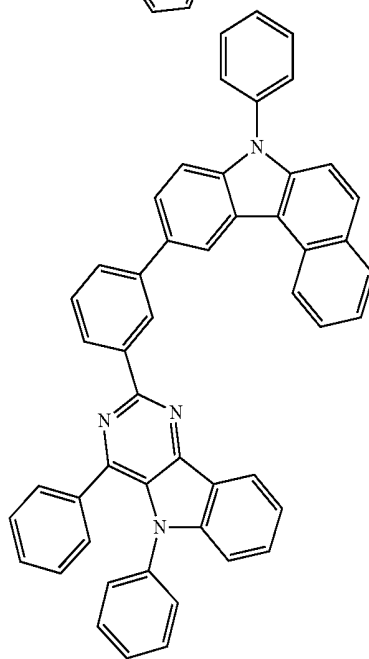
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d-46

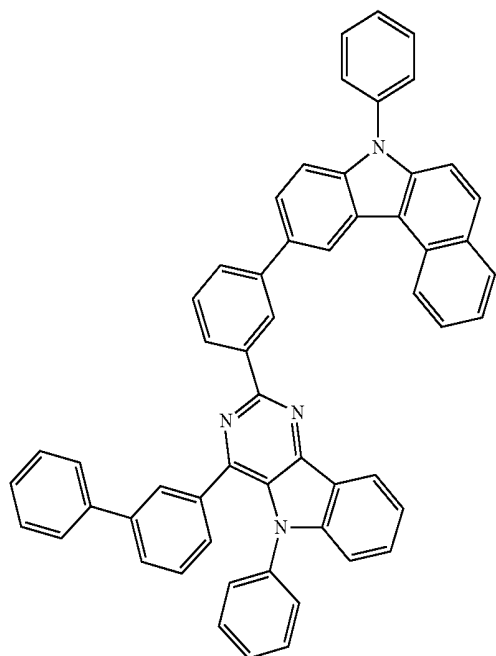


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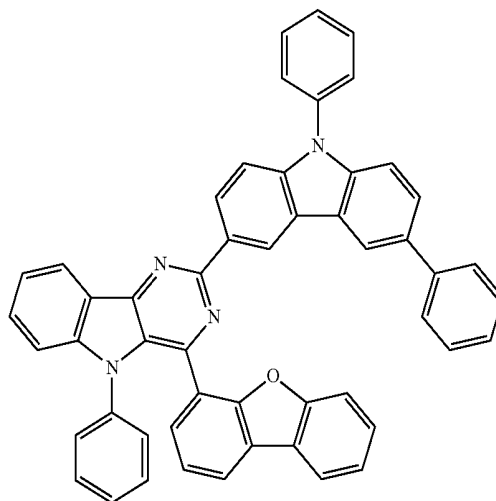
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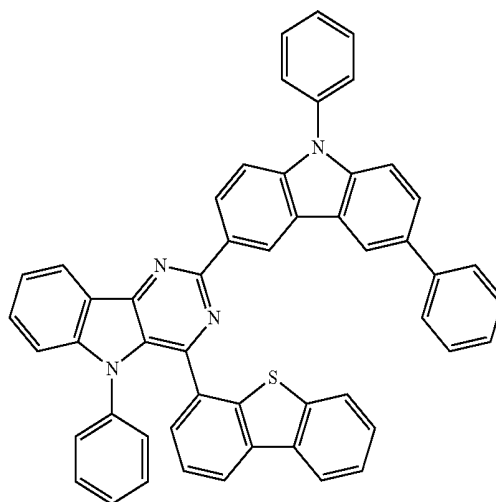
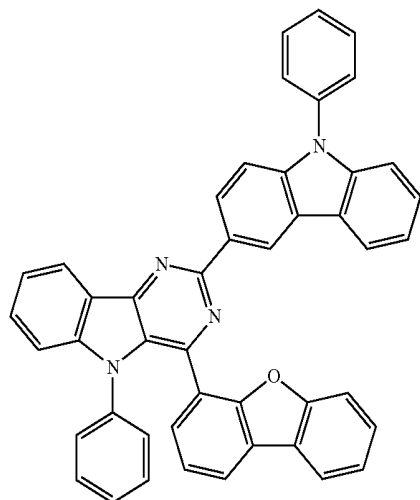
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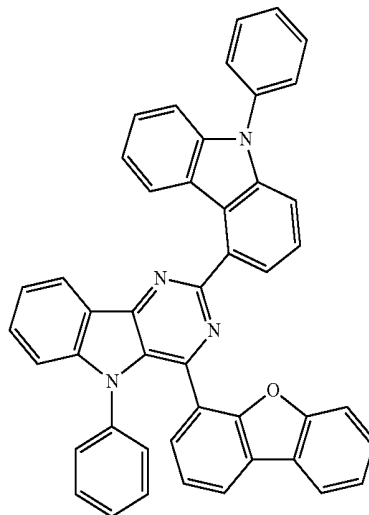
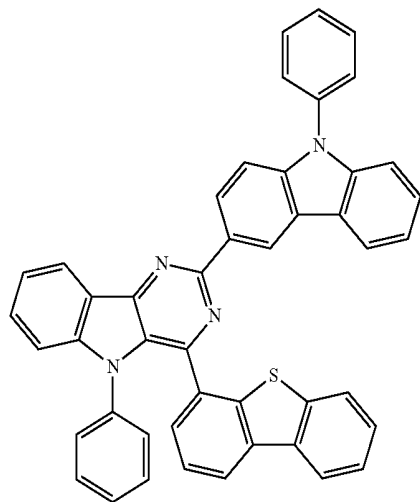
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d-51

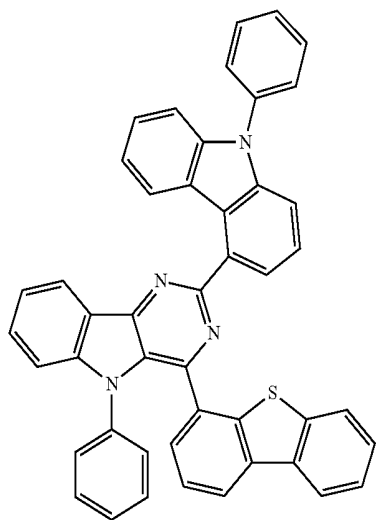


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d-52

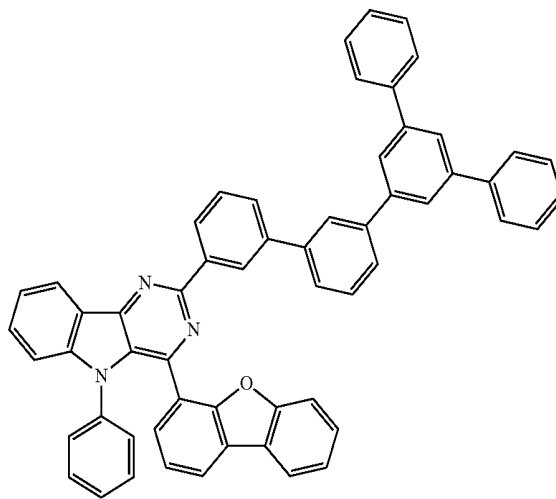


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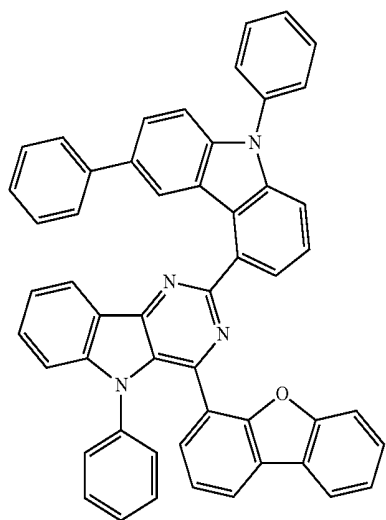


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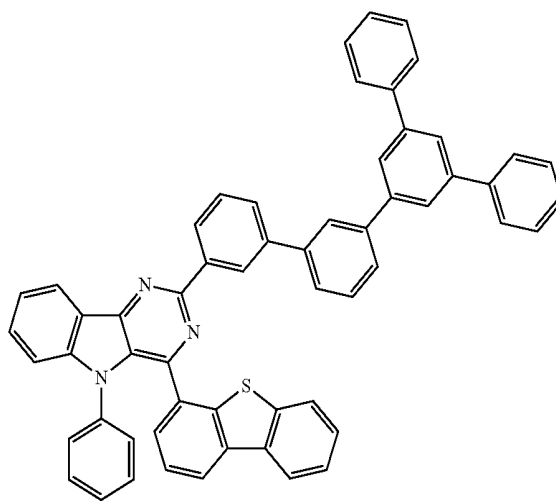
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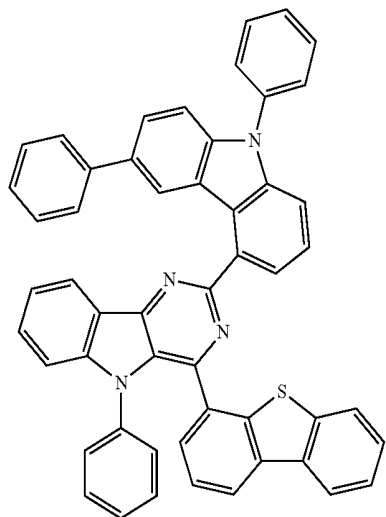
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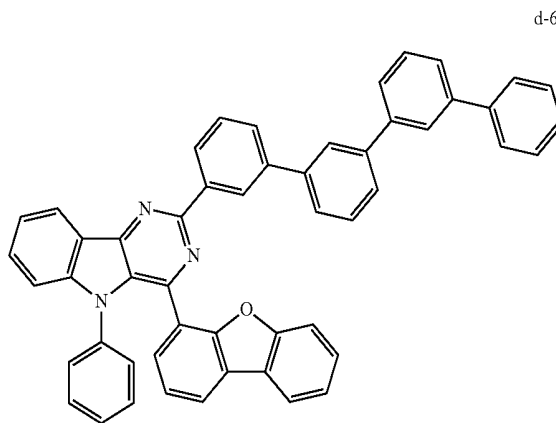
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d-60



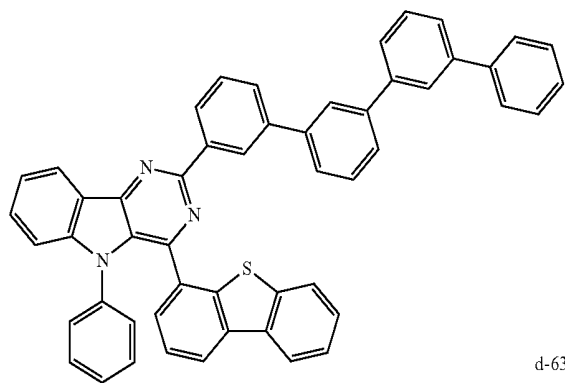
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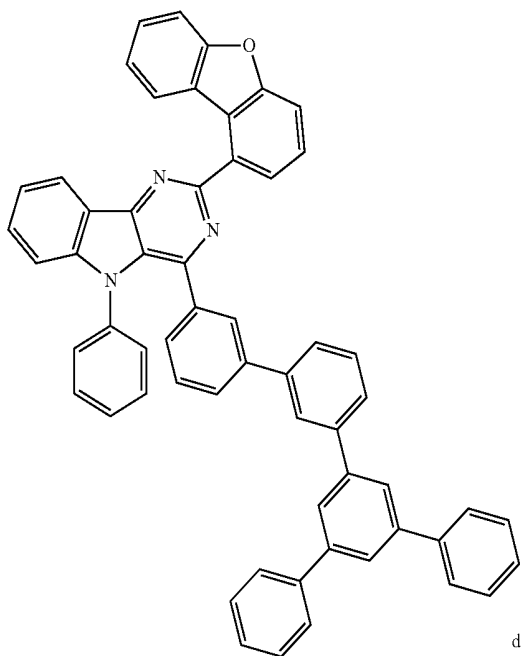
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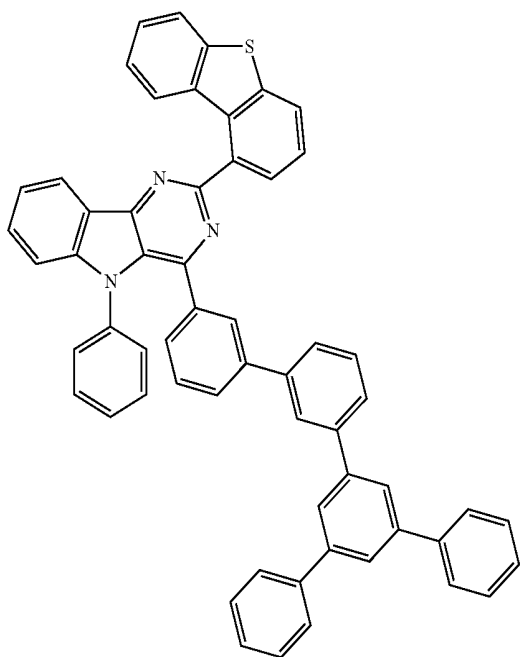
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d-63

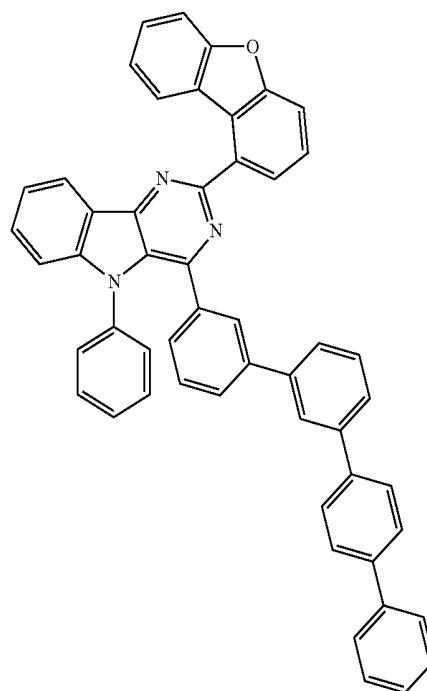


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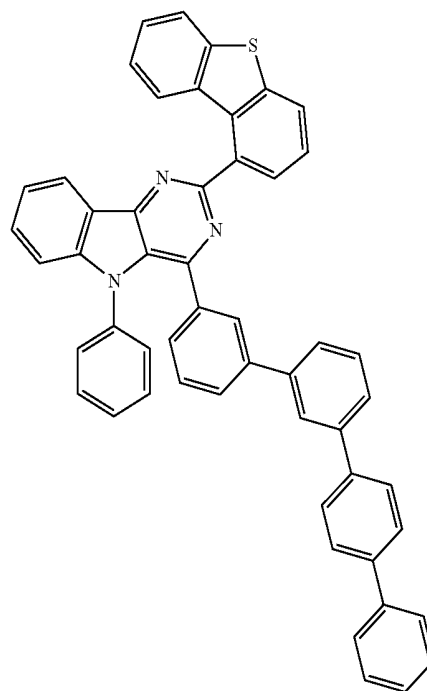


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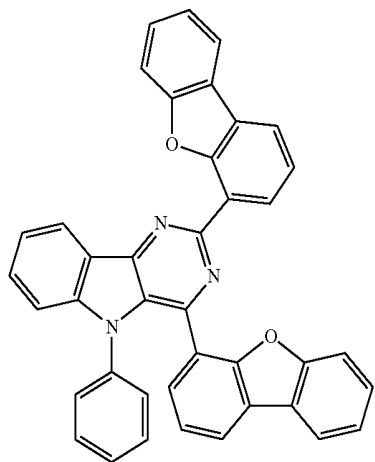
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d-66

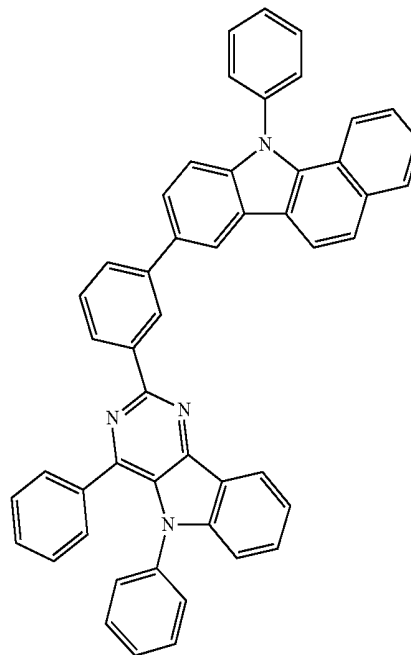


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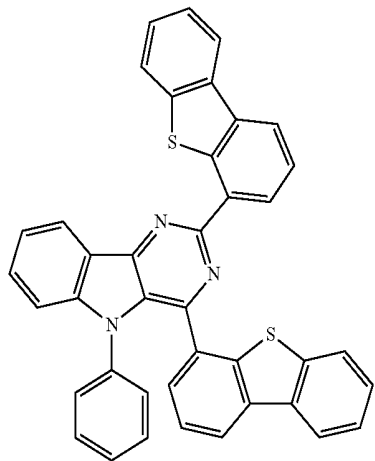
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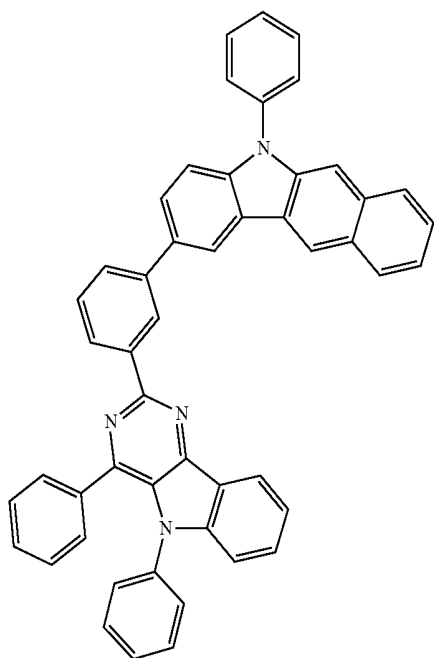


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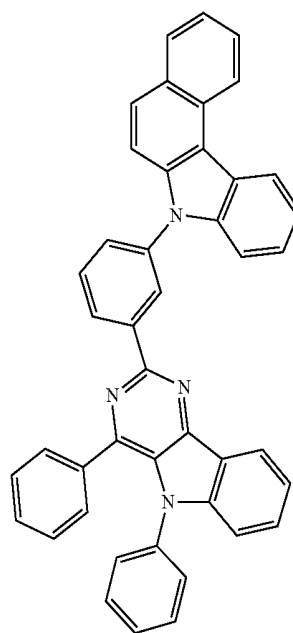
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d-69

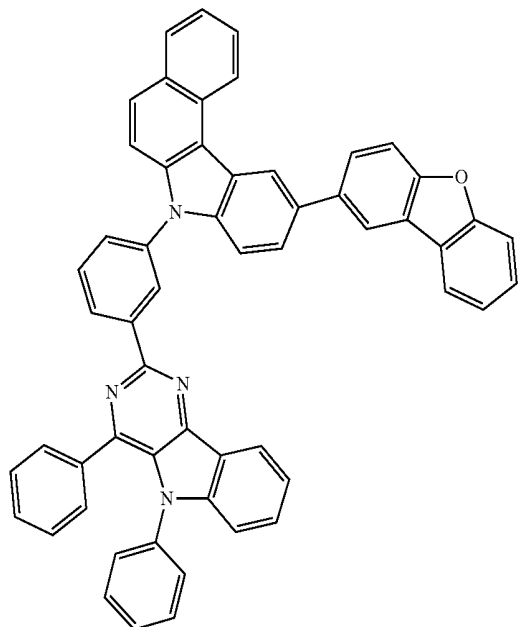


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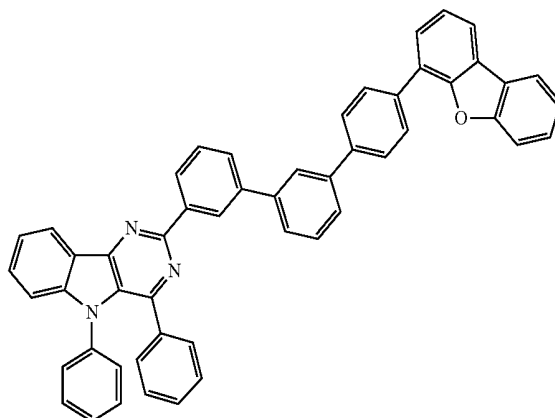
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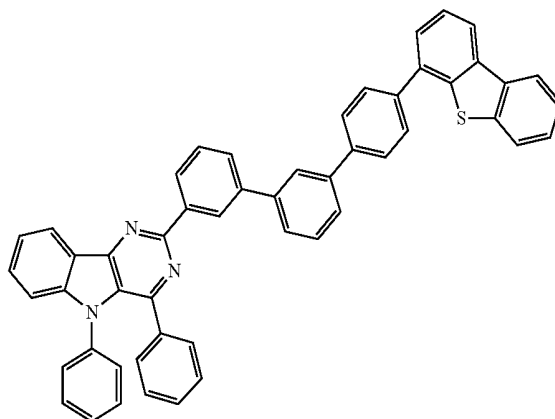


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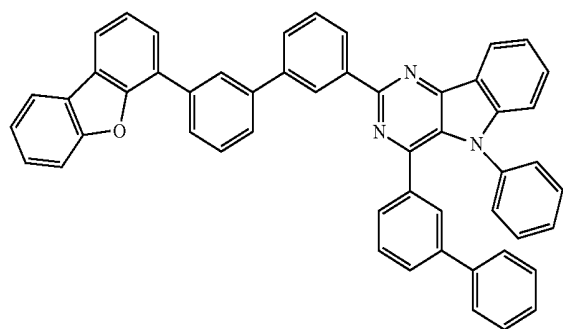
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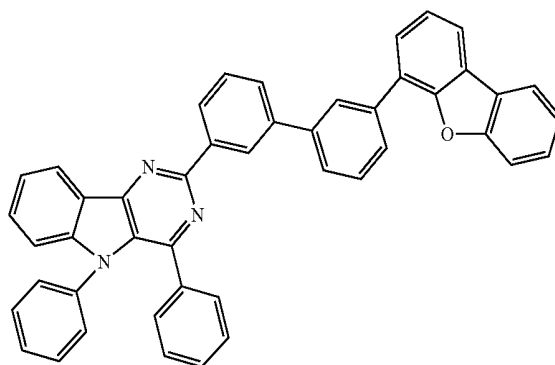
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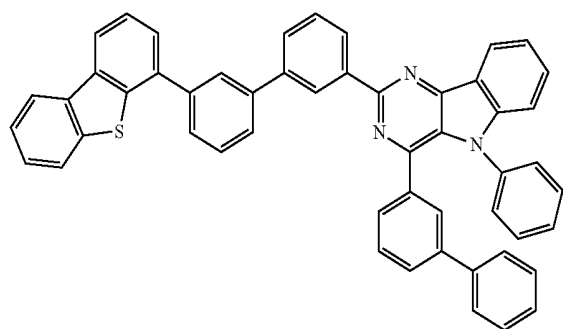
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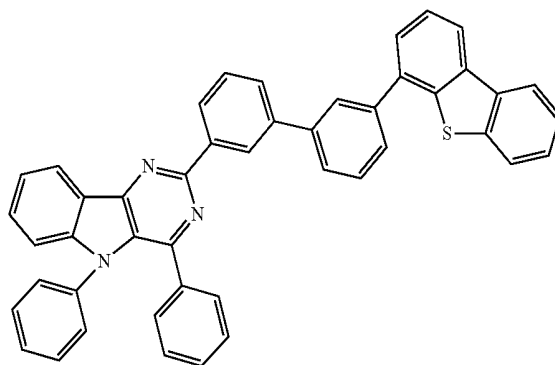
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d-74

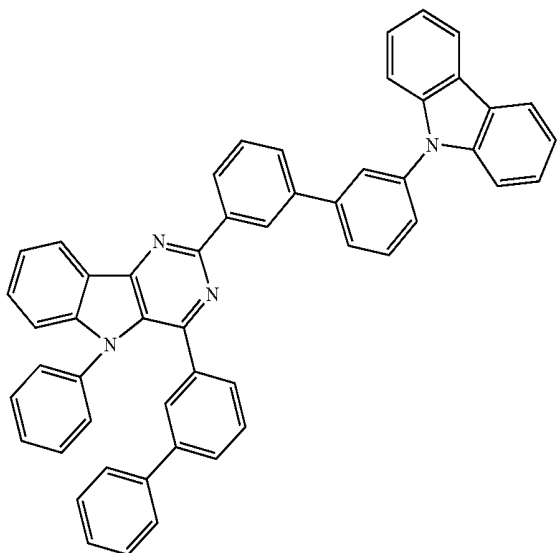


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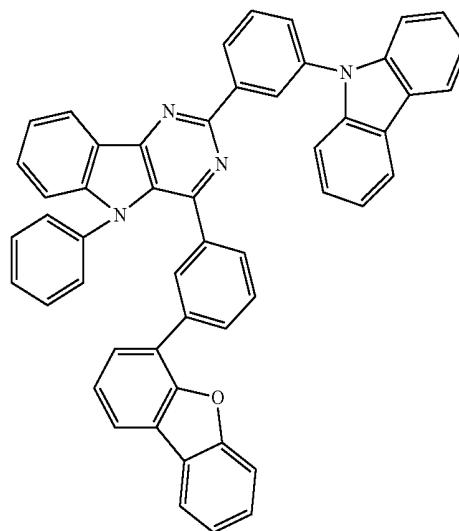
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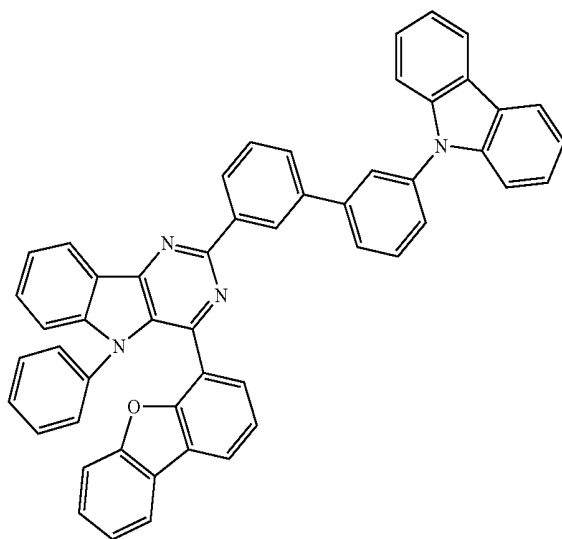


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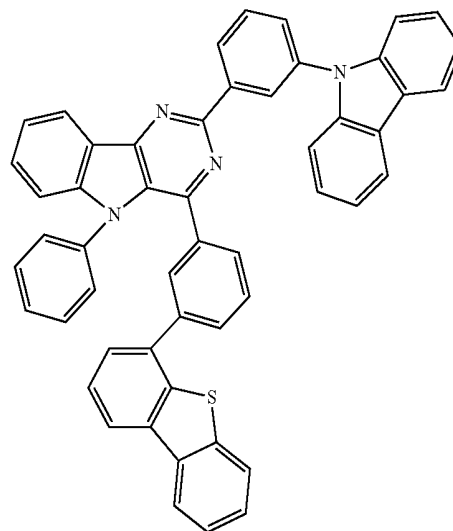
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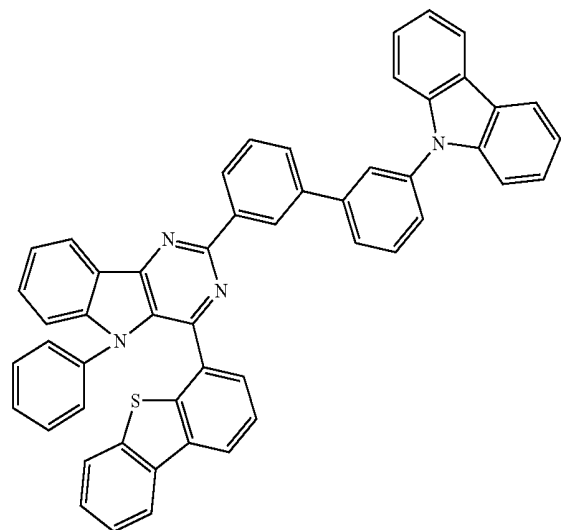
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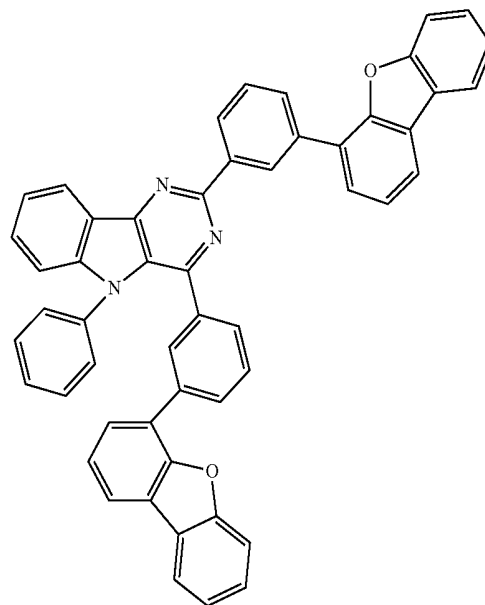
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d-81

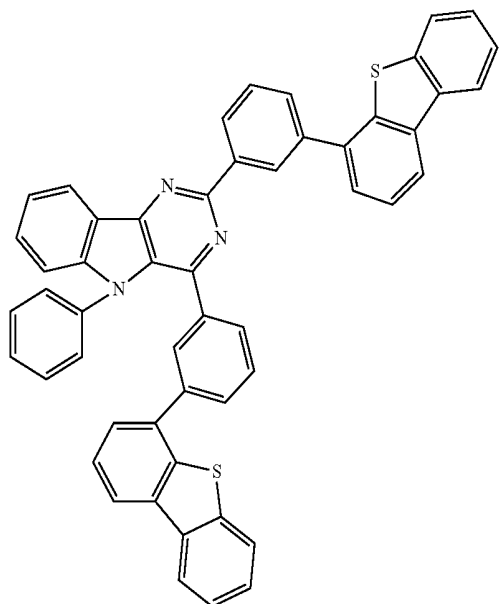


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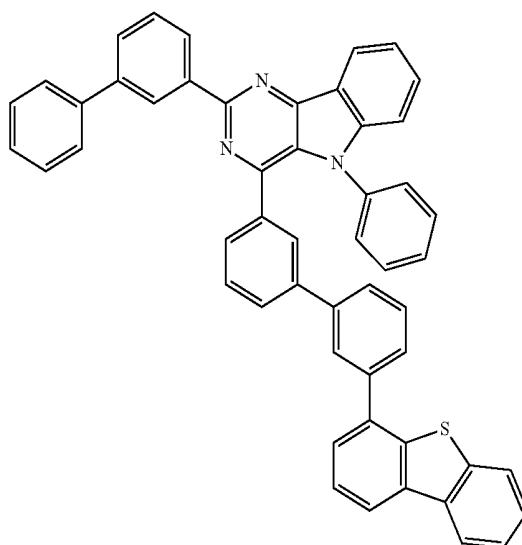
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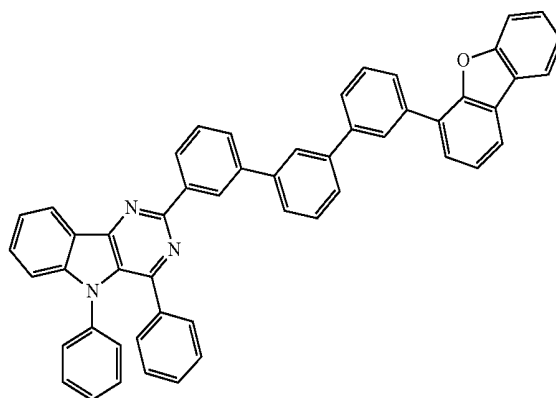


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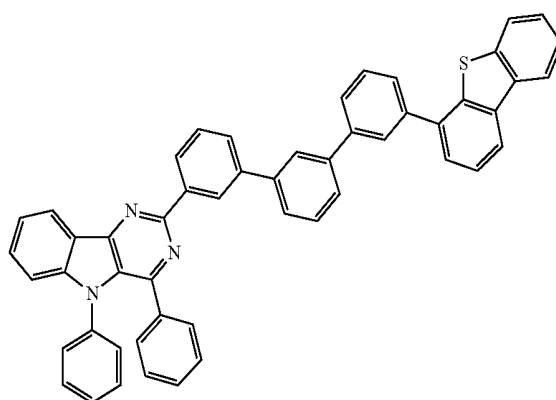
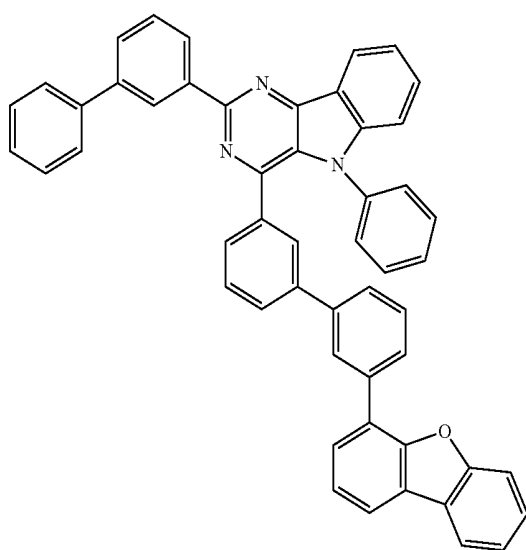


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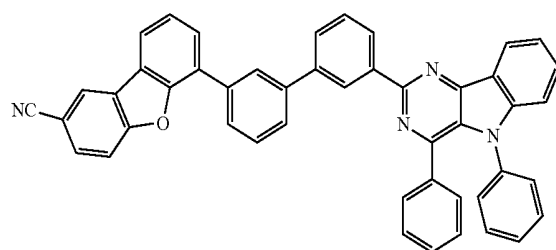


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d-89

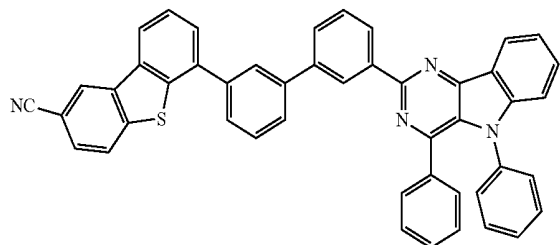


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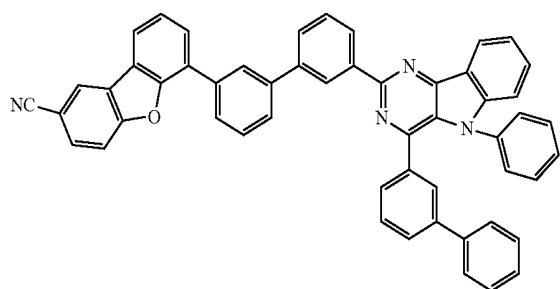


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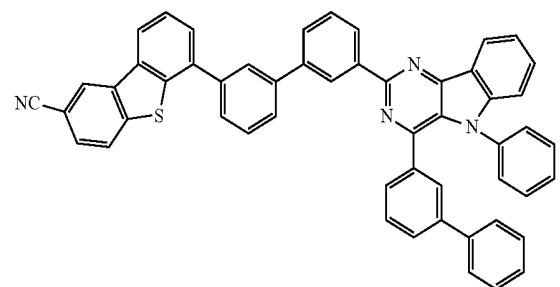
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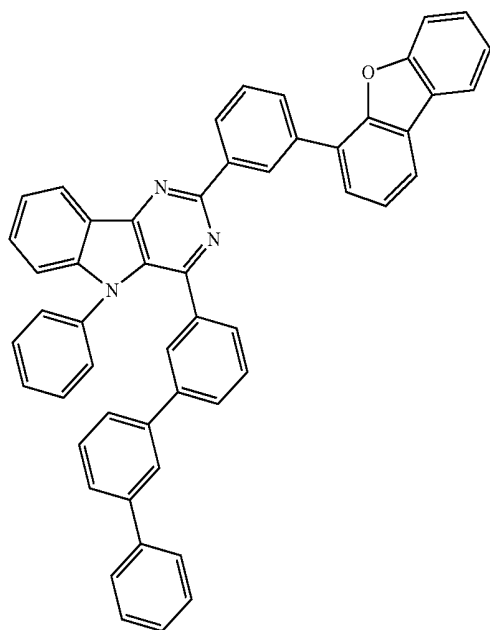
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d-93

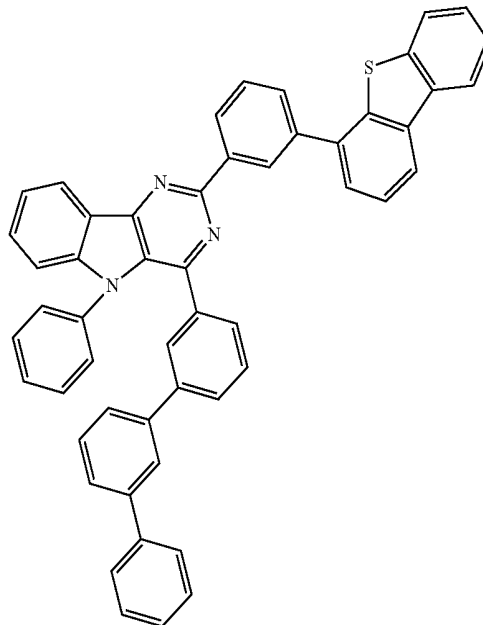


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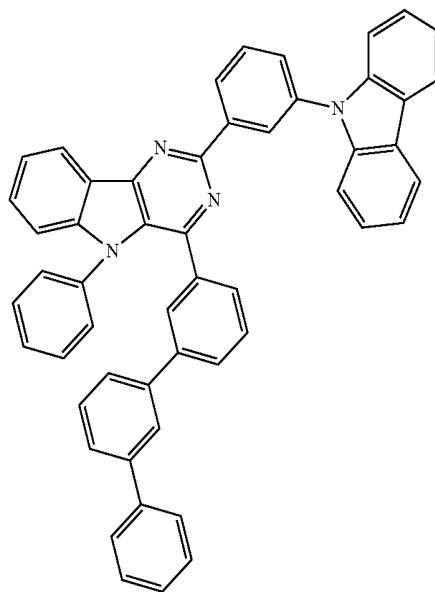


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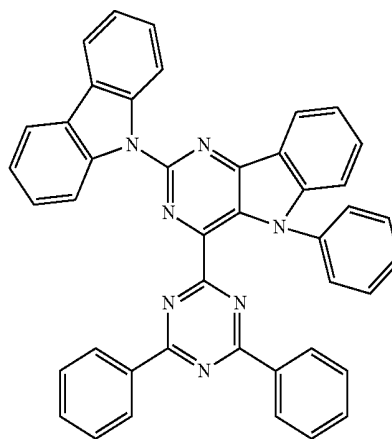
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d-96

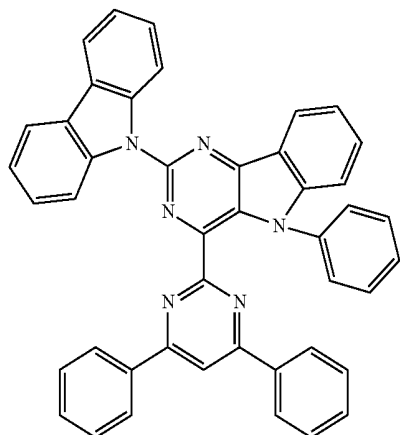


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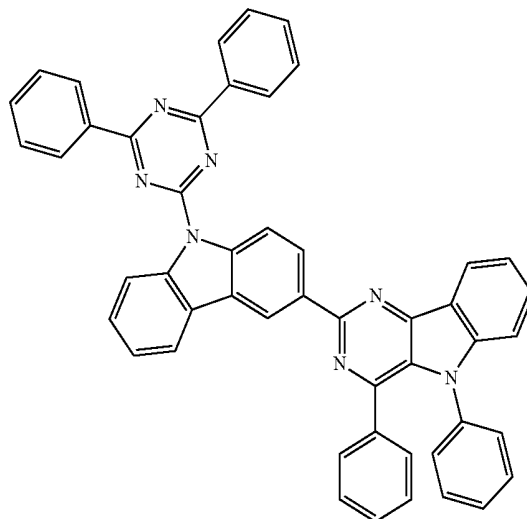
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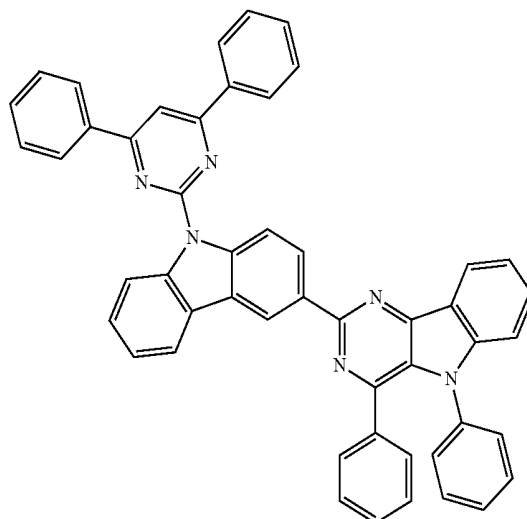
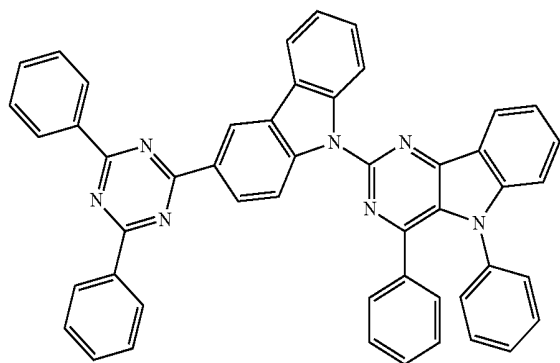
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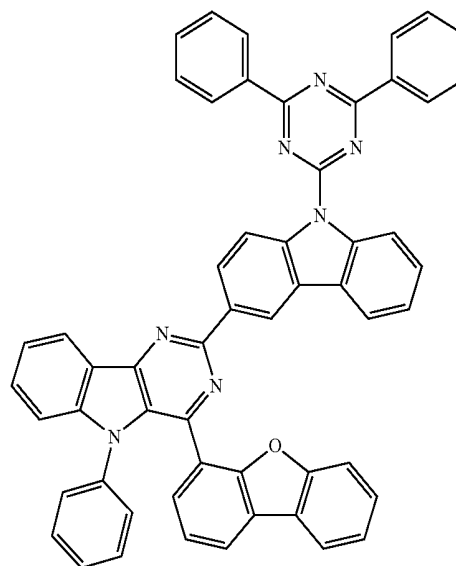
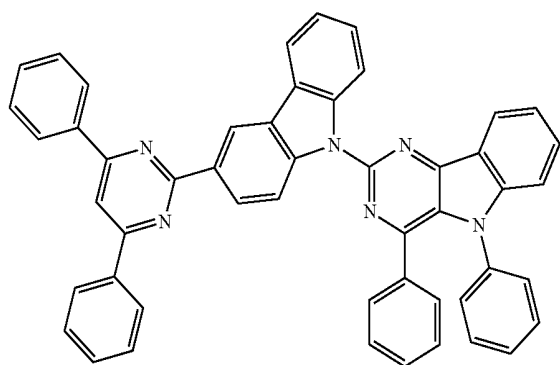
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d-99



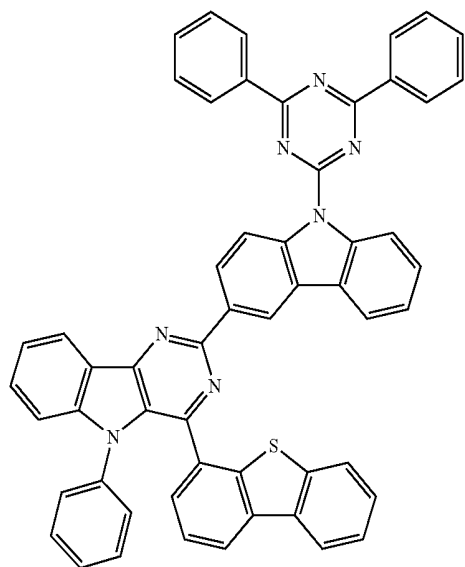
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d-100

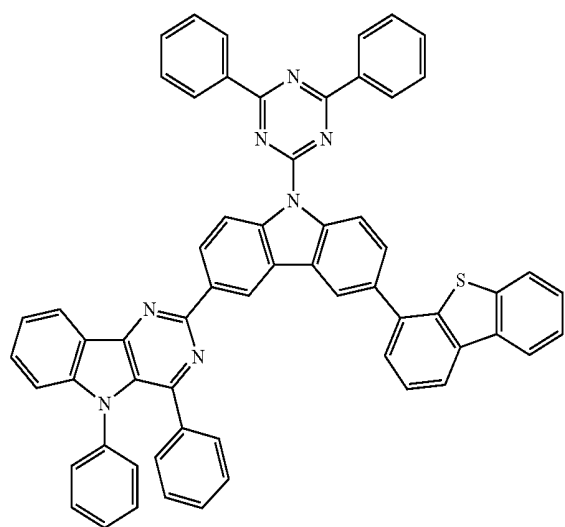


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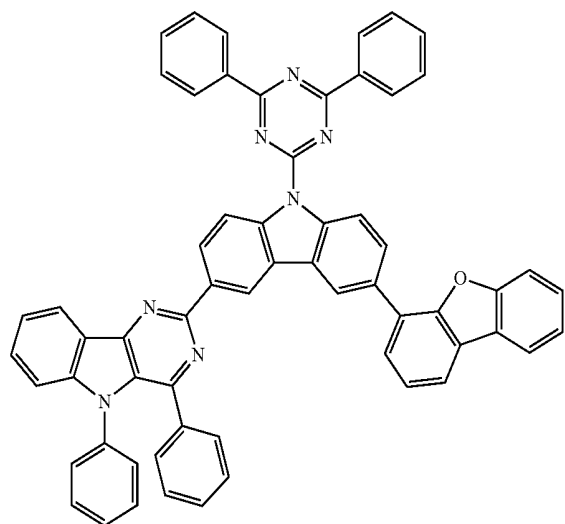
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d-105

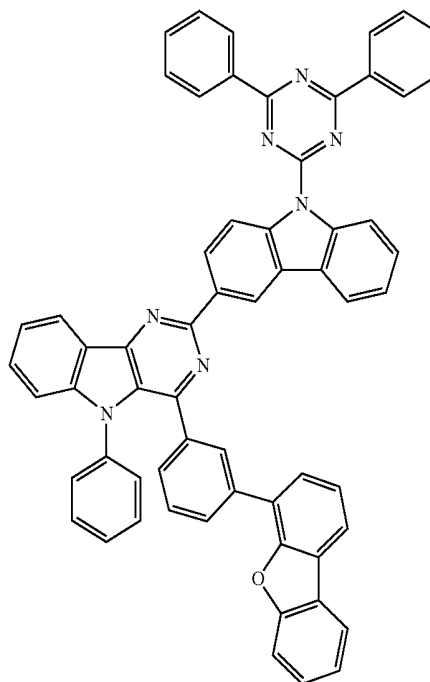


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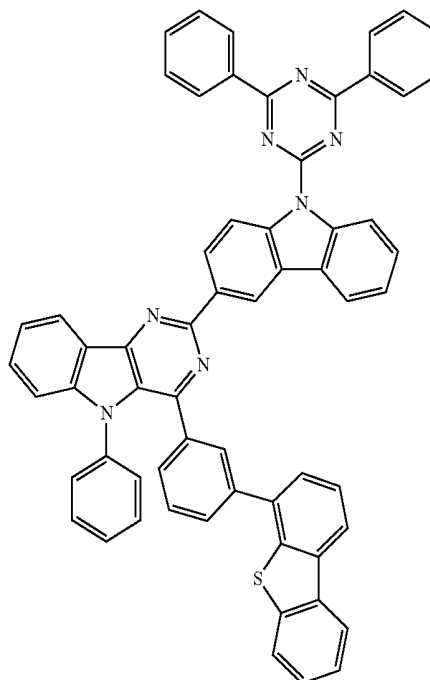


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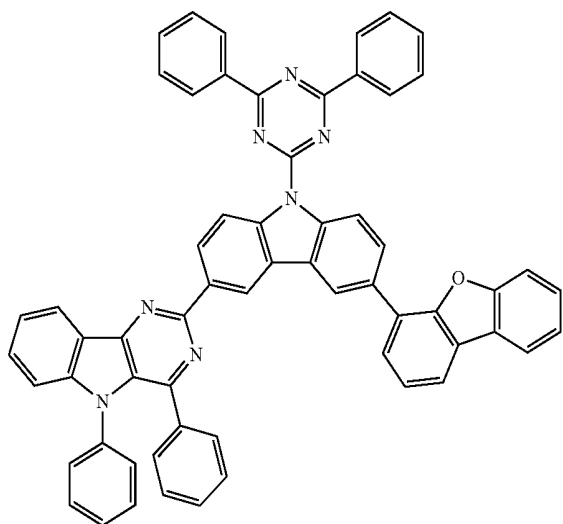


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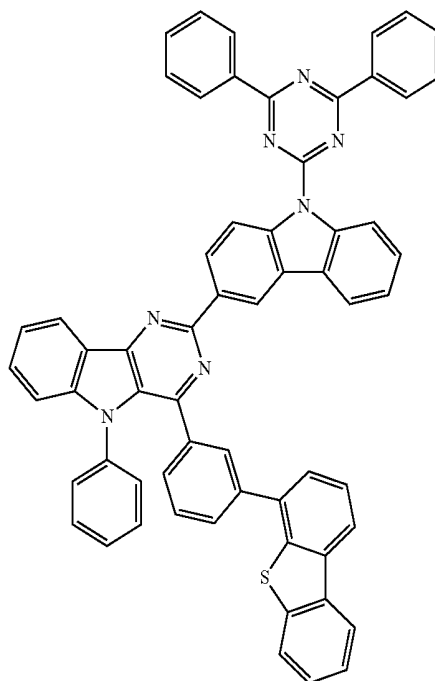
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d-109



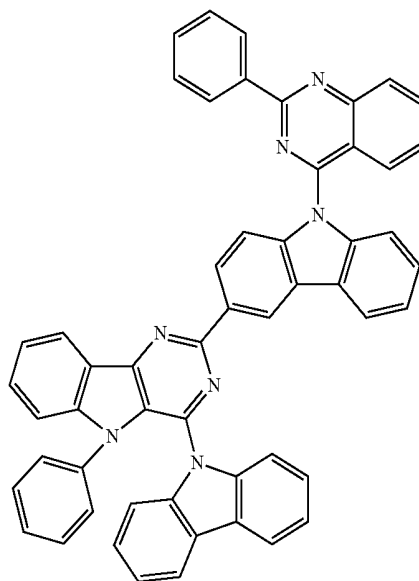
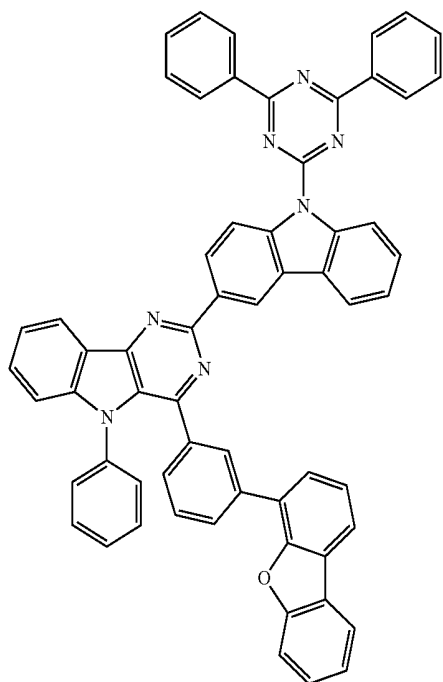
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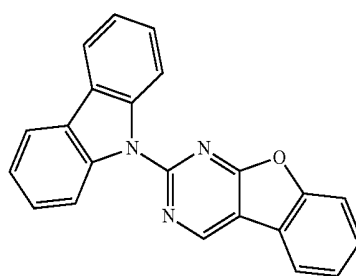
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d-110

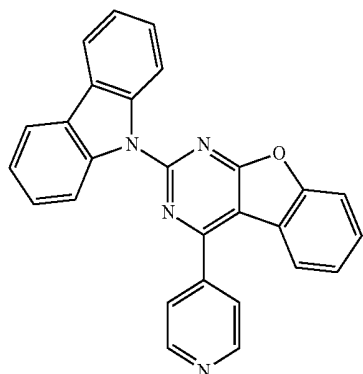


[0160] Group of X<sub>1</sub>=O in Formula 1-2

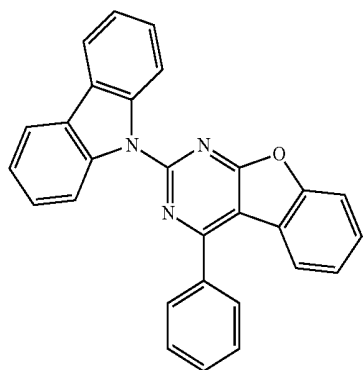
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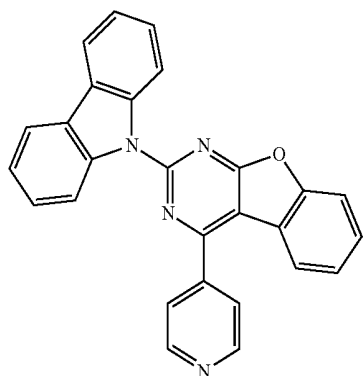
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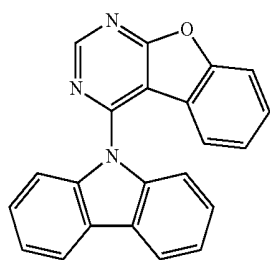
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165

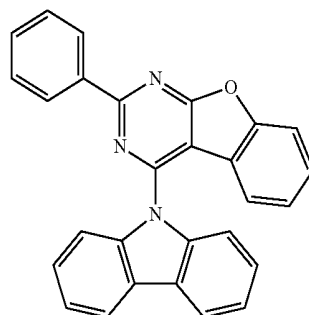


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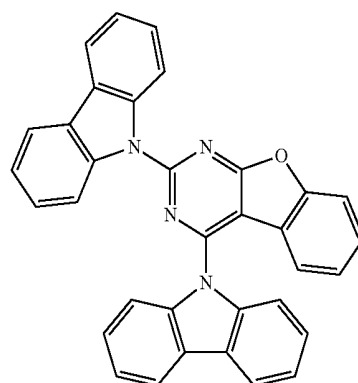


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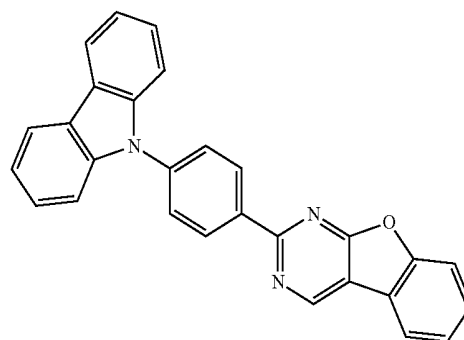
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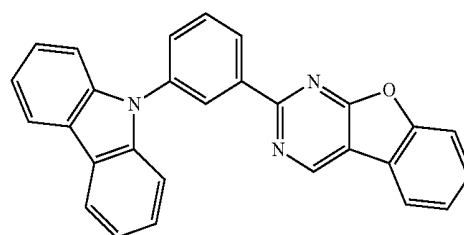
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169



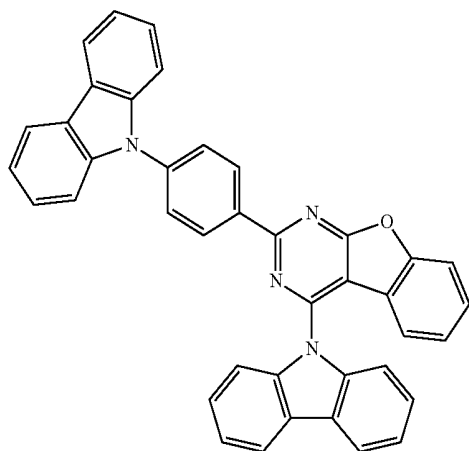
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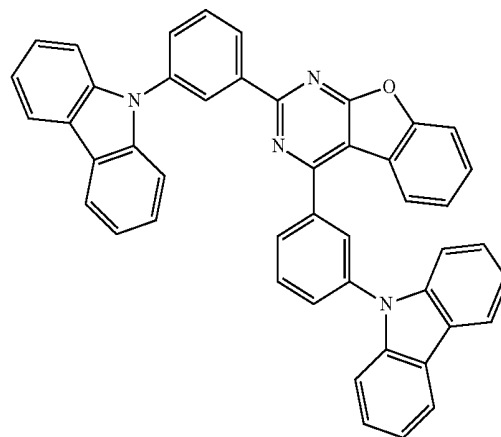
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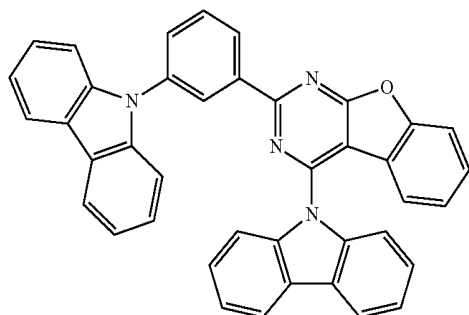
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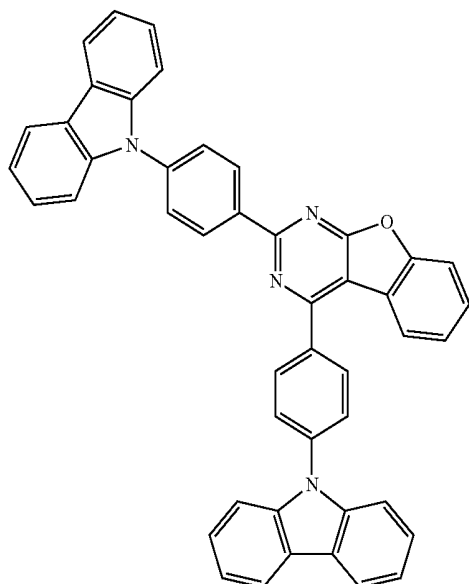
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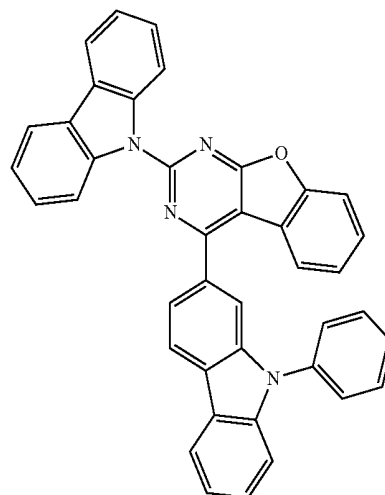


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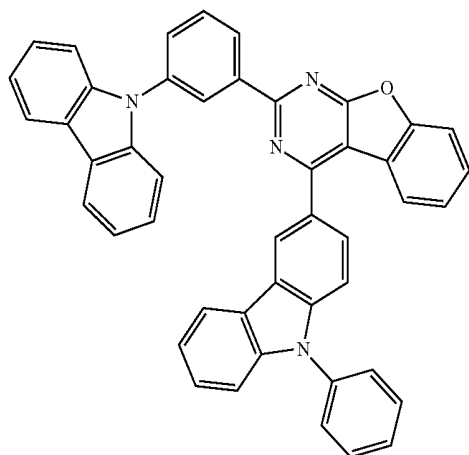
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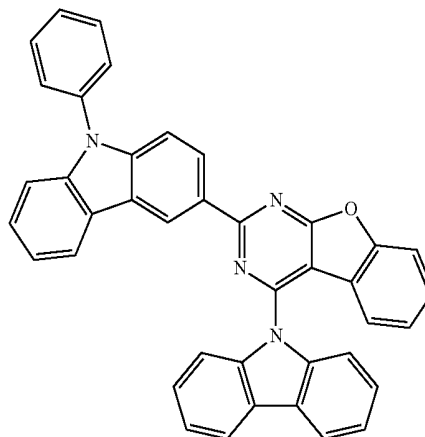


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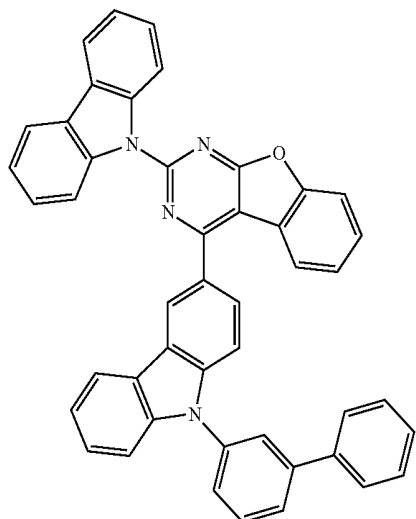


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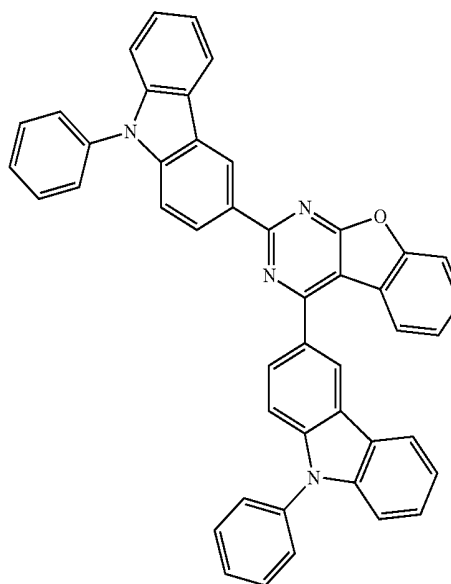
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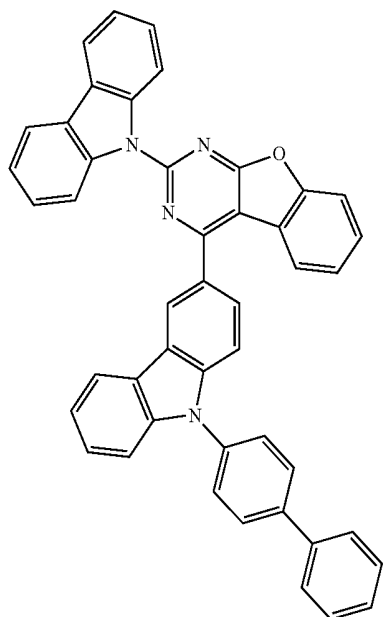
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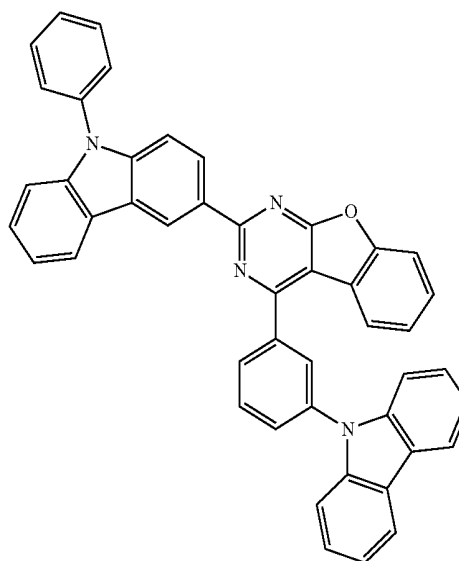
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182

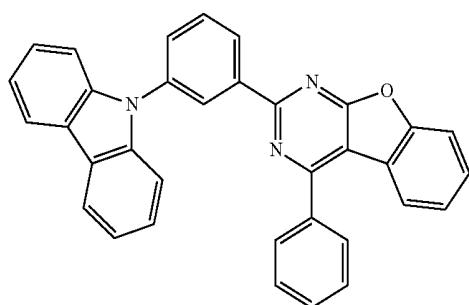
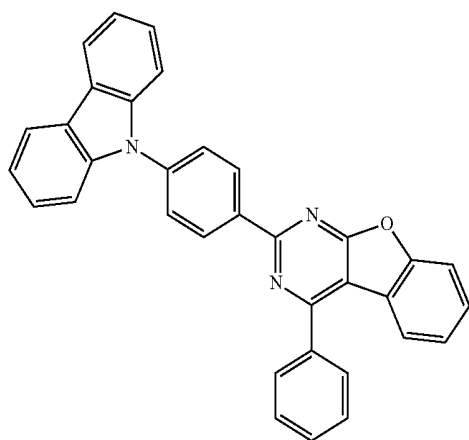
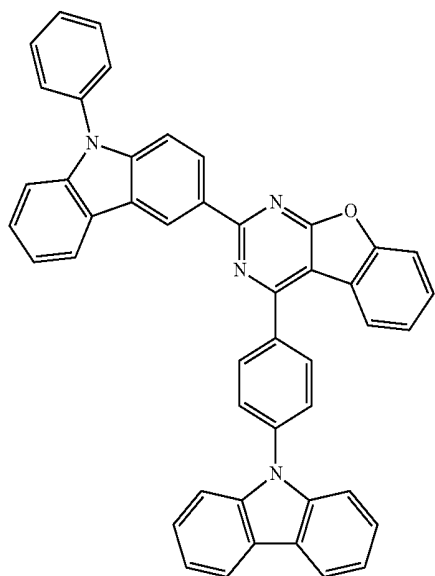


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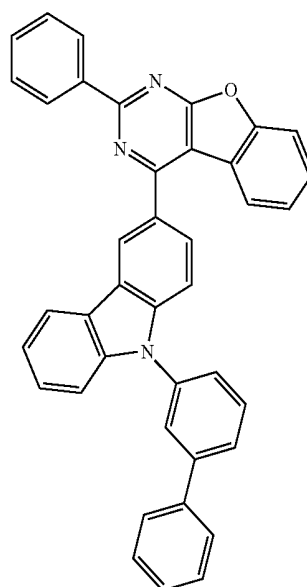
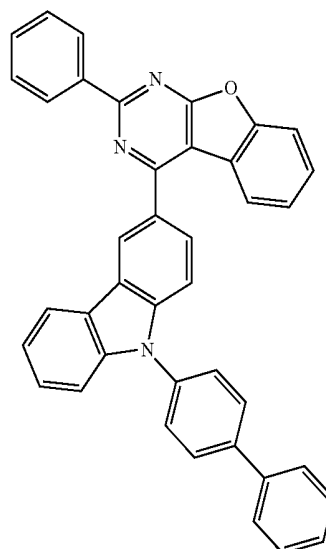
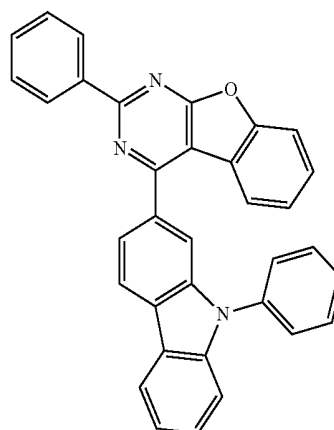


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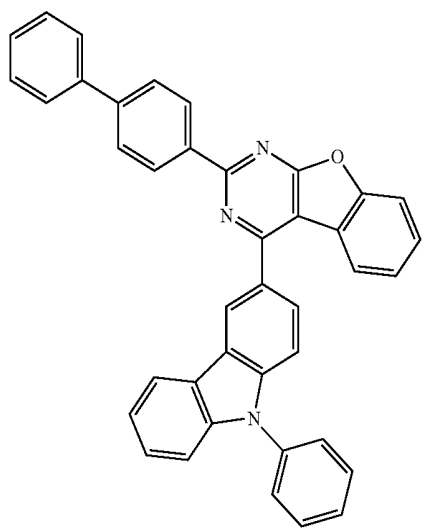
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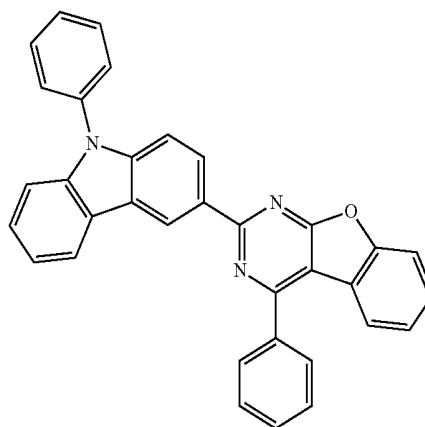


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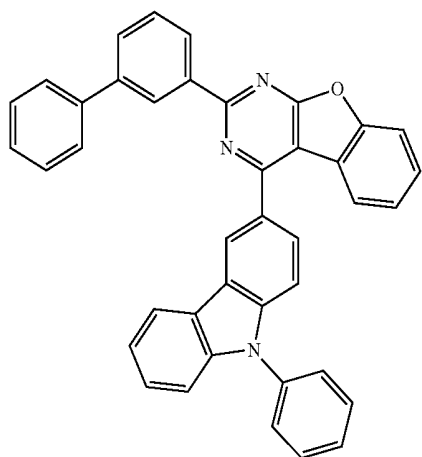


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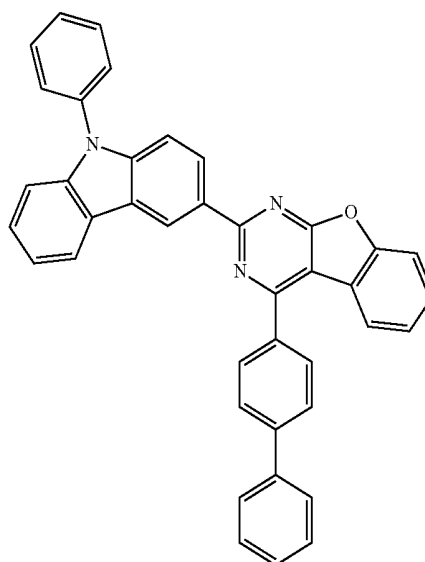
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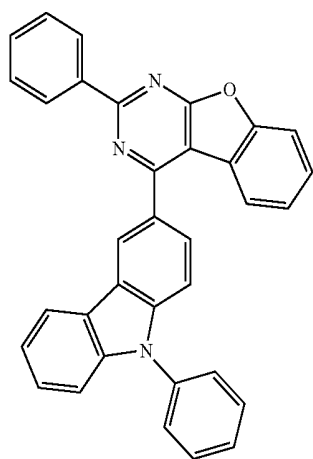
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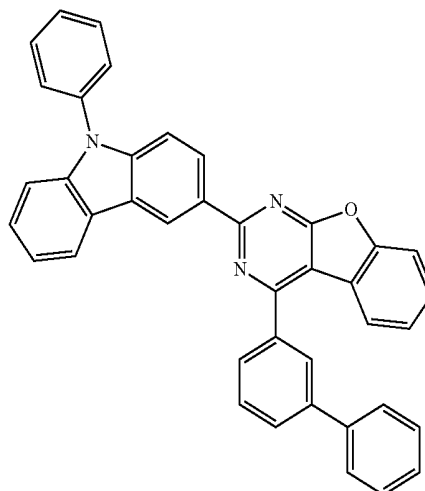
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e-2



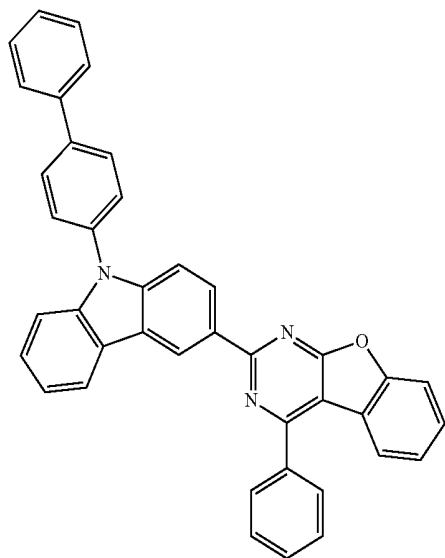
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e-3

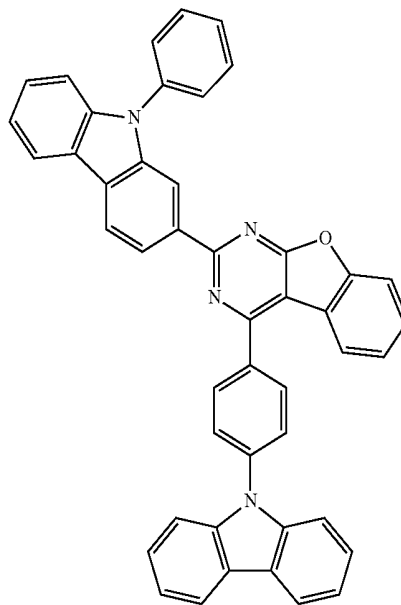
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e-4

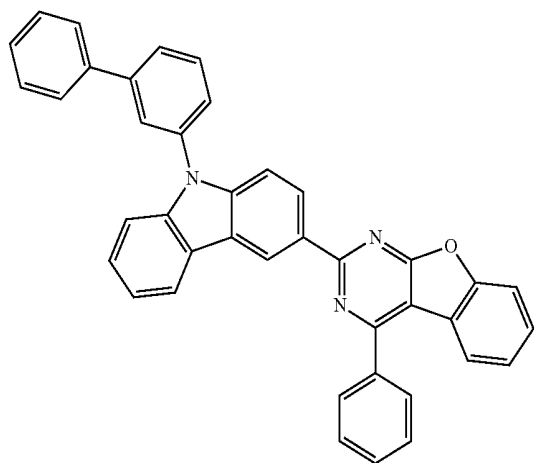


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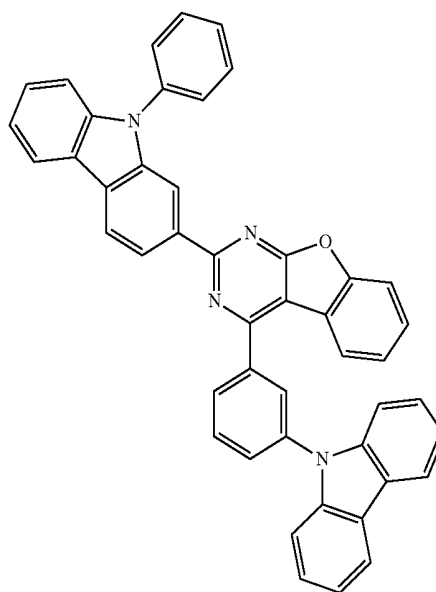
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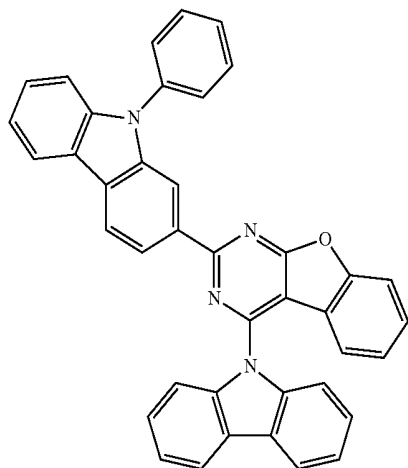
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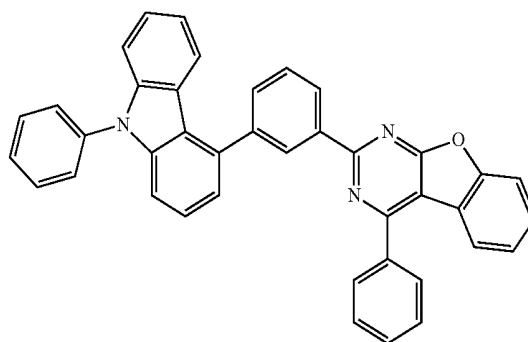
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e-6

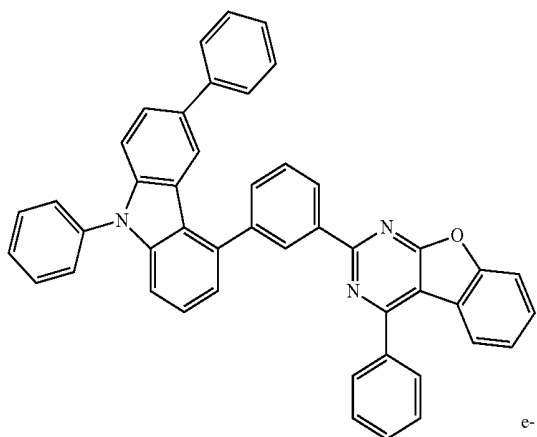


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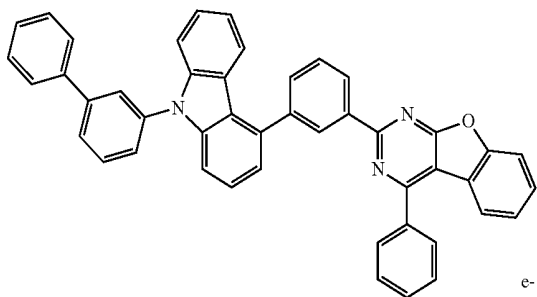


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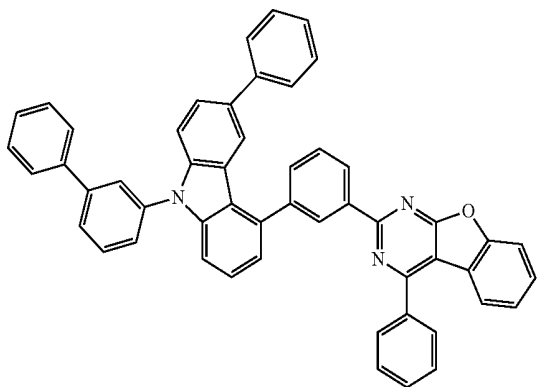
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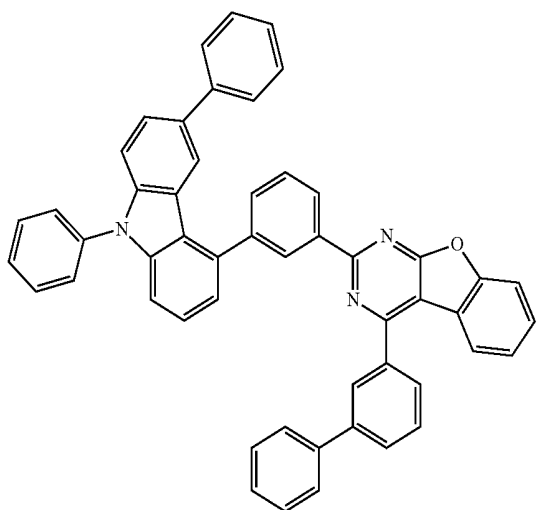
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e-12

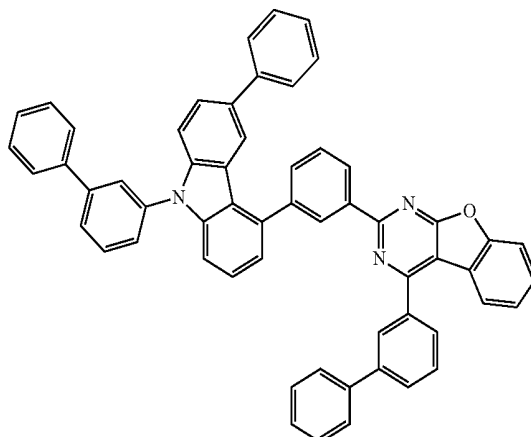


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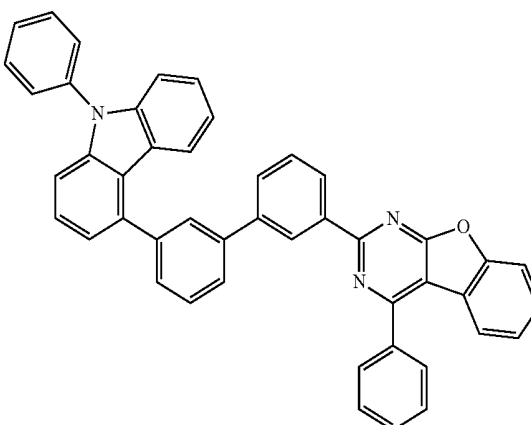


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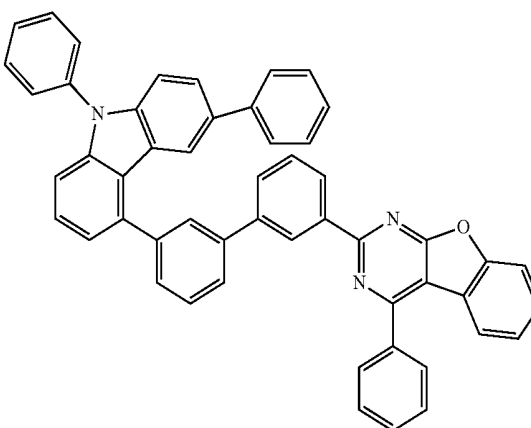
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e-15

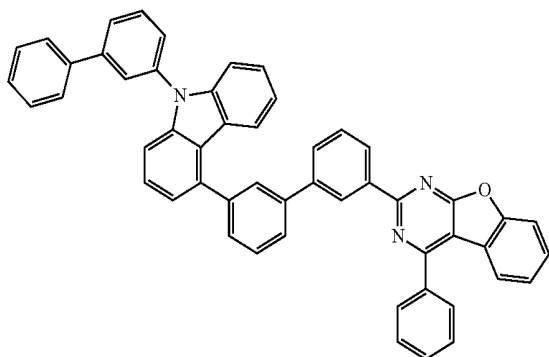


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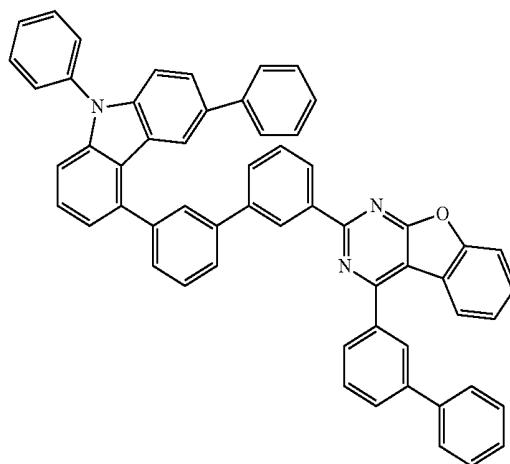
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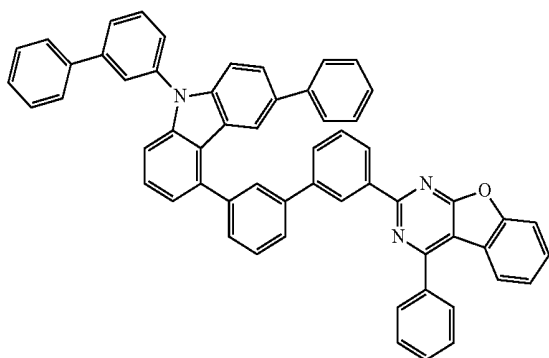


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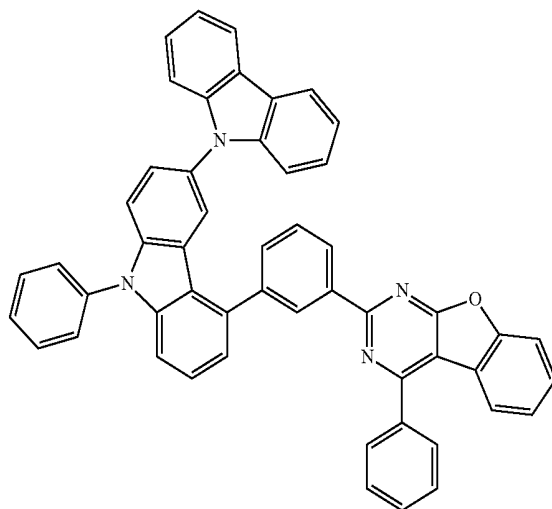
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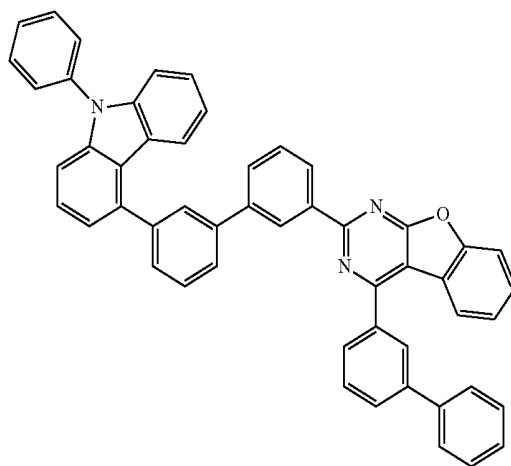
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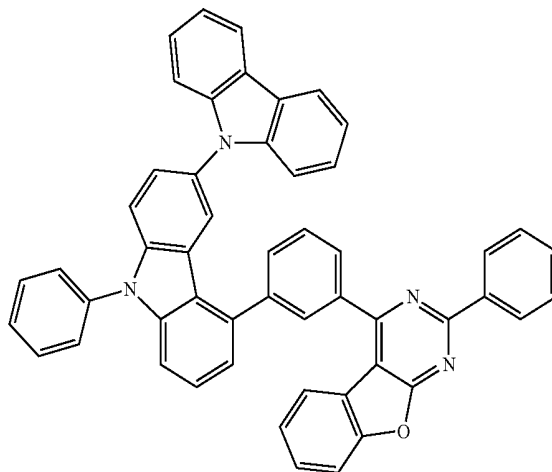
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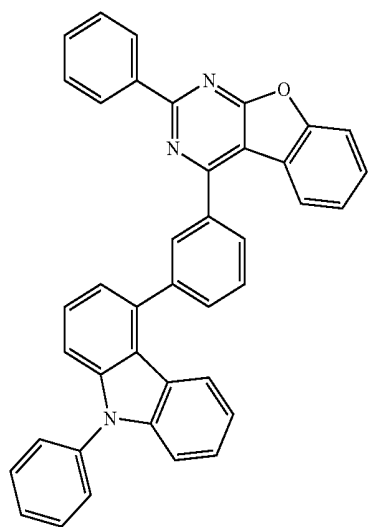
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e-22

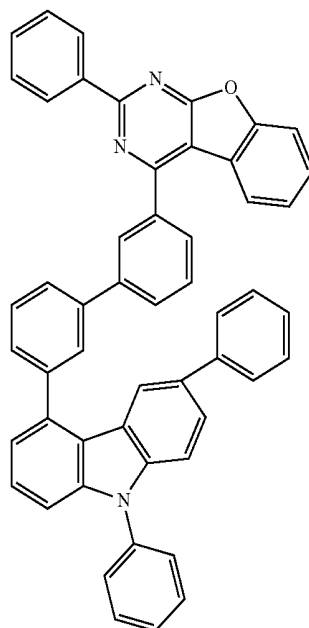


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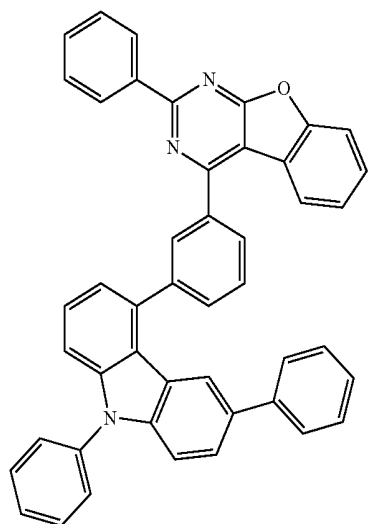


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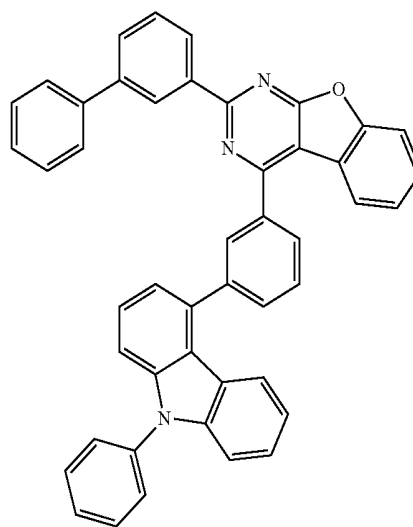
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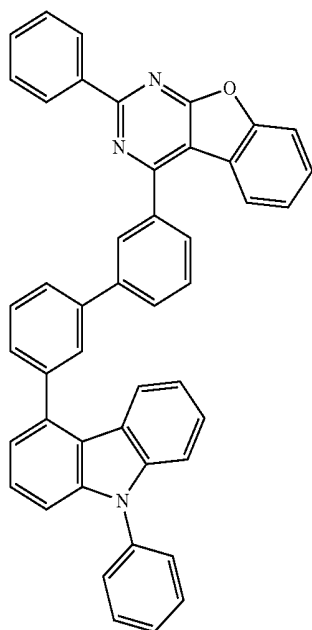
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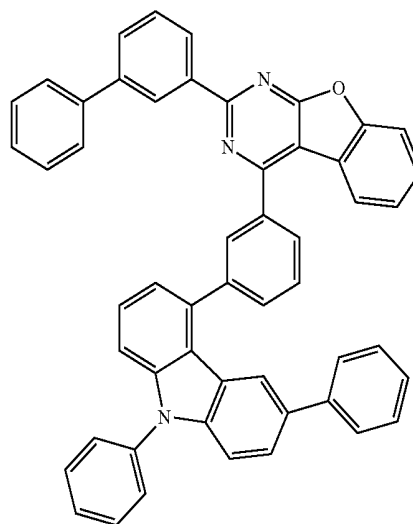
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e-27

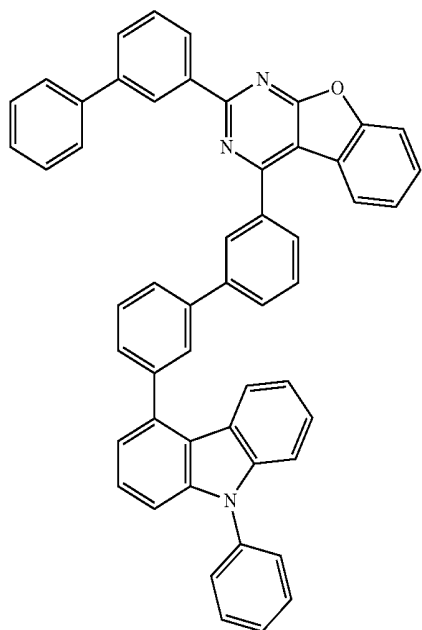


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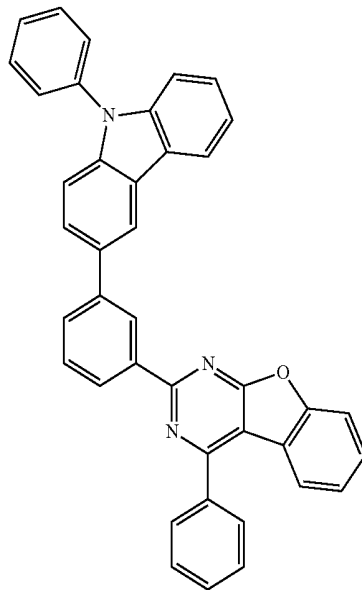
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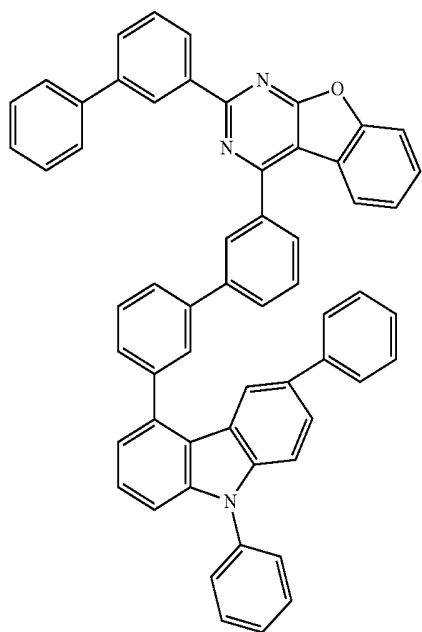


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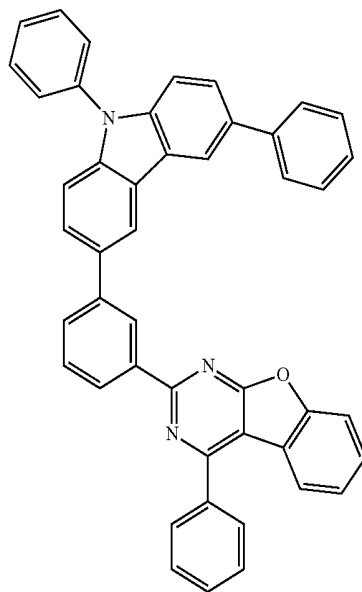
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e-31



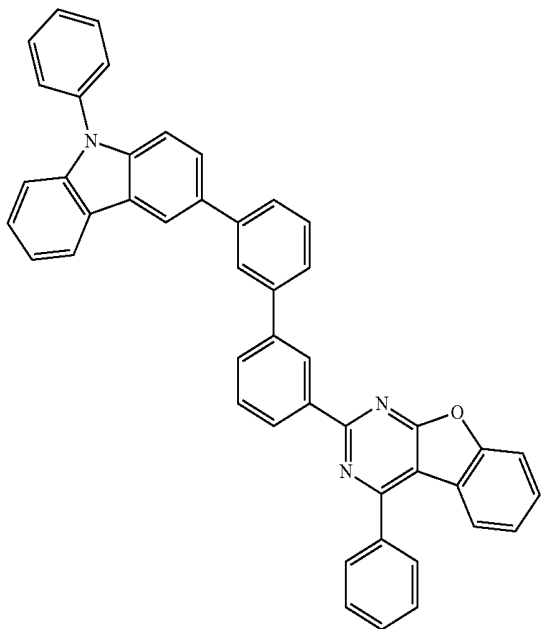
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e-32

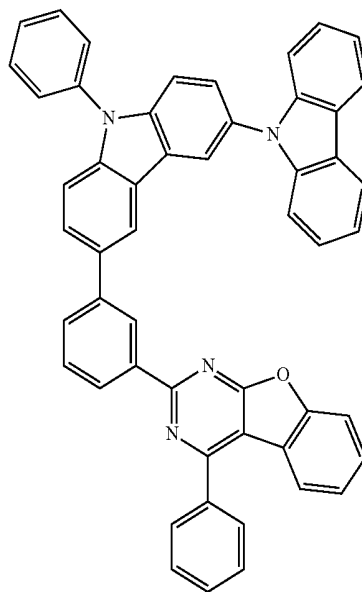
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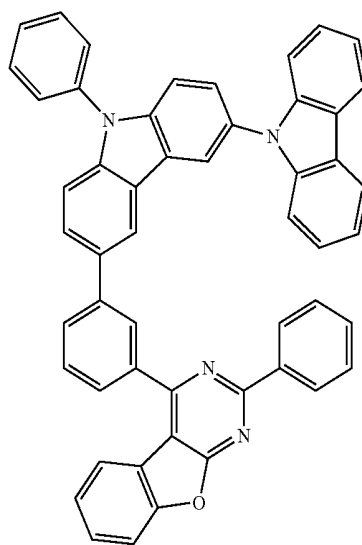


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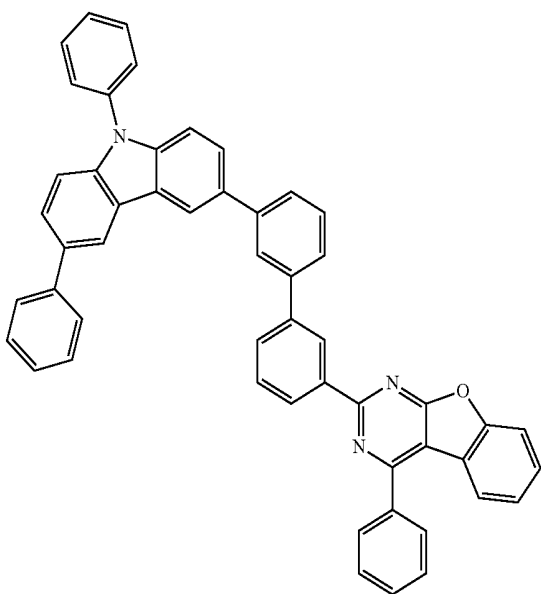
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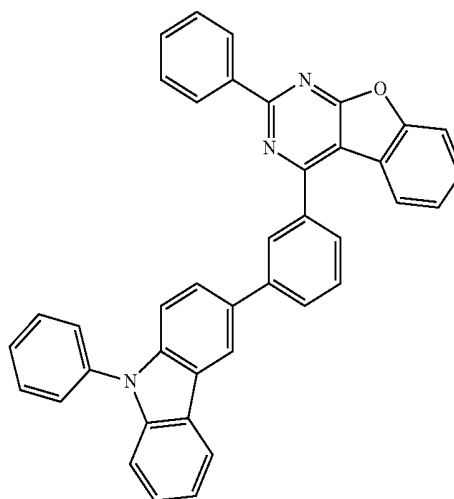
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e-34

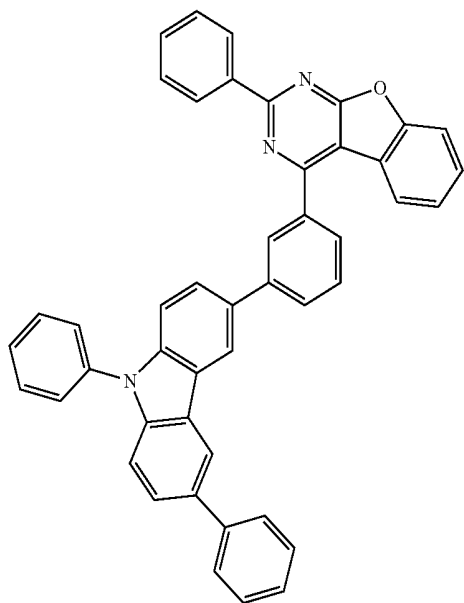


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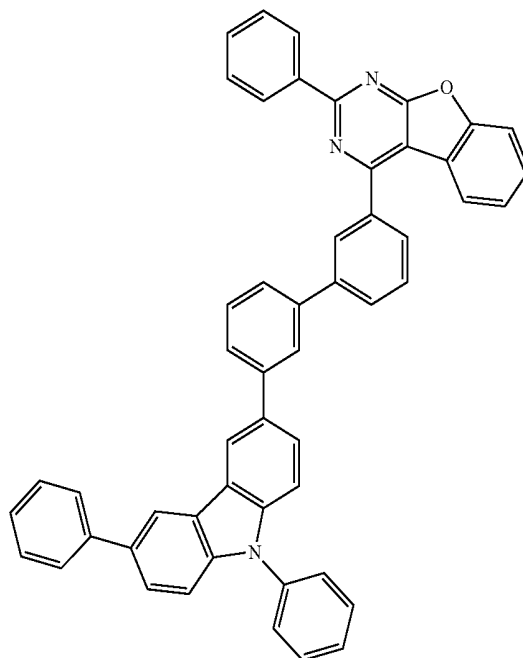
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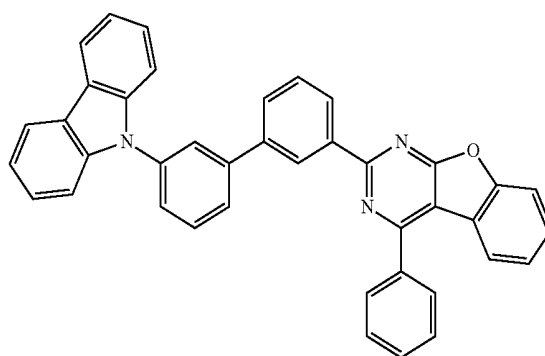
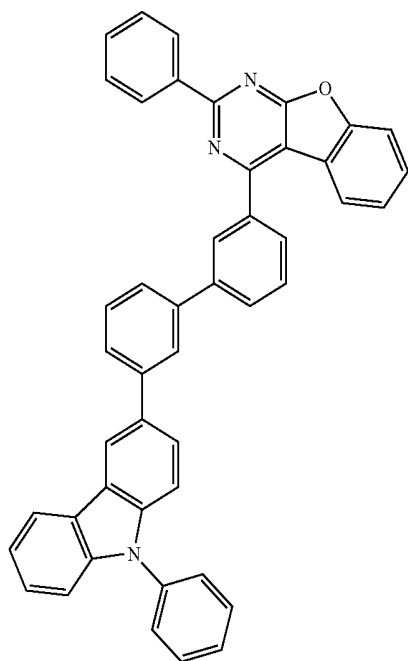
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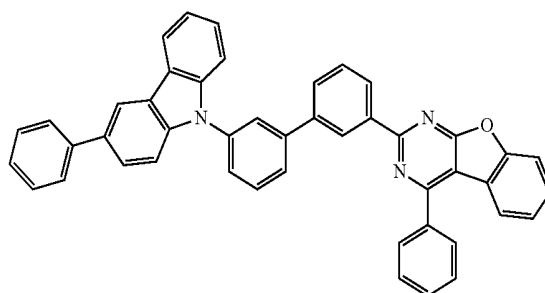


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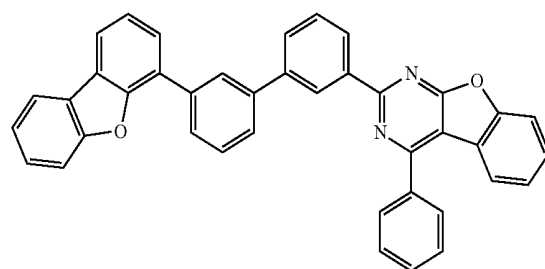
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e-42

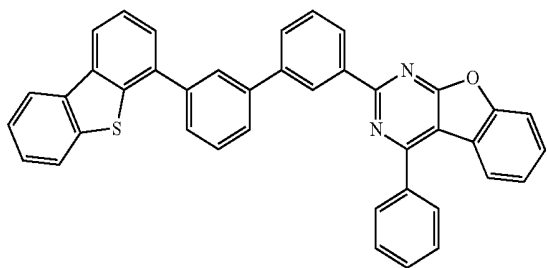


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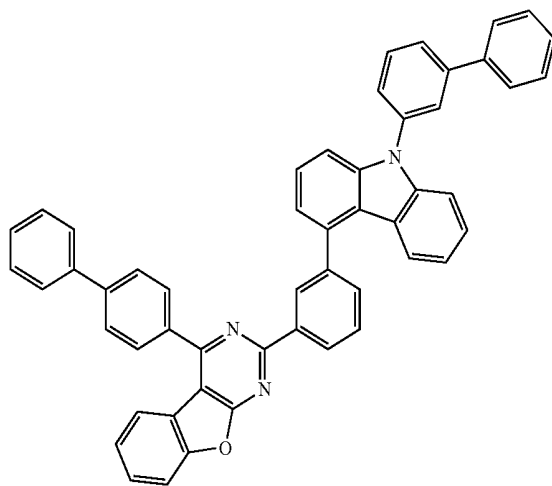
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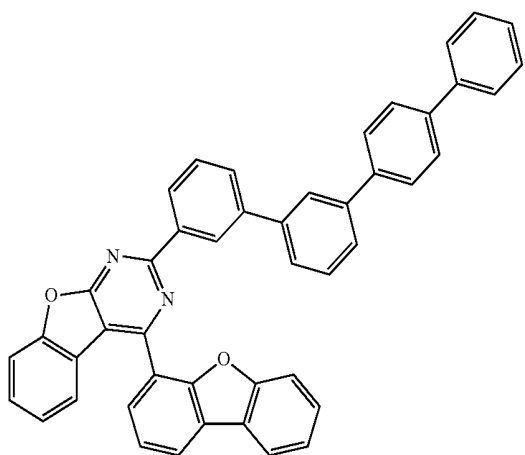


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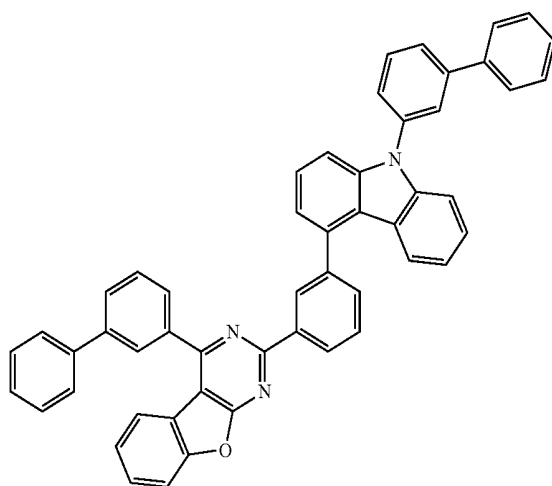
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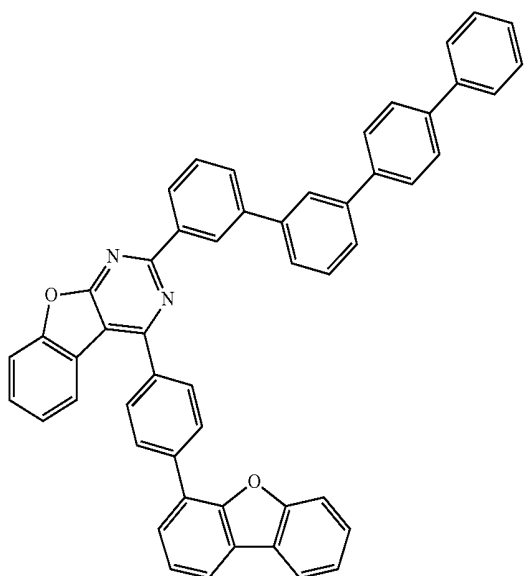
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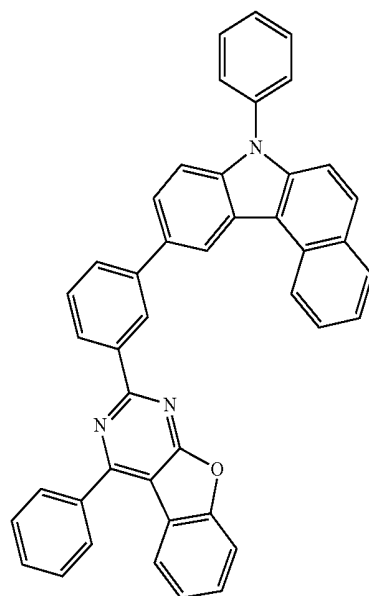
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e-46

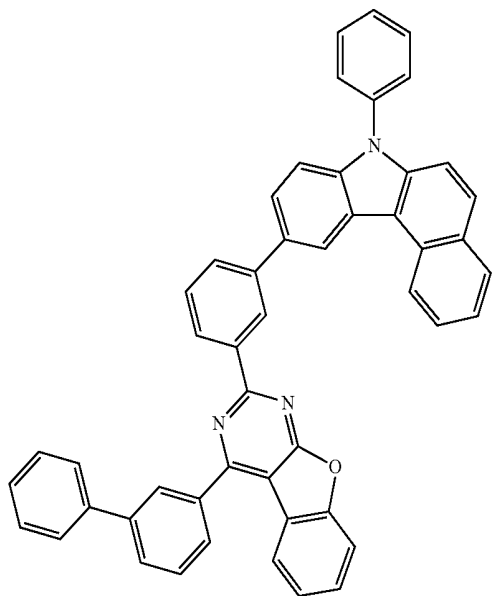


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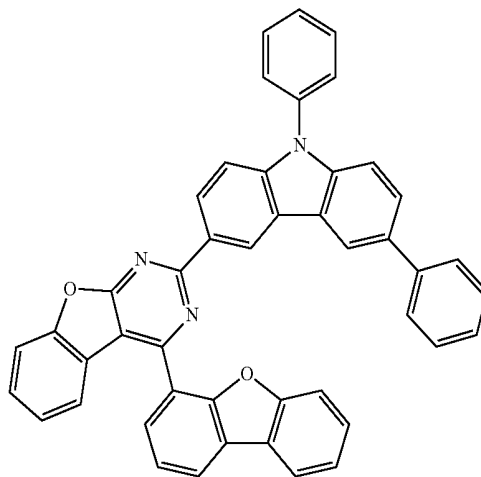
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e-50



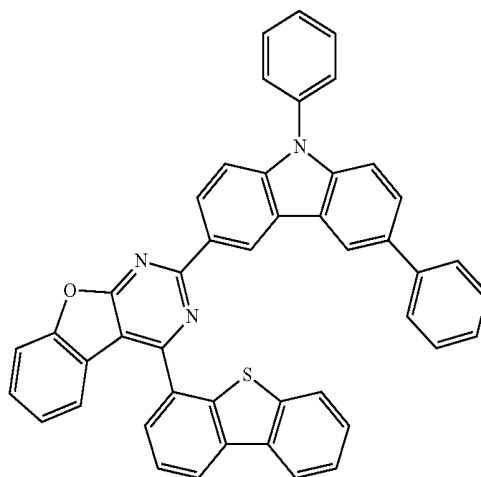
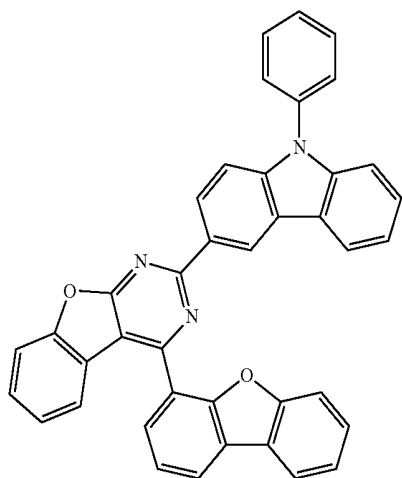
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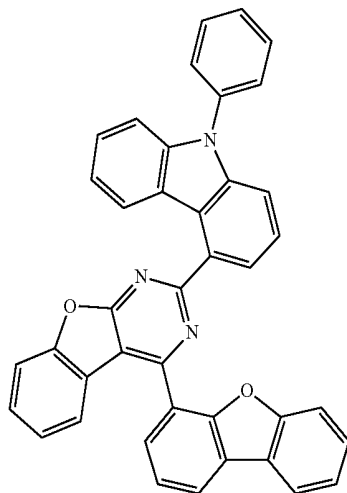
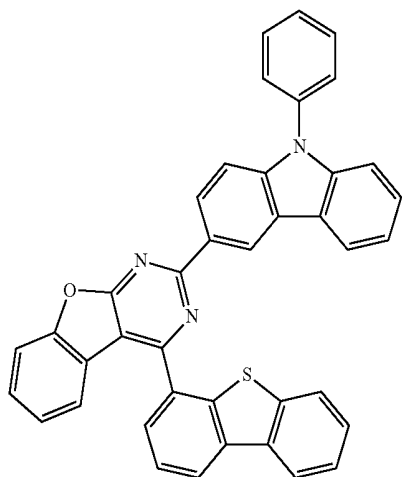
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e-51

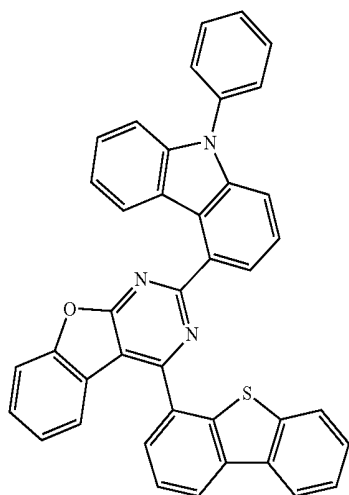


e-52

e-55

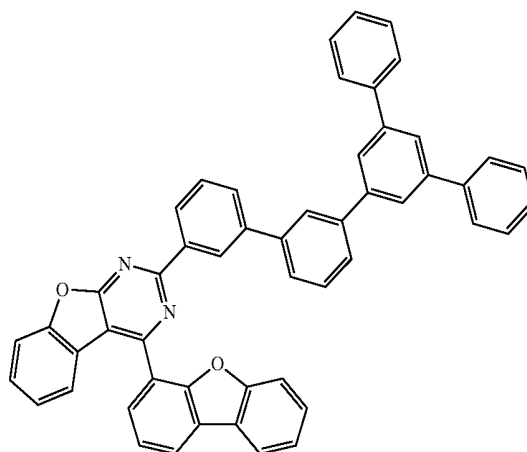


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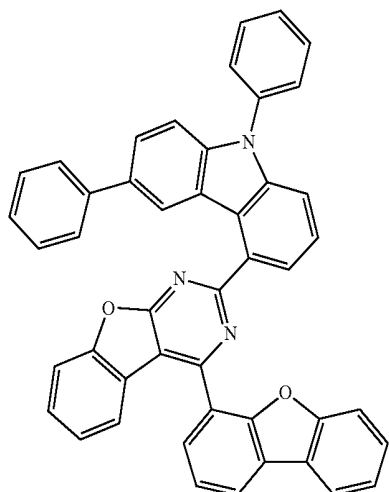


e-56

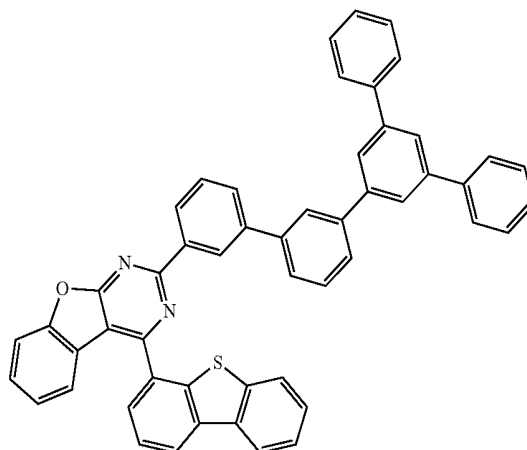
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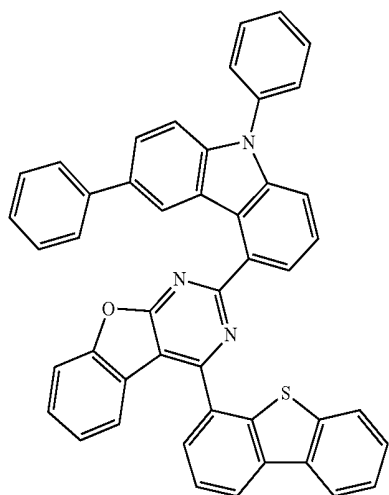
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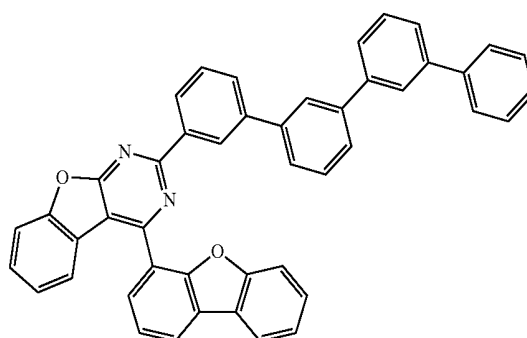
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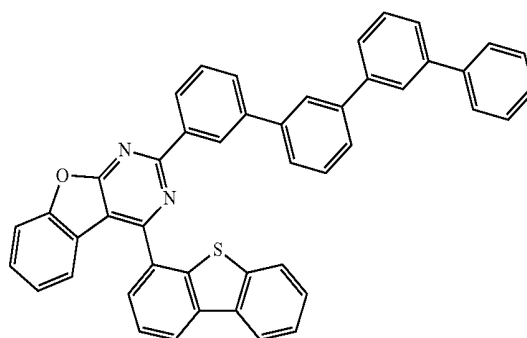
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e-58



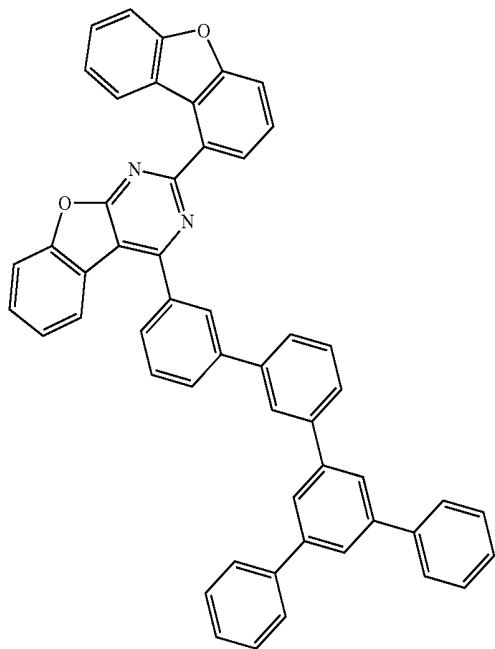
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e-62

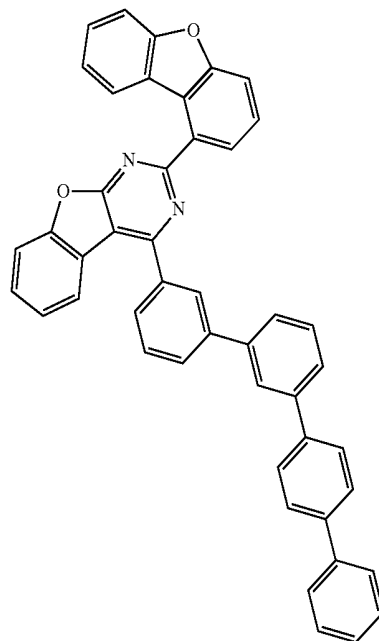
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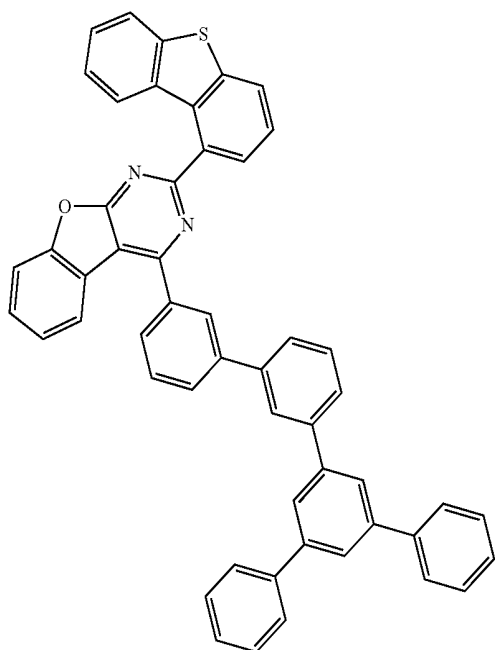


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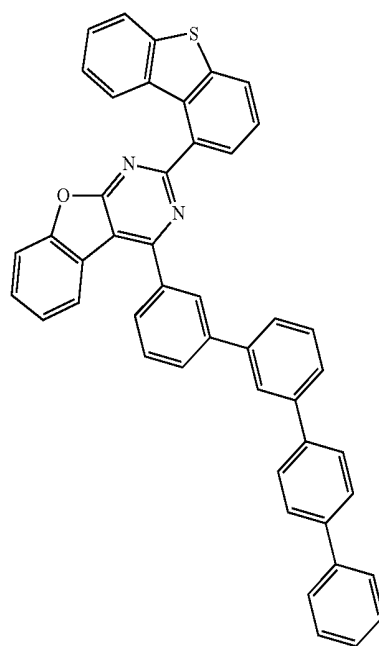
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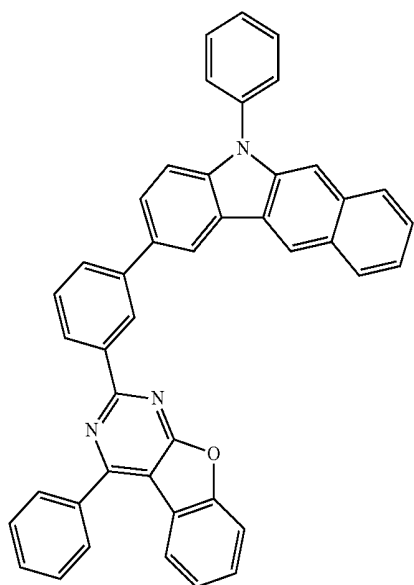
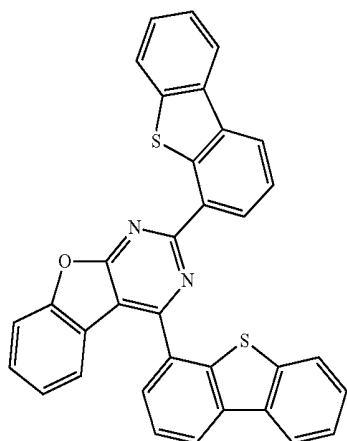
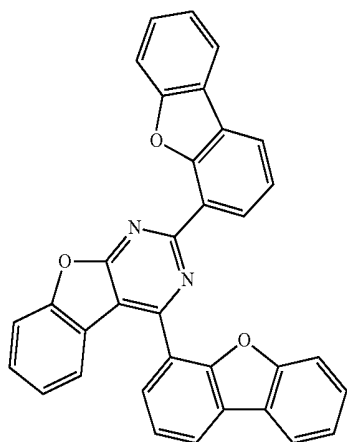
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e-66



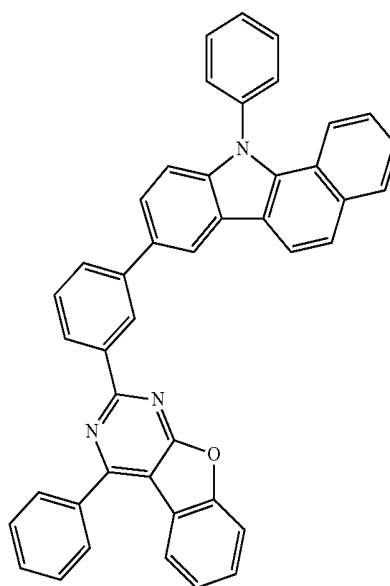
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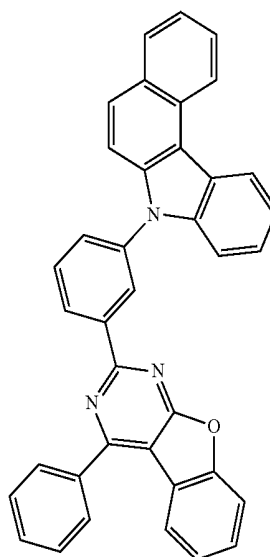
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e-68

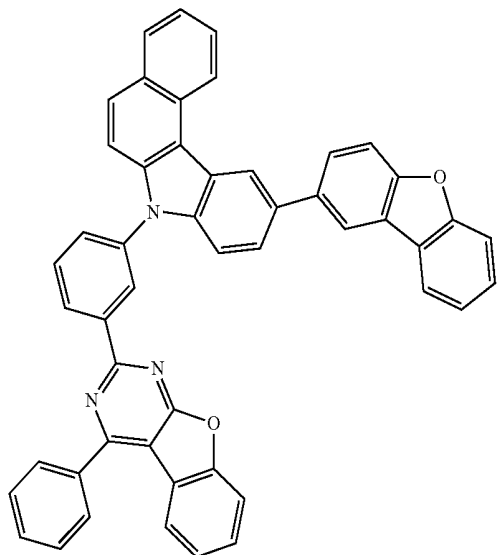
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e-69



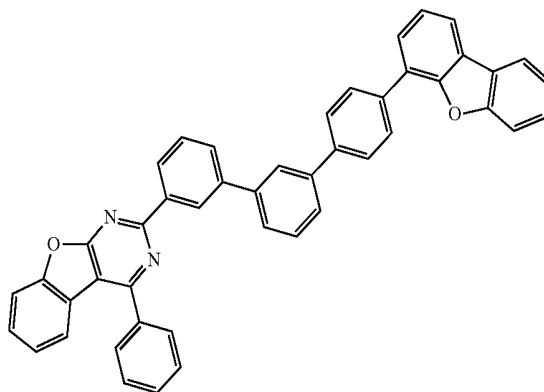
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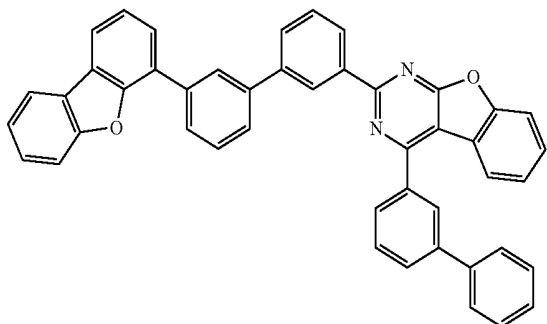


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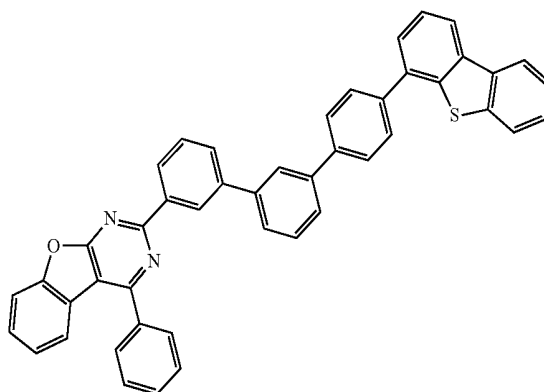
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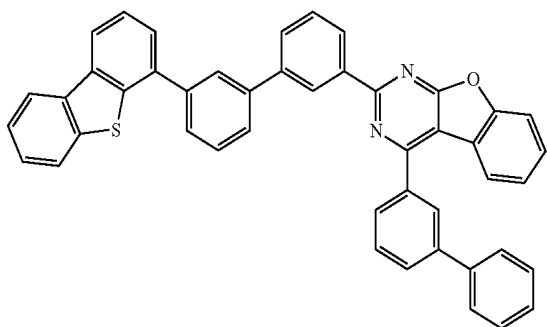
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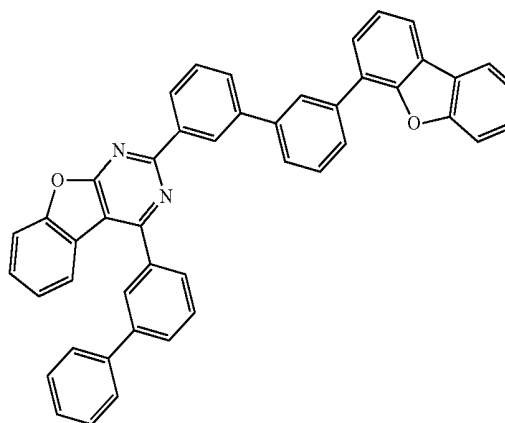
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e-74

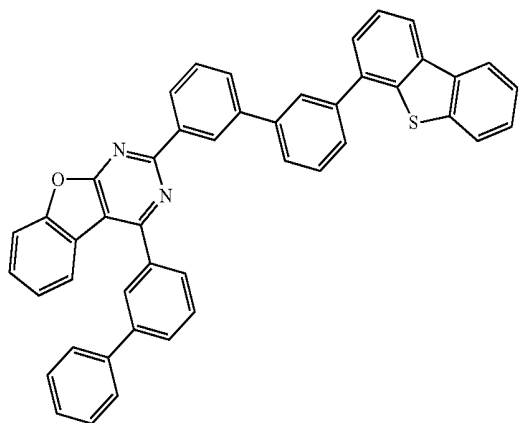


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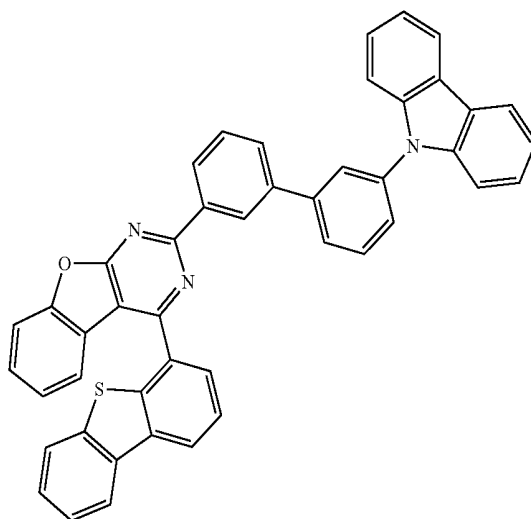
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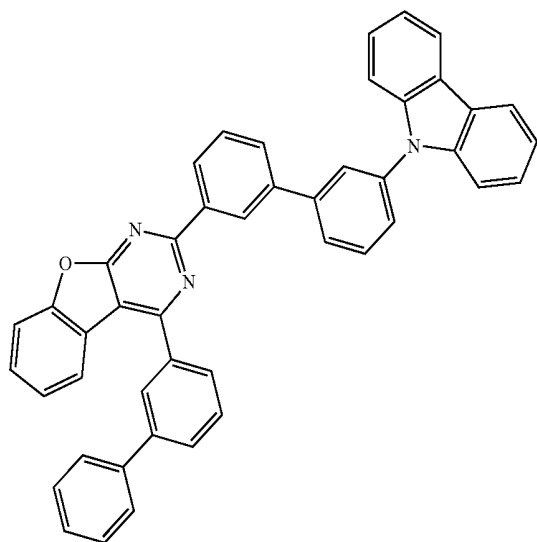


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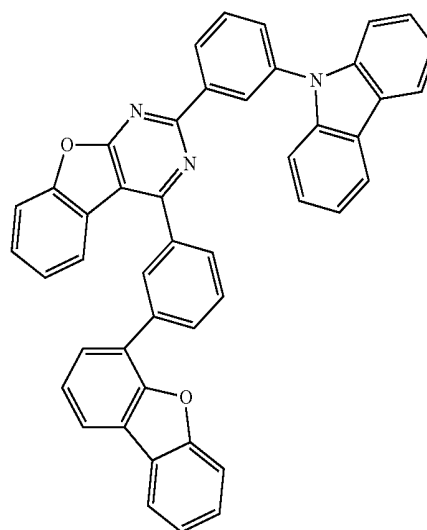
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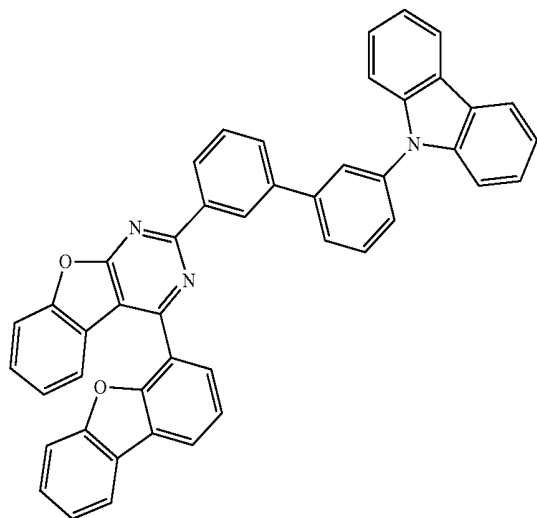
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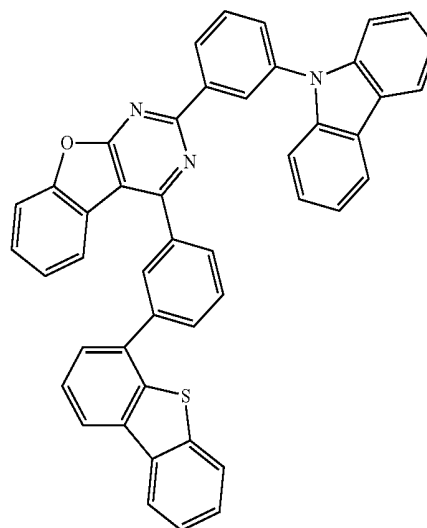
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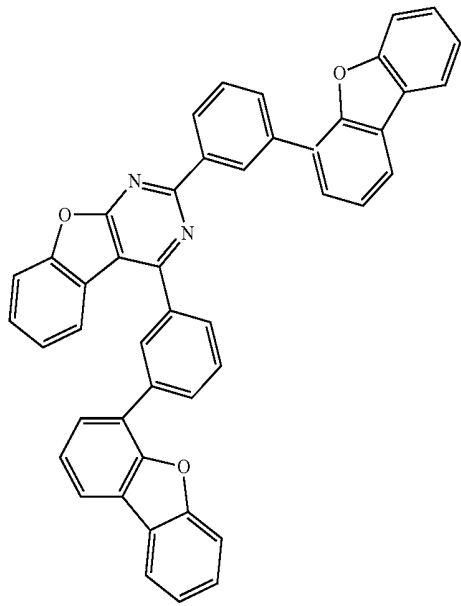
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e-83

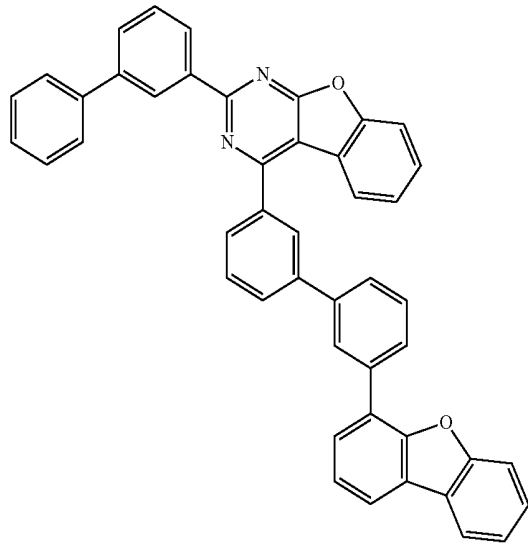


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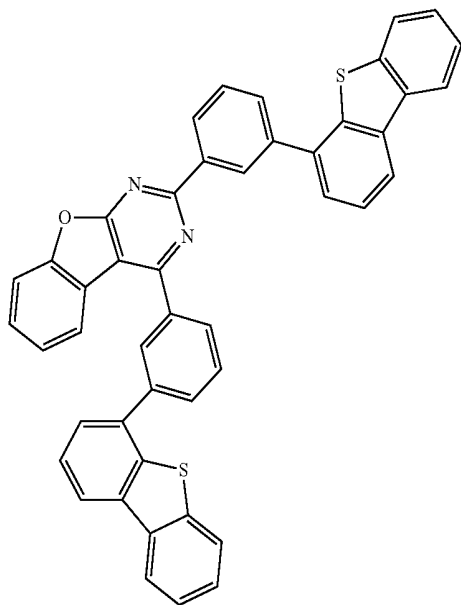


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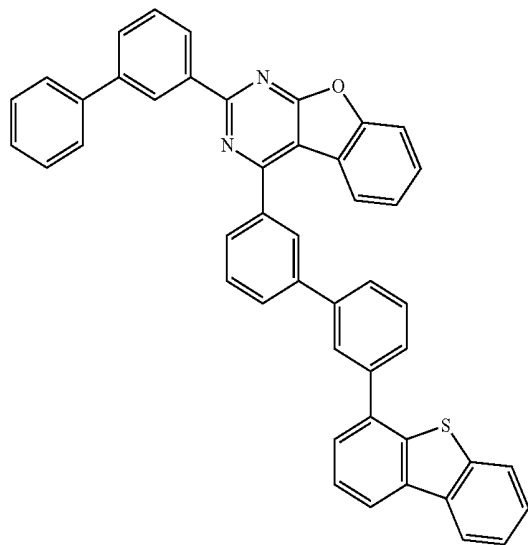
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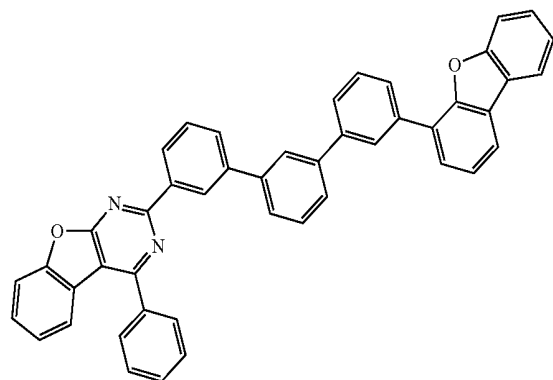
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e-85

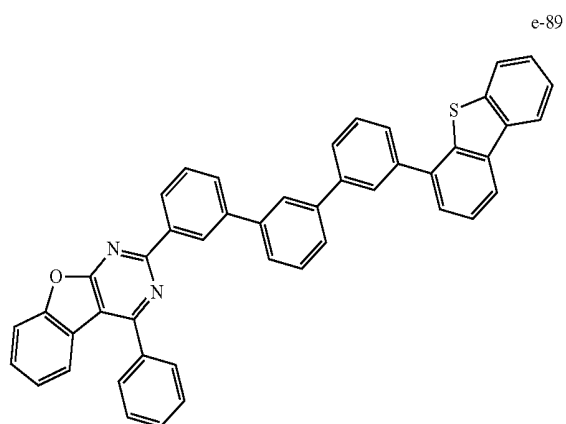


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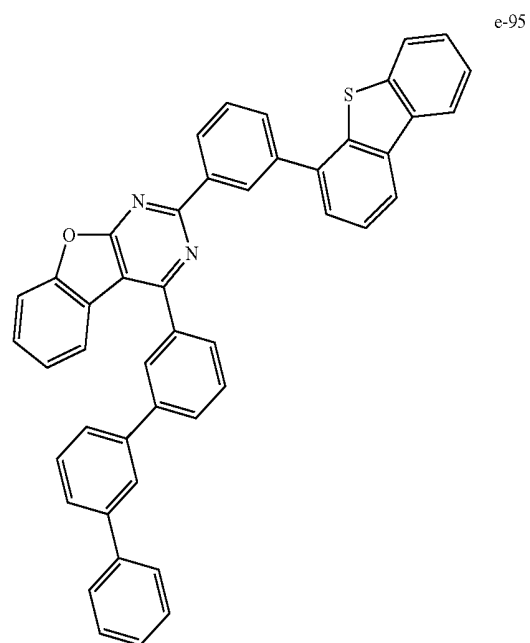
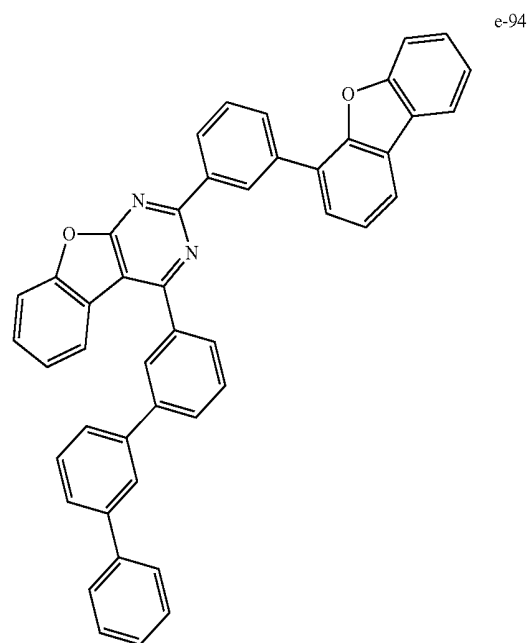
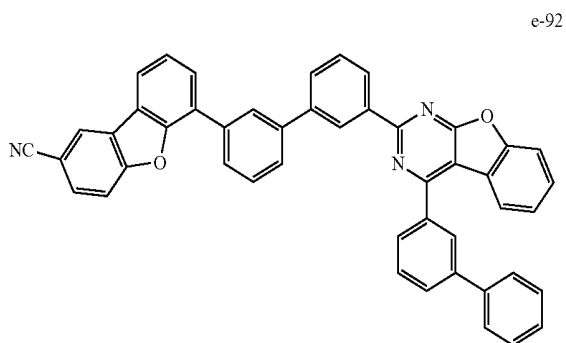
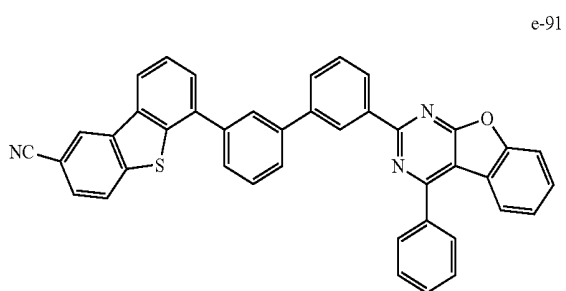
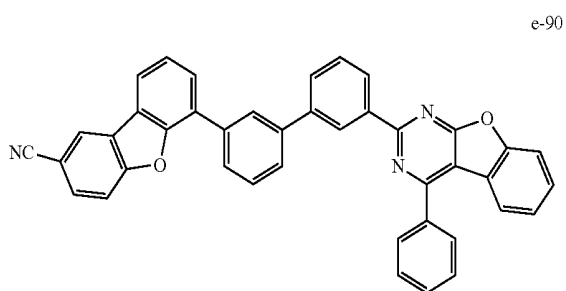
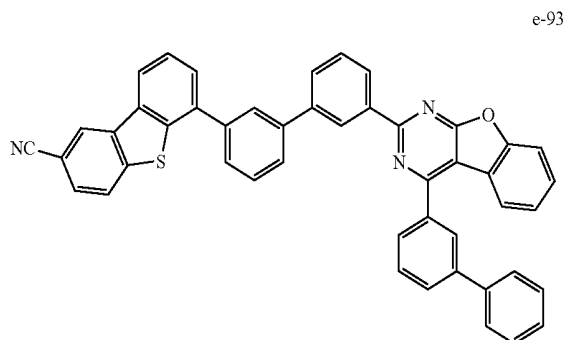


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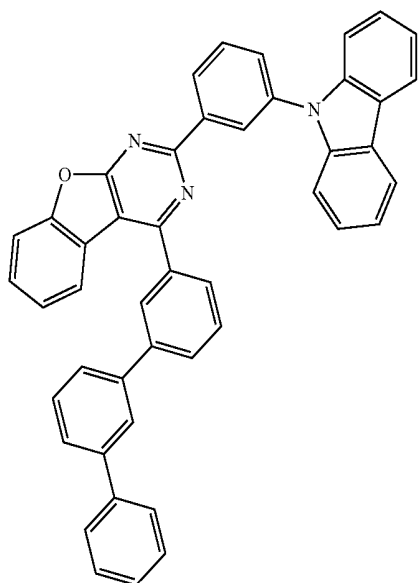
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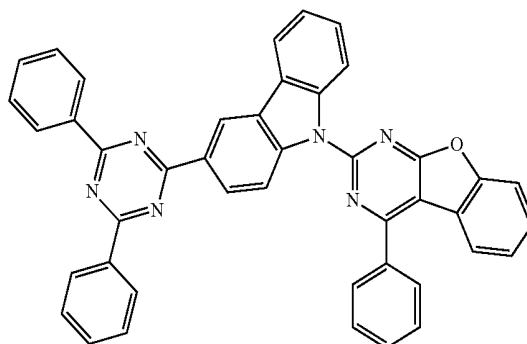


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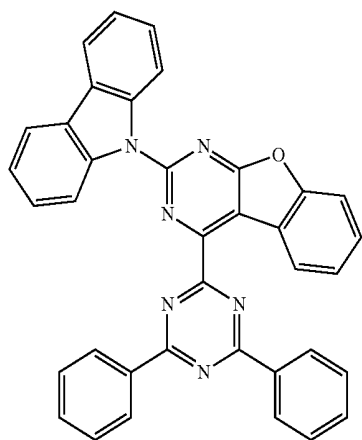


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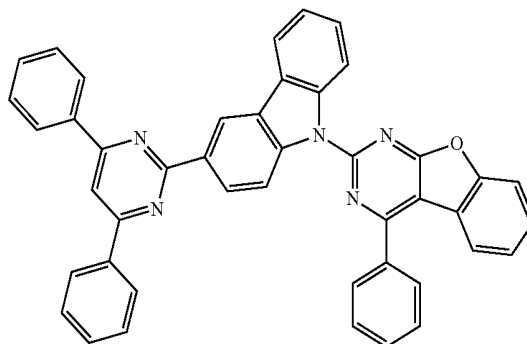
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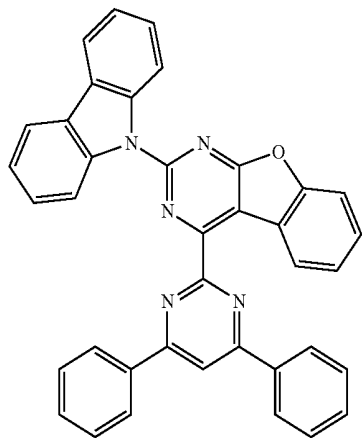
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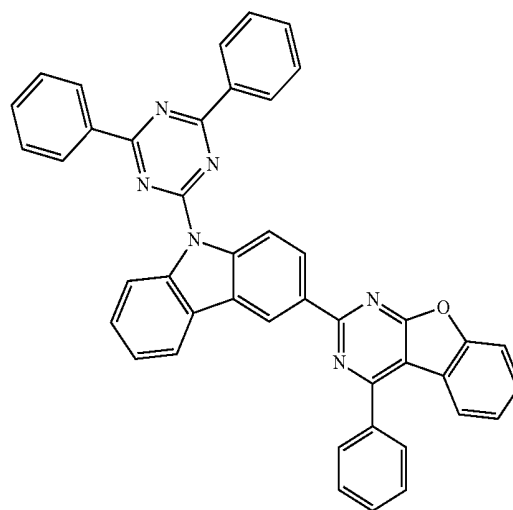
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e-100



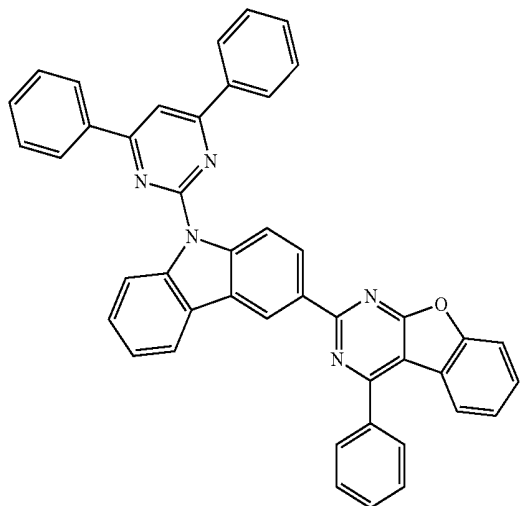
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e-101

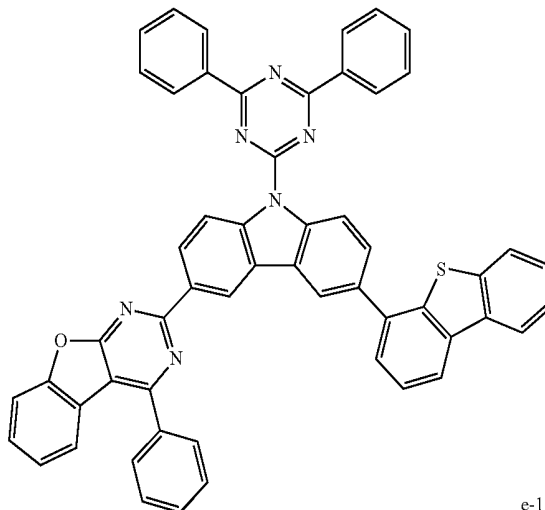
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e-102

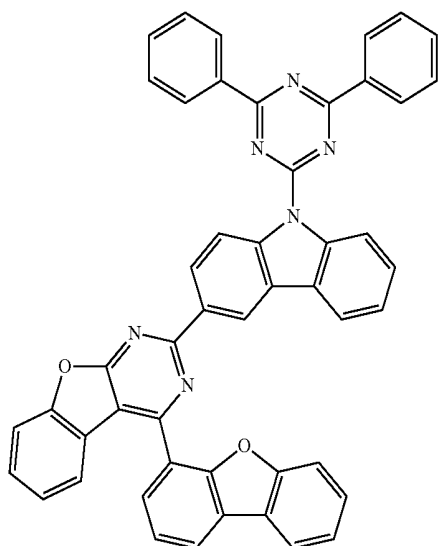


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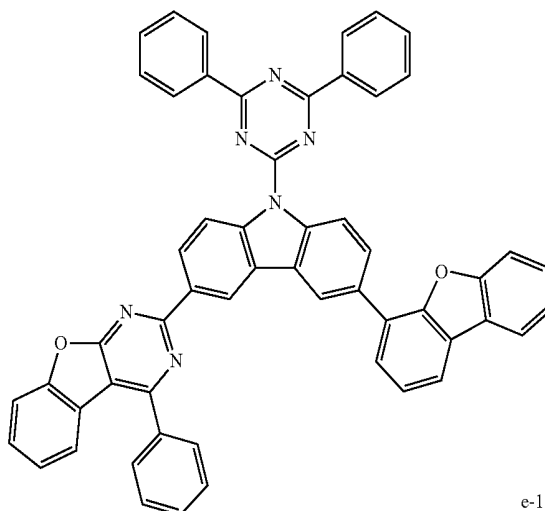
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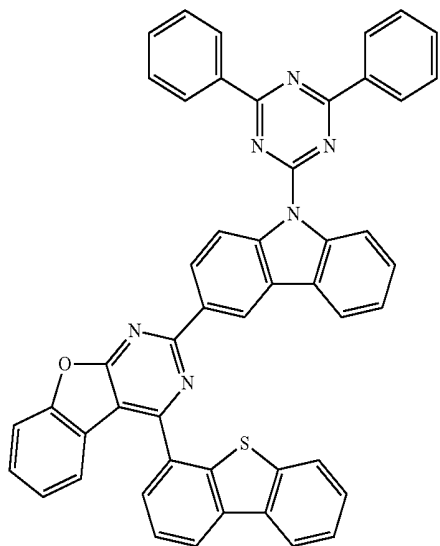
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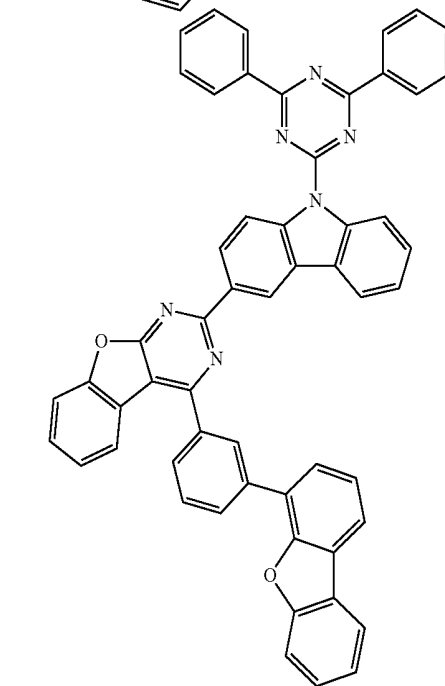
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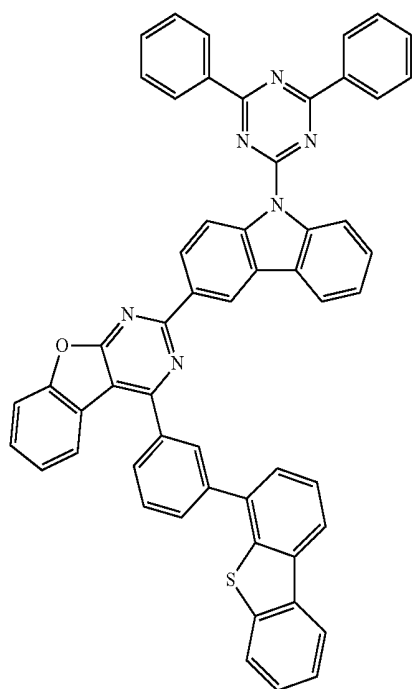
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e-107

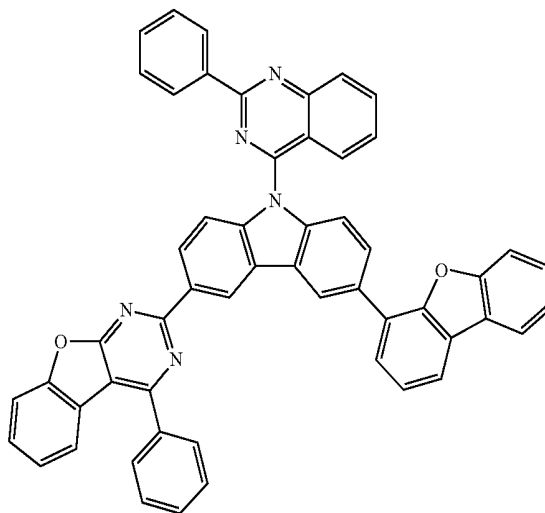


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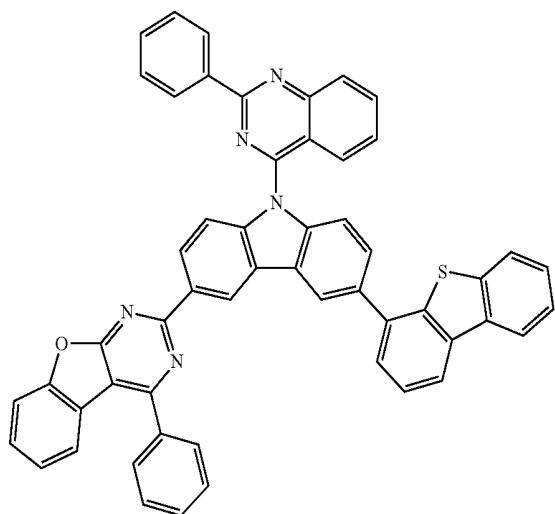
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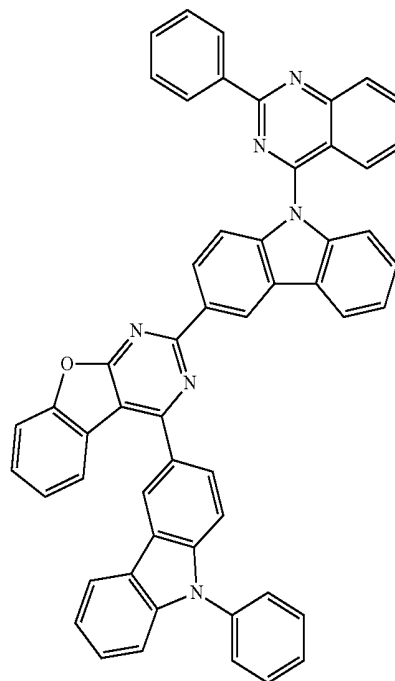


e-110

e-109

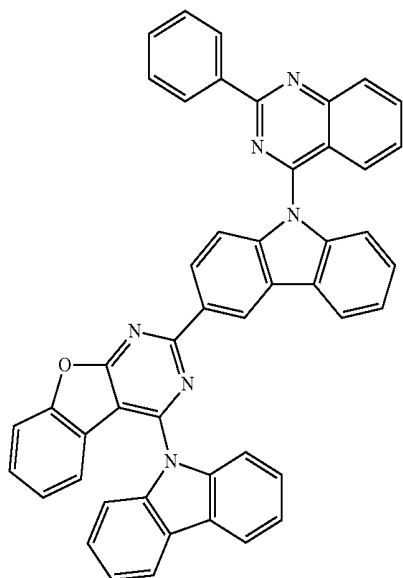


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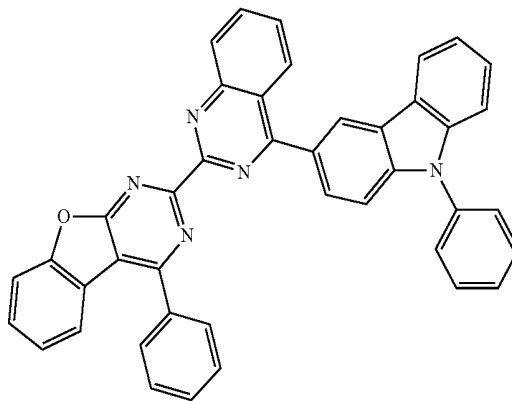
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e-112



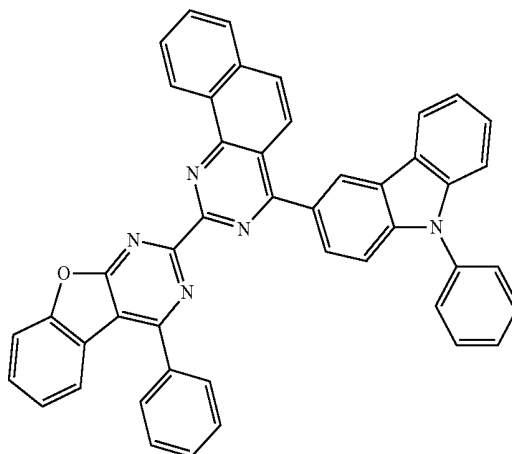
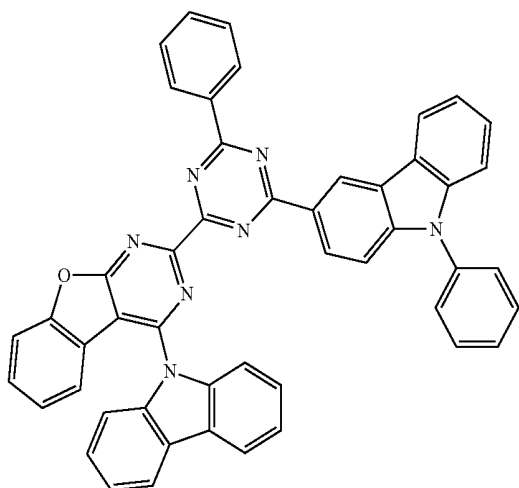
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e-115



e-116

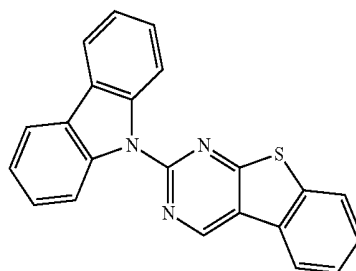
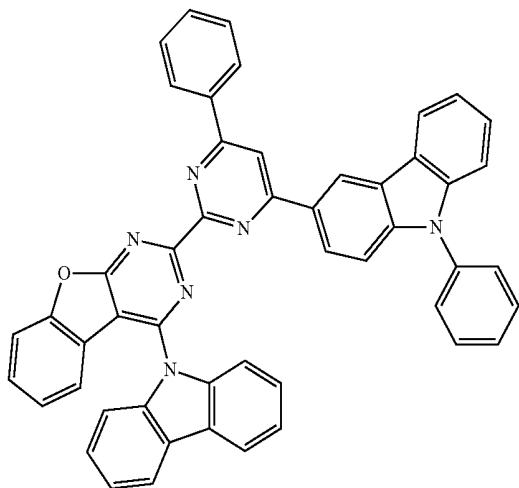
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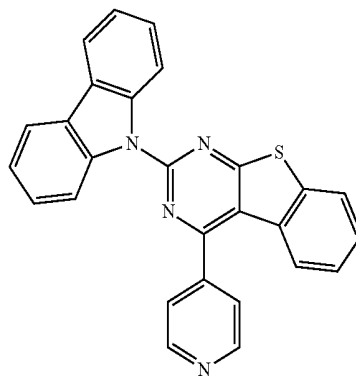
[0161] Group of  $X_1=S$  in Formula 1-2

131

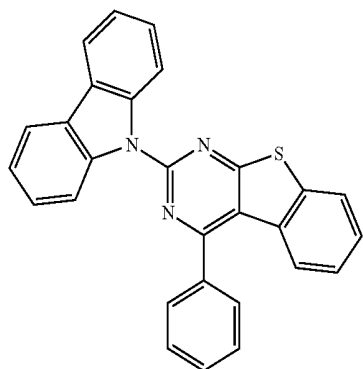
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132

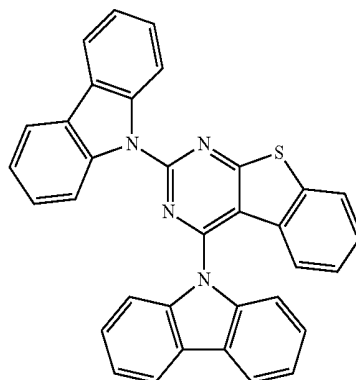


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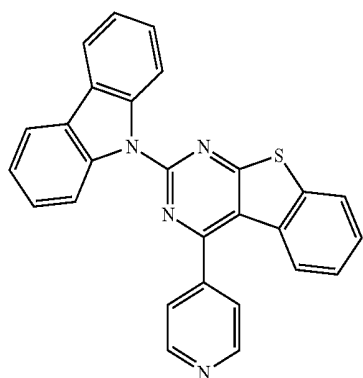


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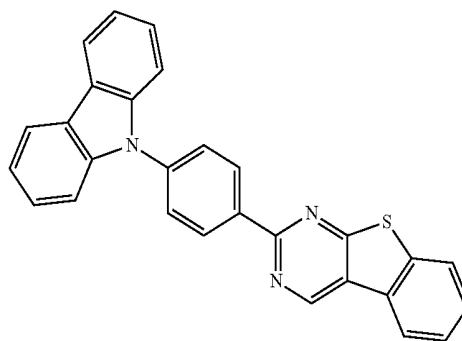
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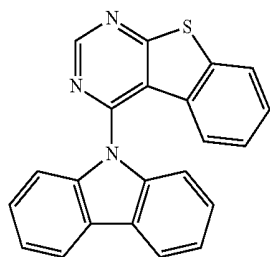
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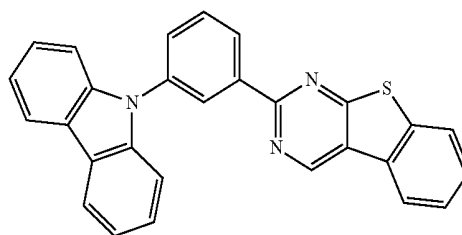
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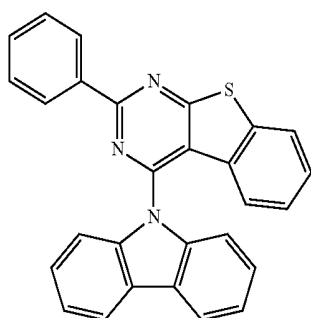
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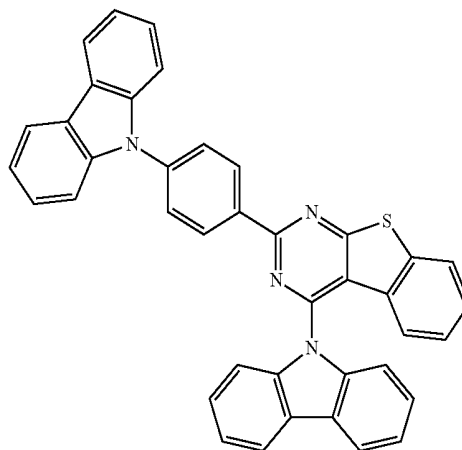
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139

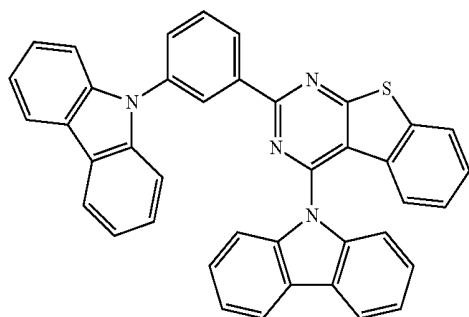


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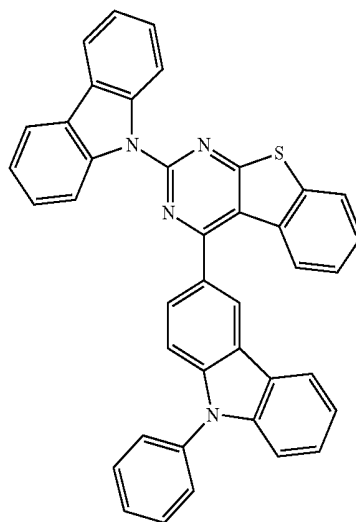
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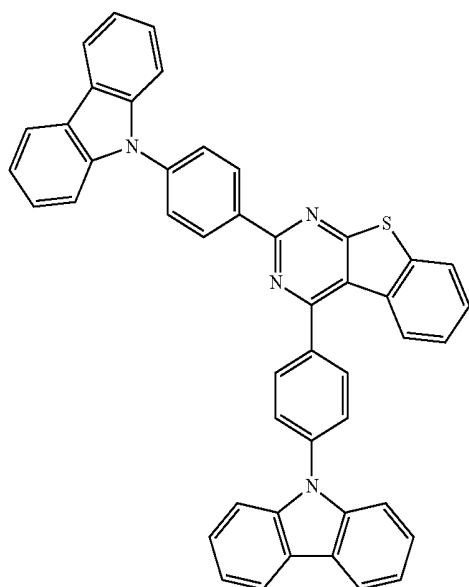


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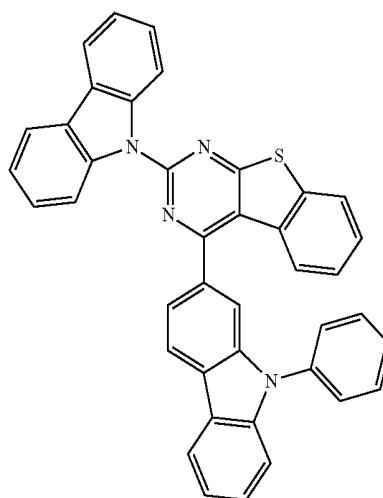
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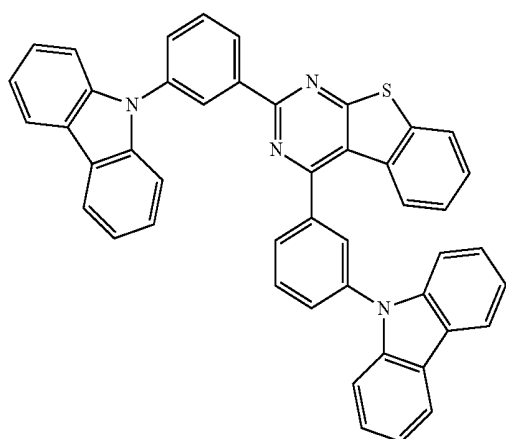
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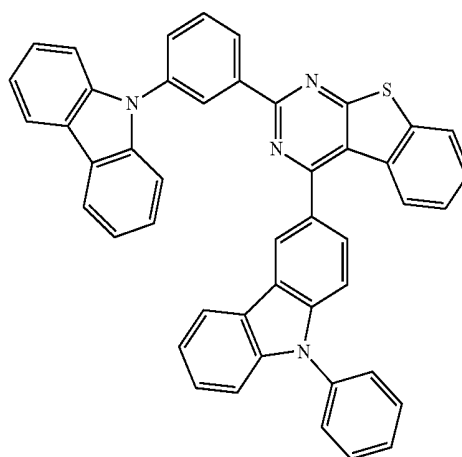
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145

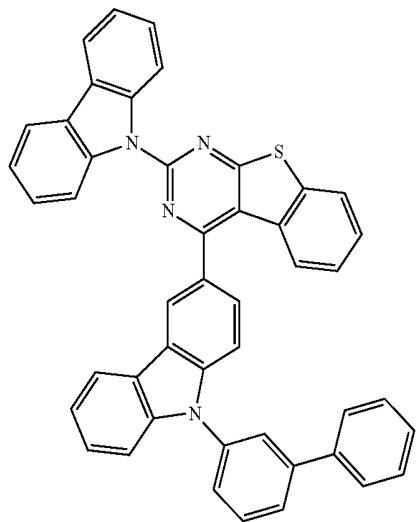


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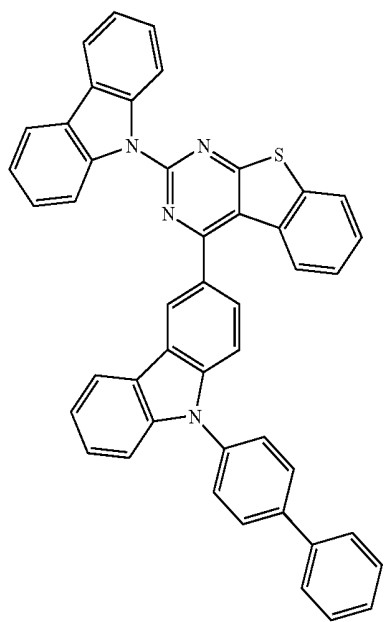


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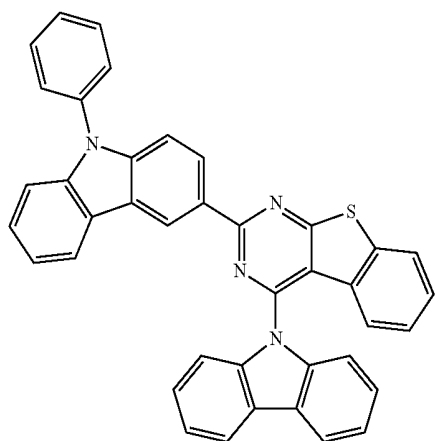
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147

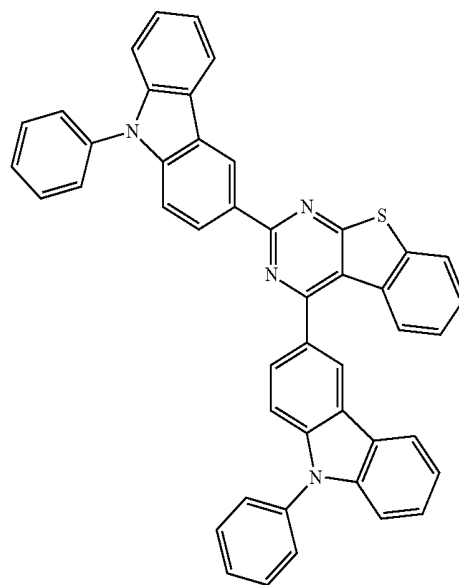


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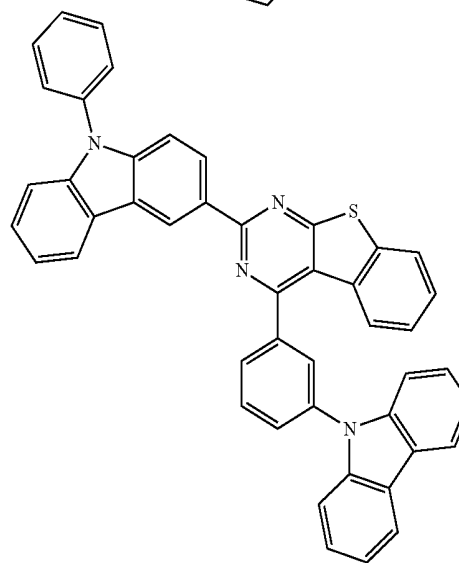


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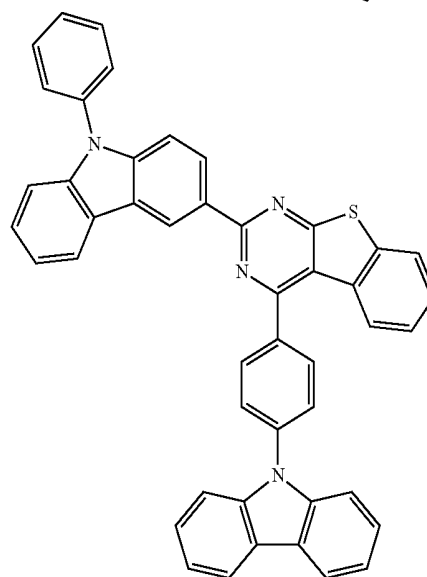
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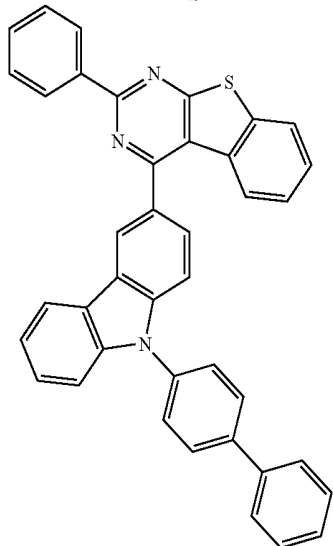
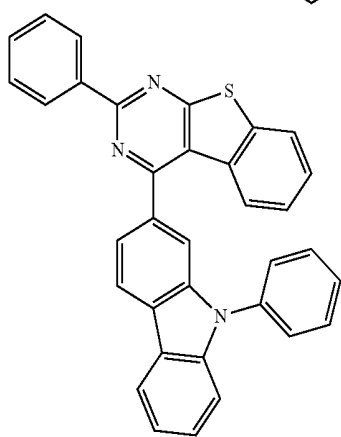
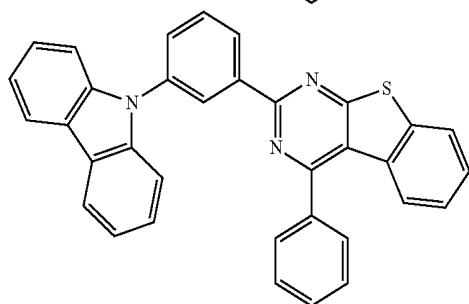
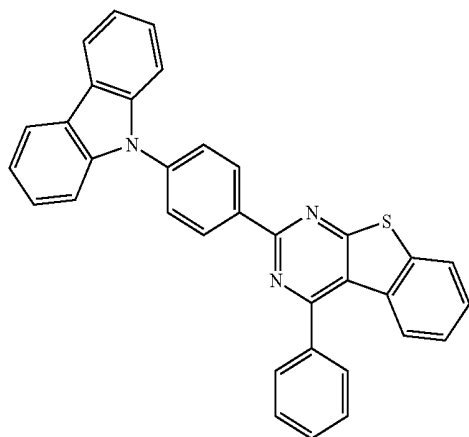


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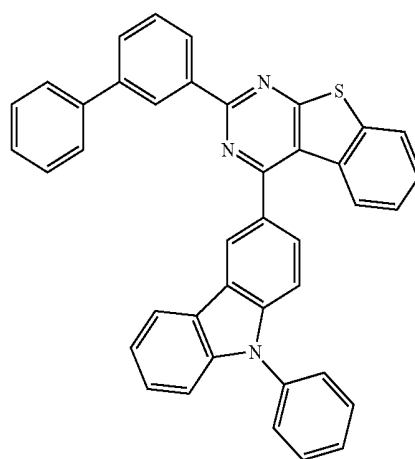
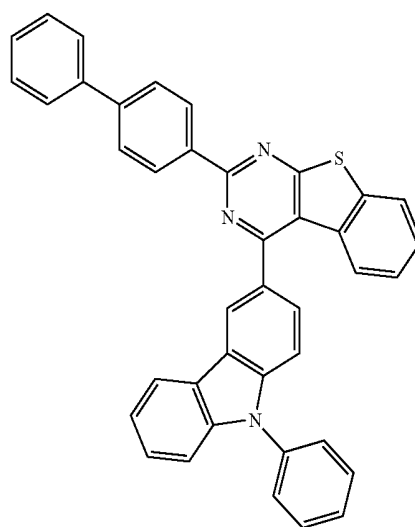
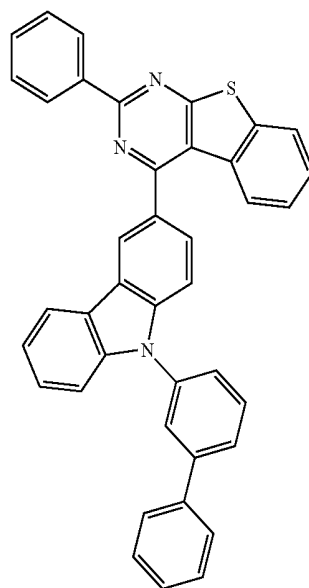


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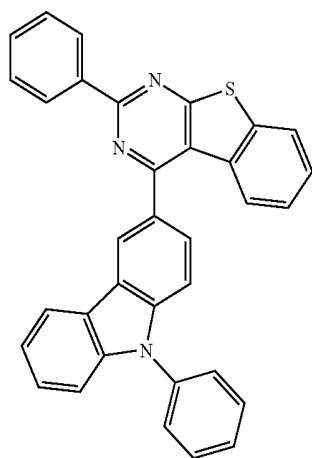
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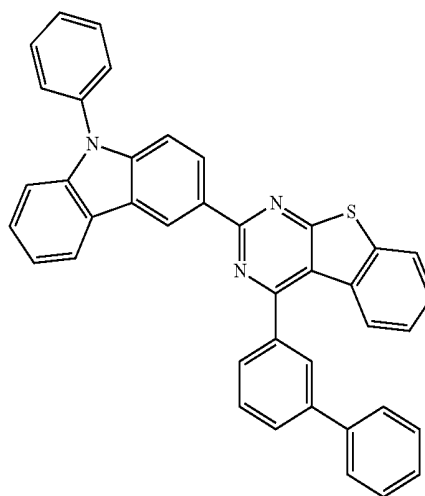


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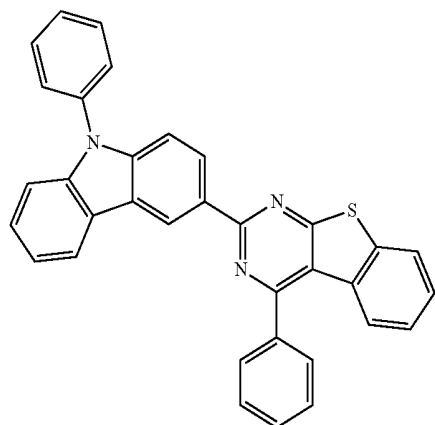
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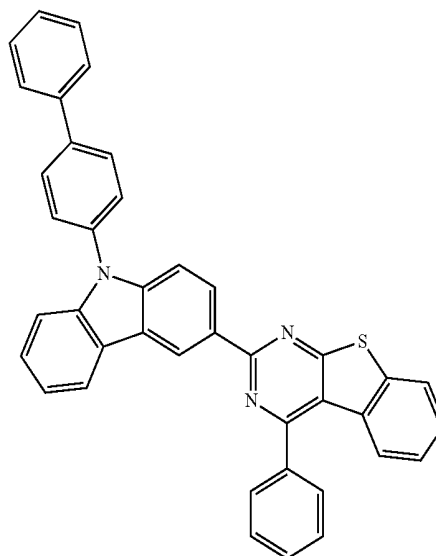


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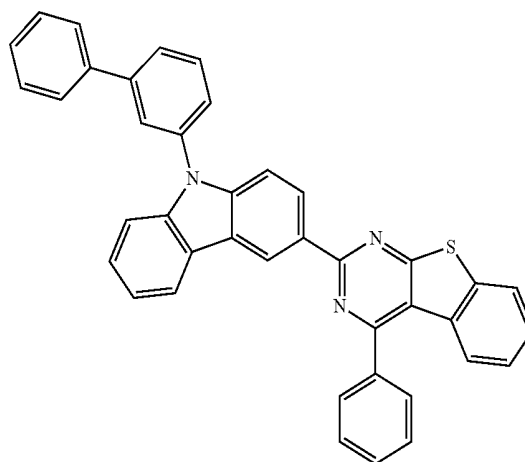
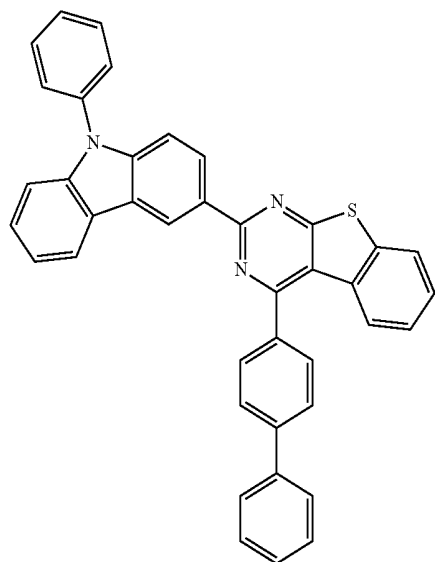


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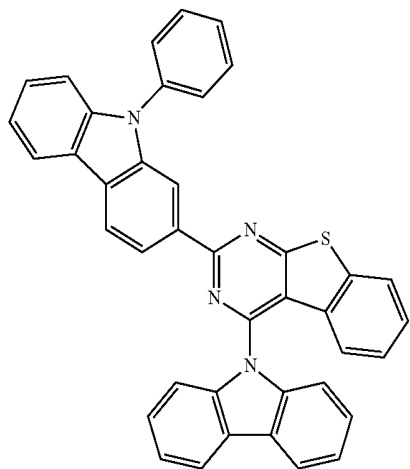


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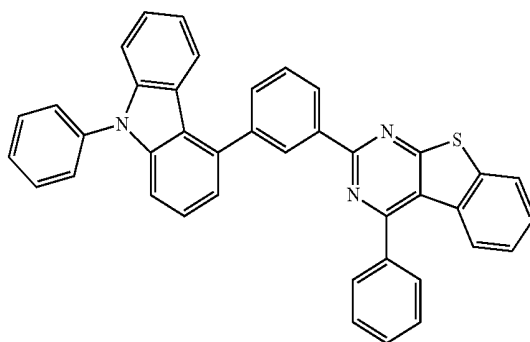


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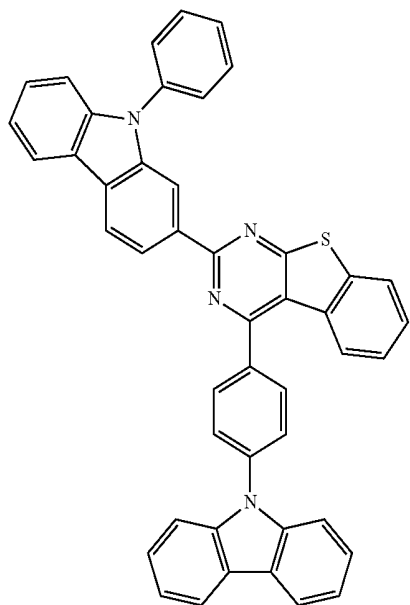
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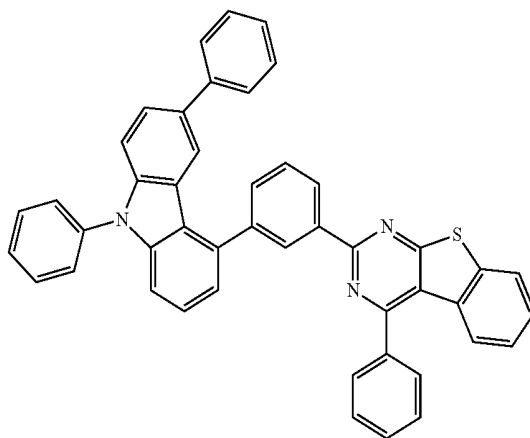


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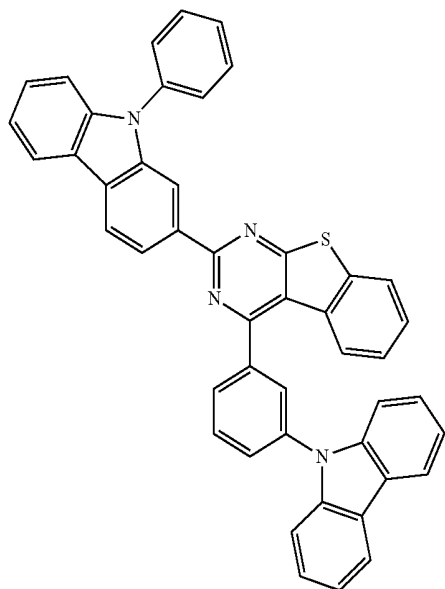
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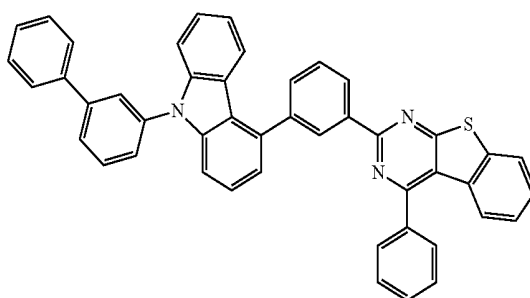
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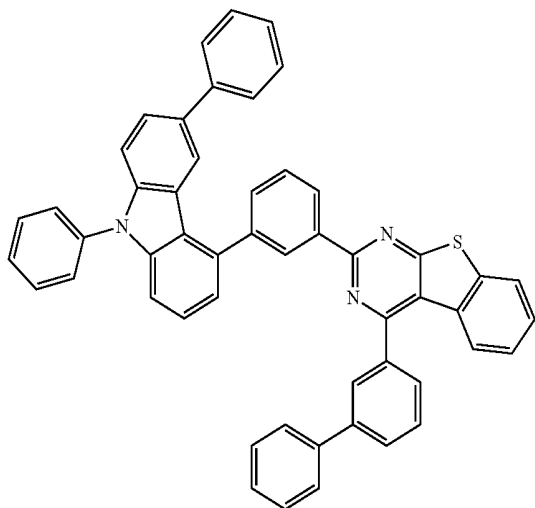
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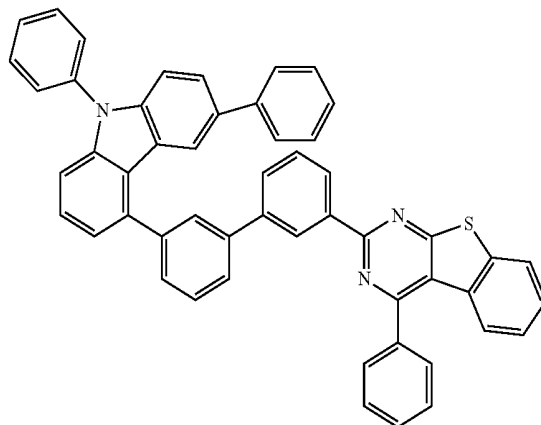
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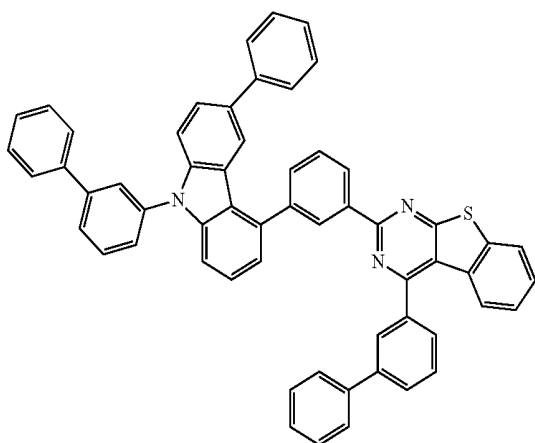


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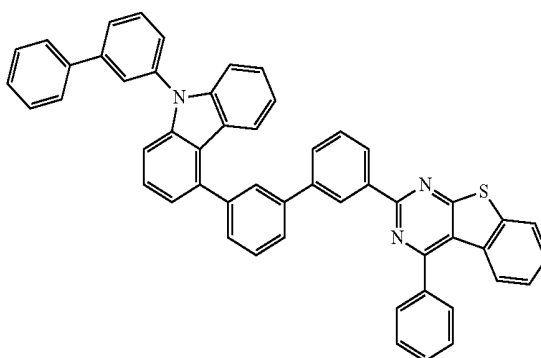
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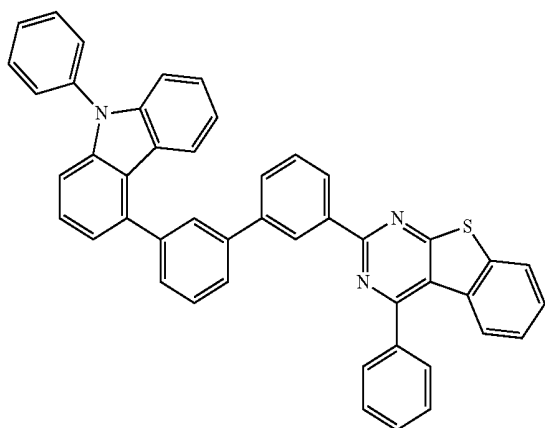
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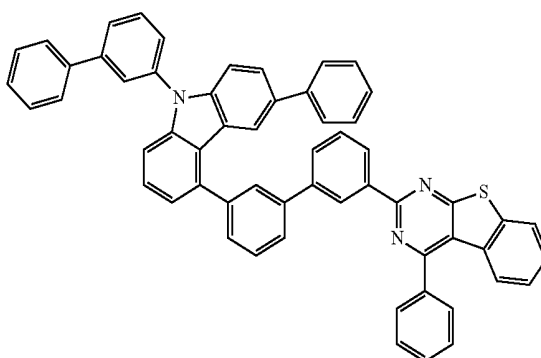
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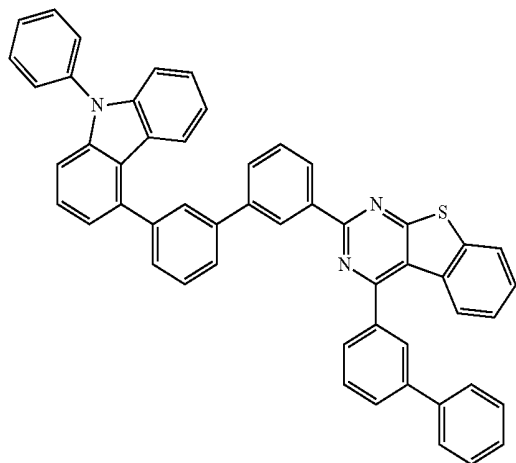


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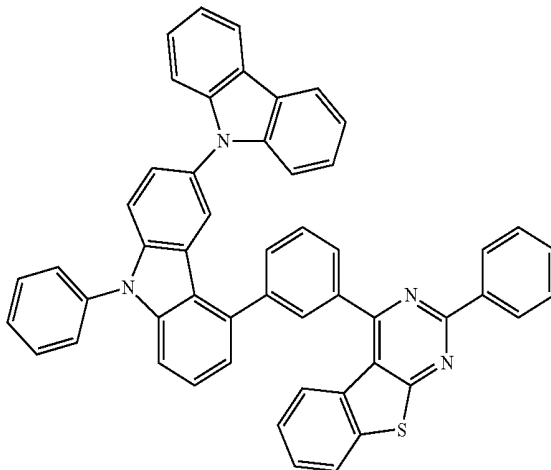
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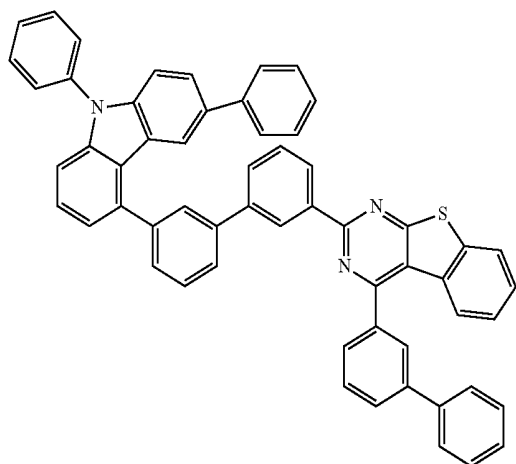


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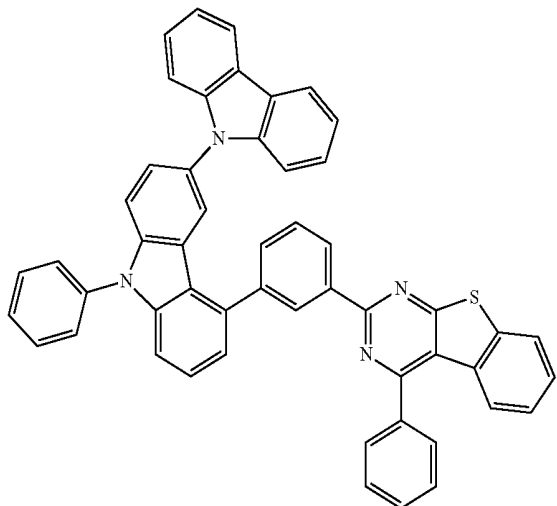
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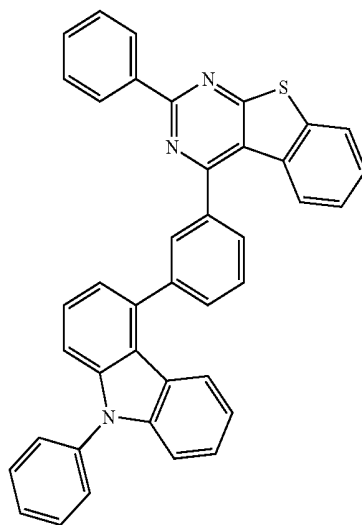
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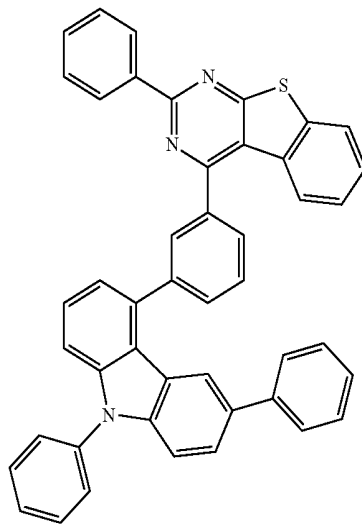
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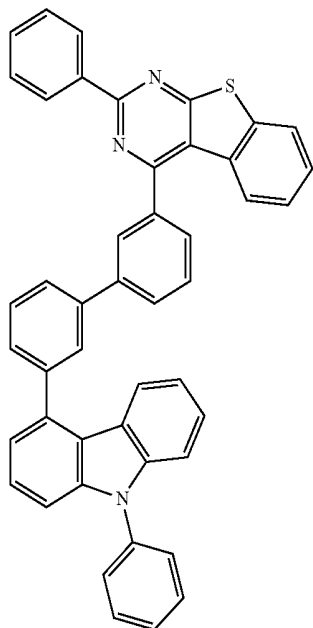
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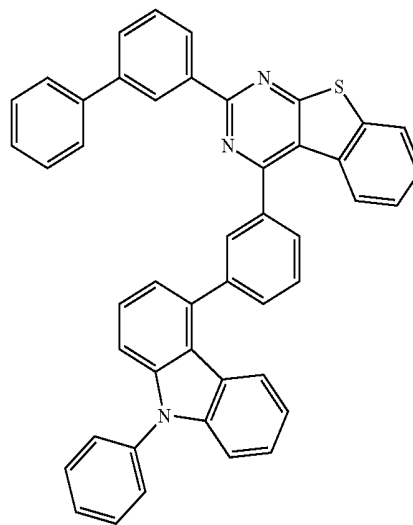


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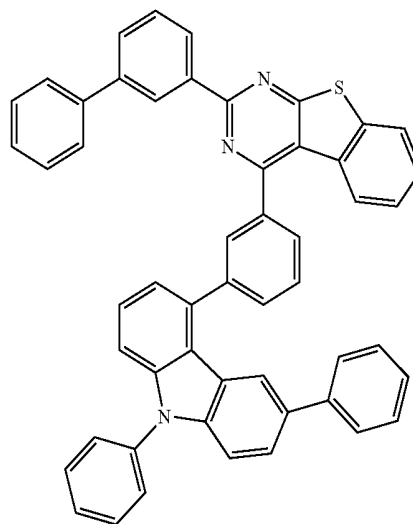


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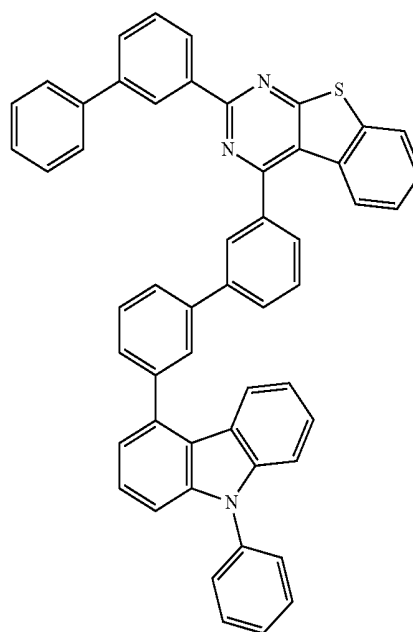


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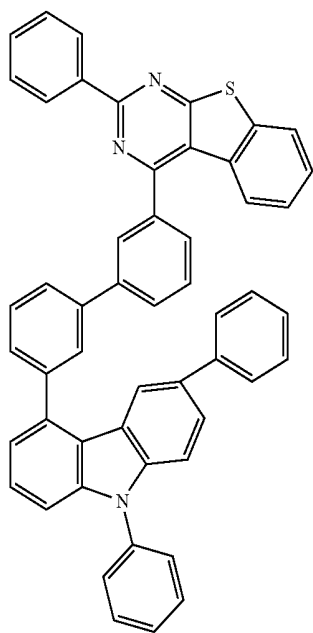


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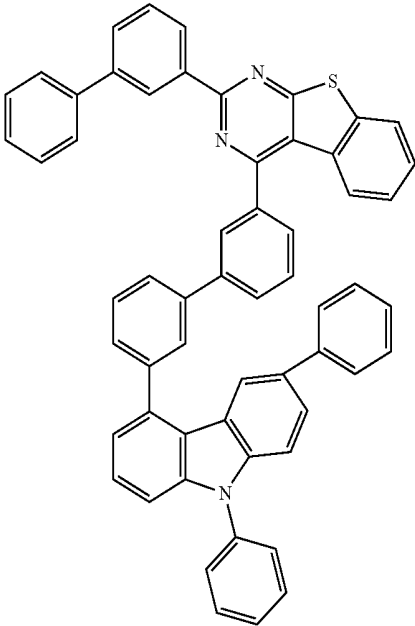
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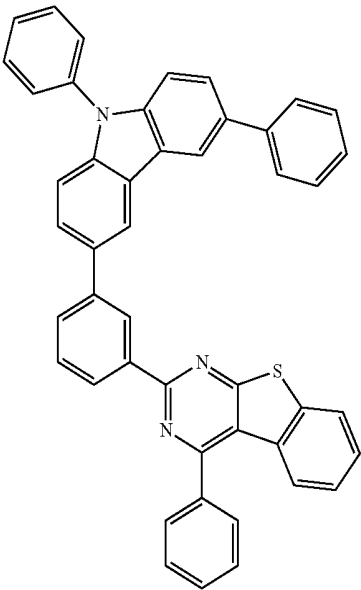


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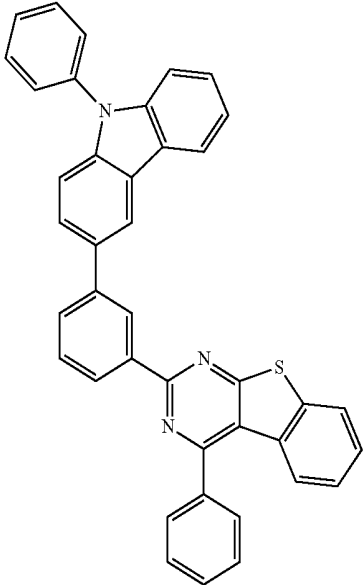
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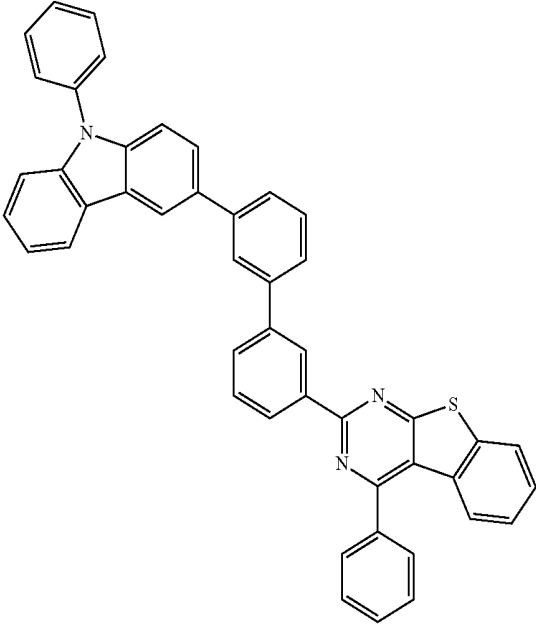


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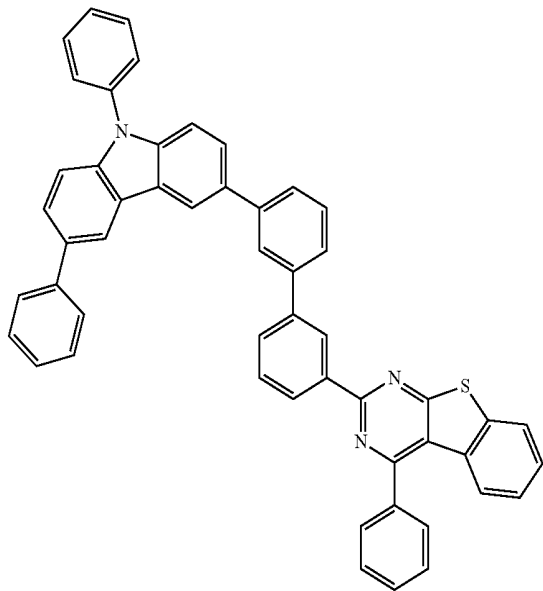


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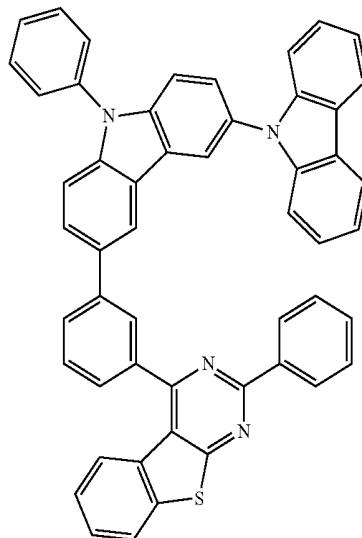
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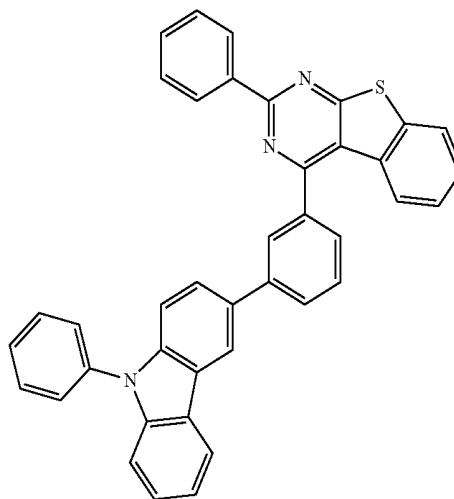


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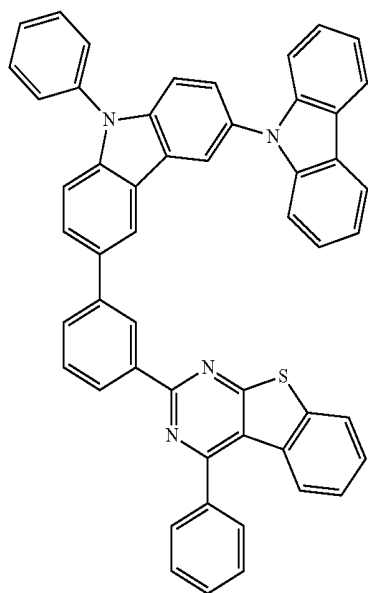
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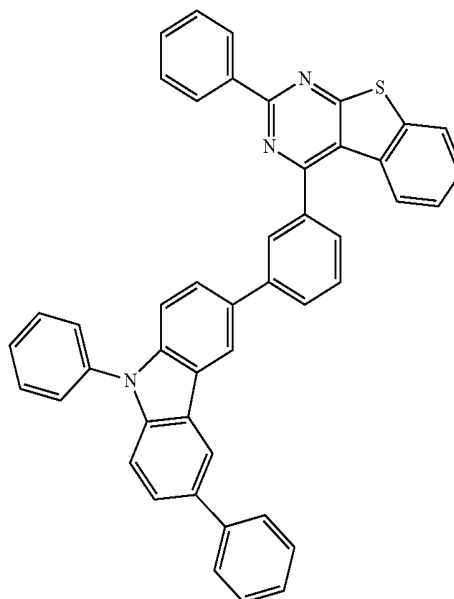
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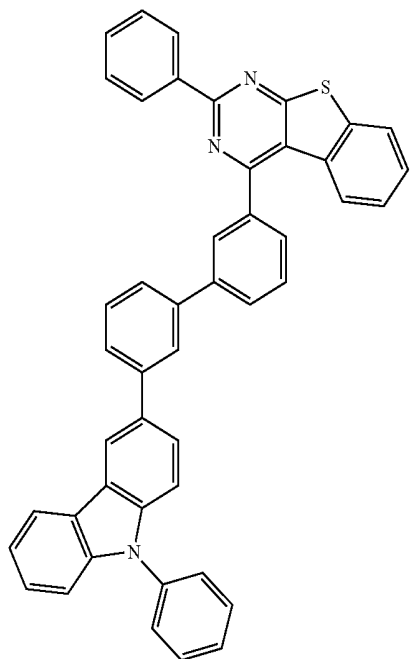


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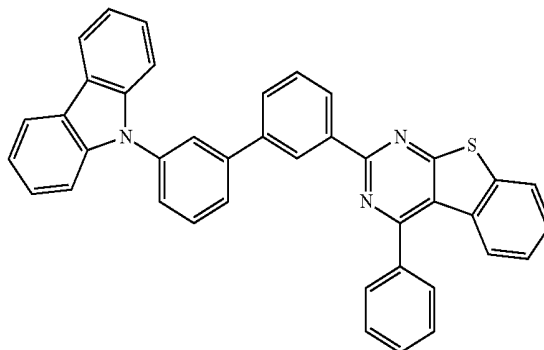
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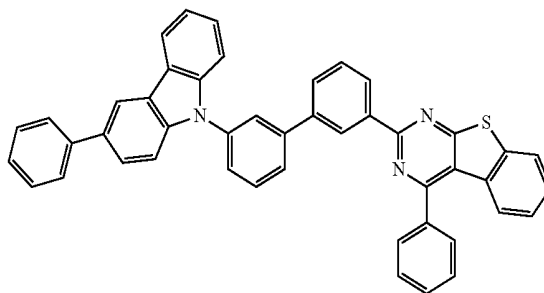


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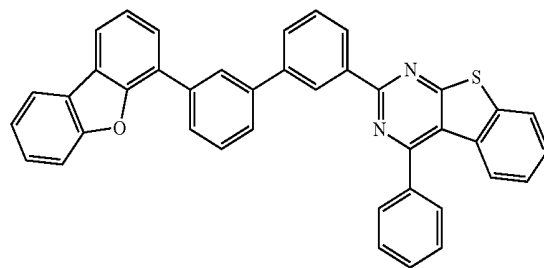
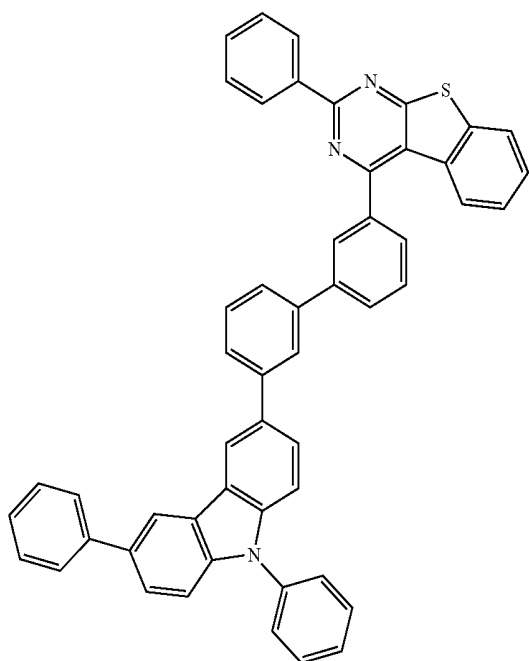


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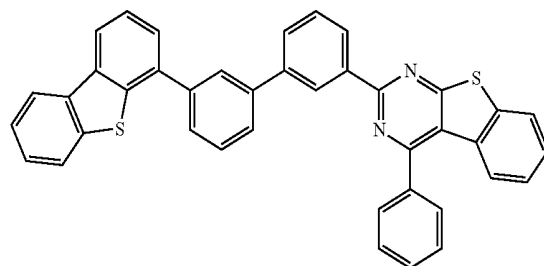


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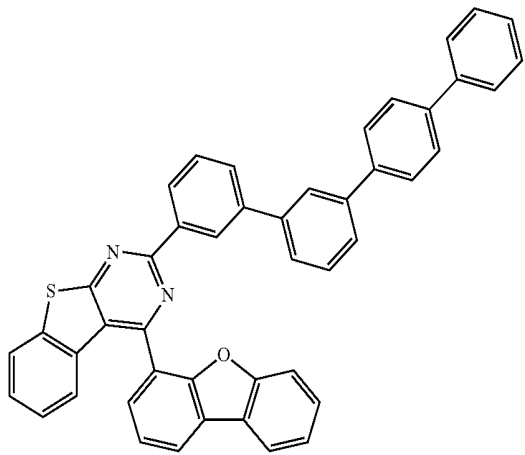


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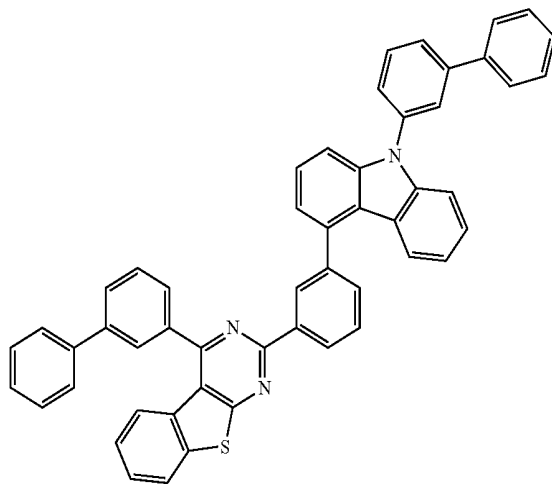
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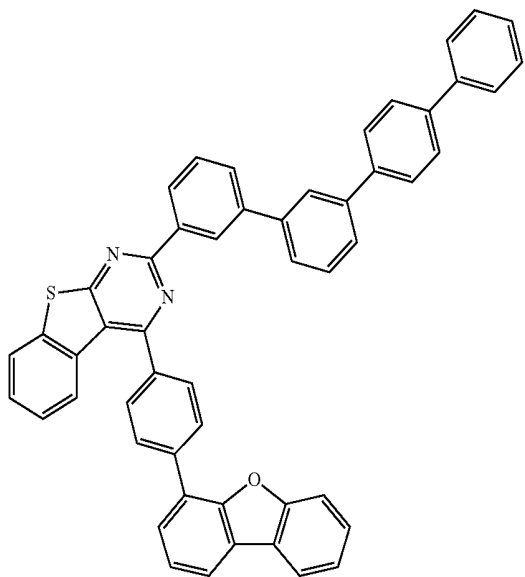


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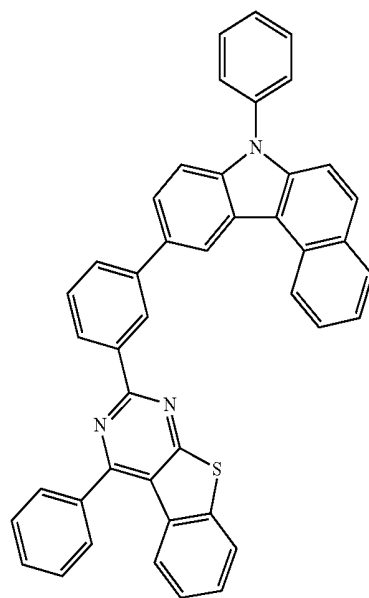
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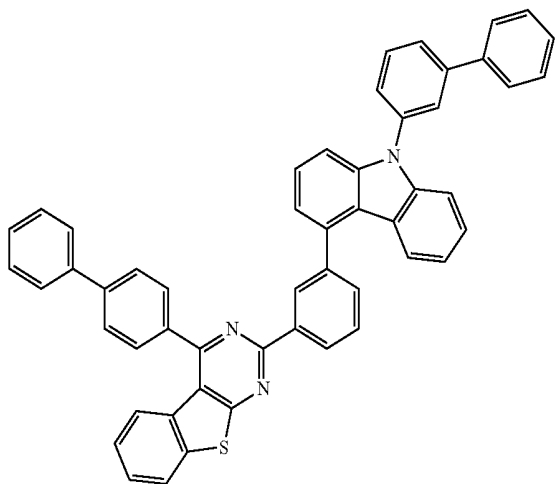
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f-49

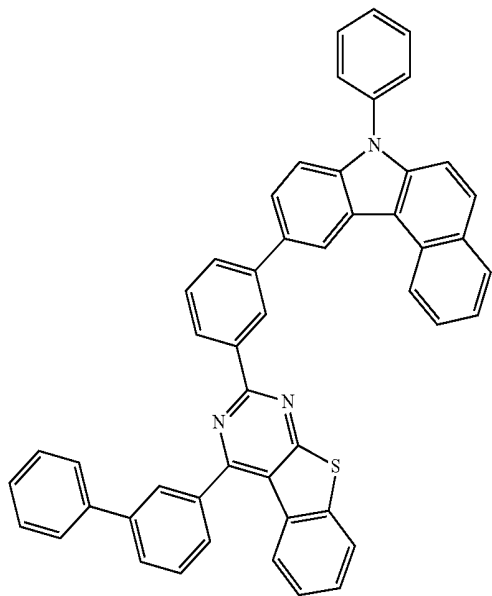


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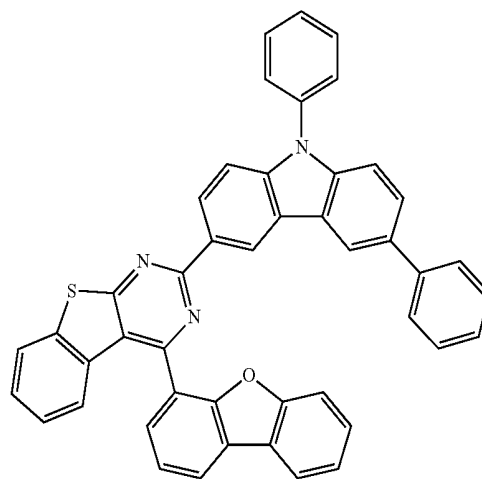
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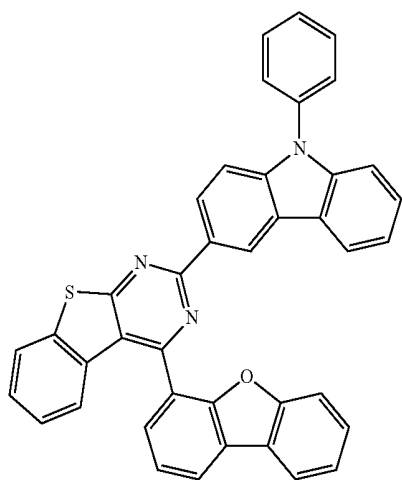
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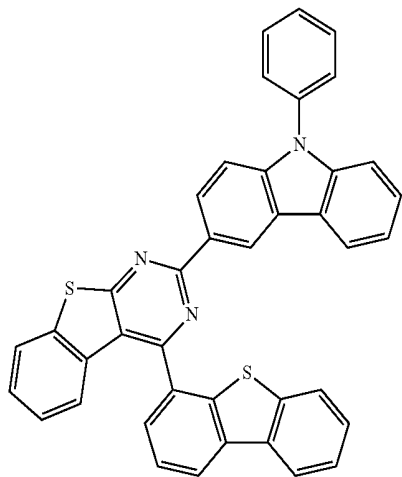


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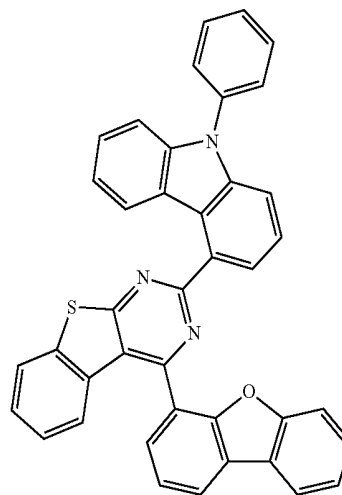
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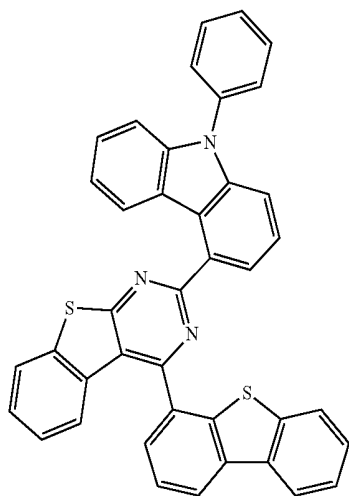
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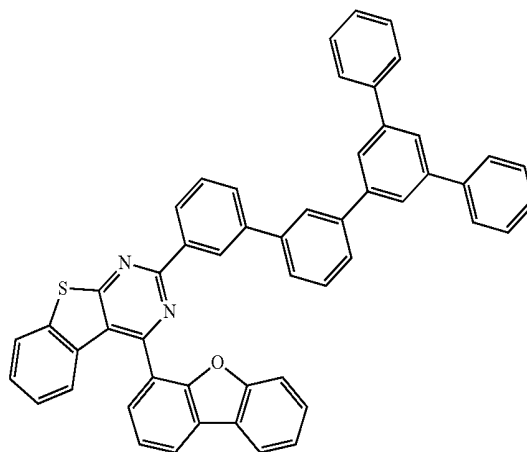


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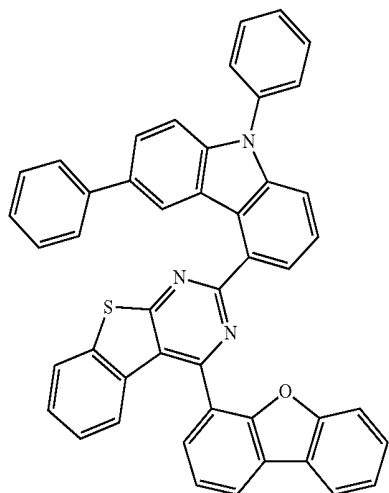


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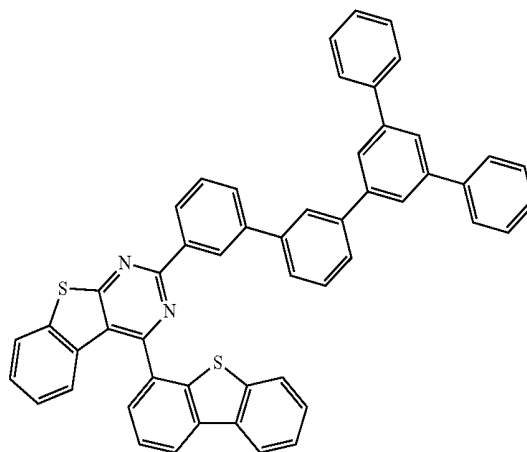
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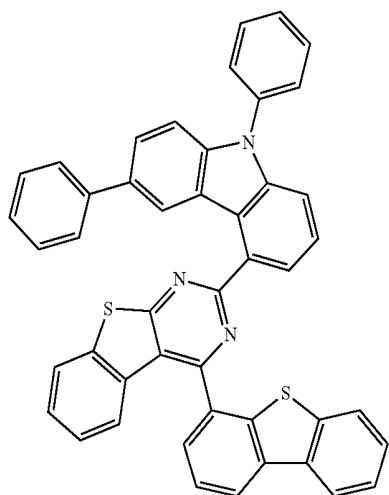
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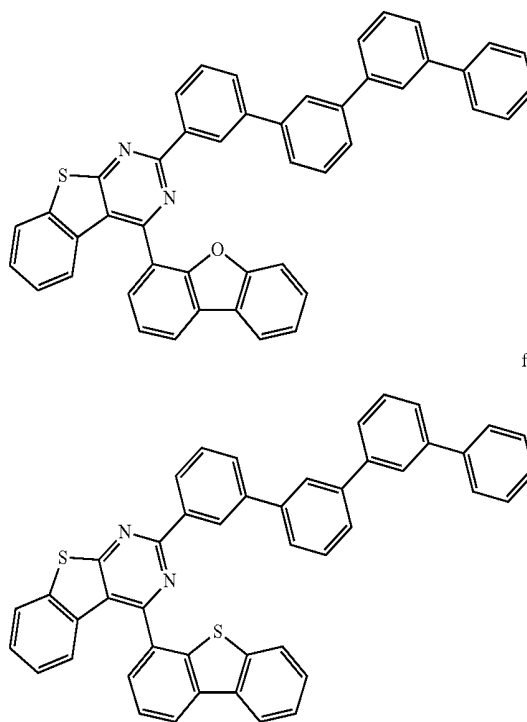
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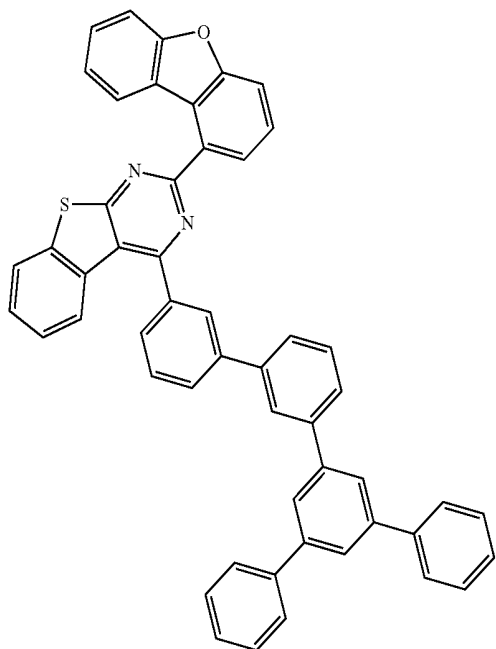


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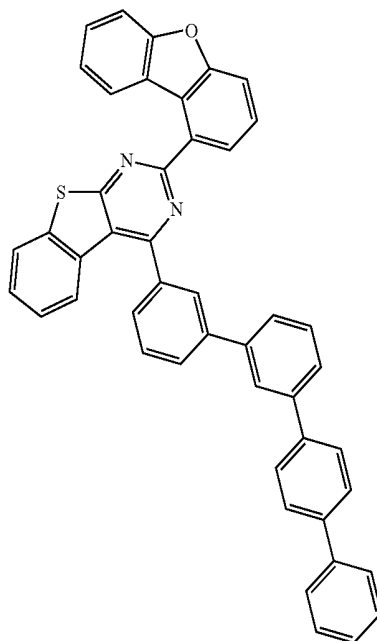
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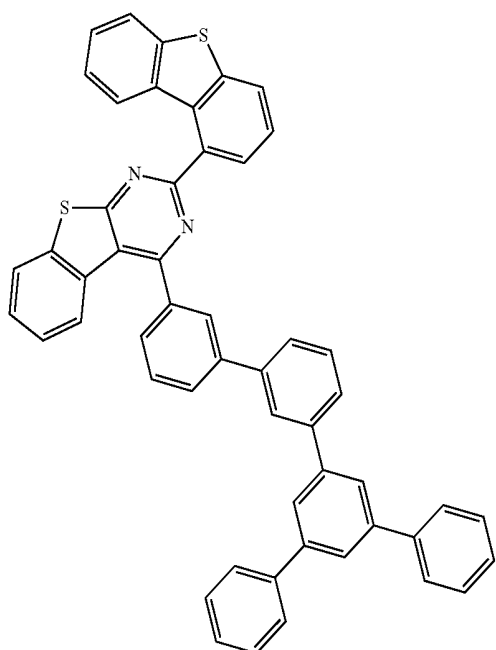


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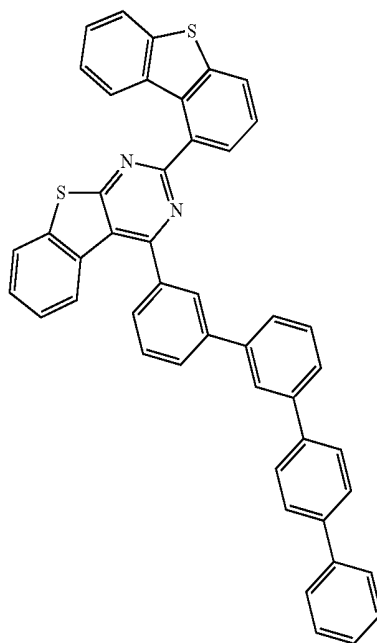
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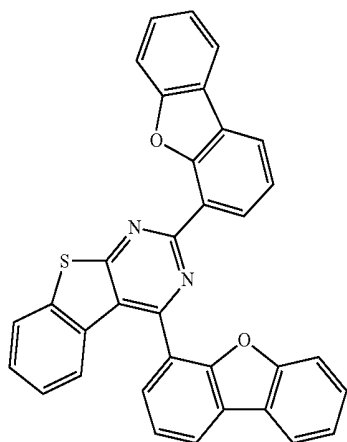
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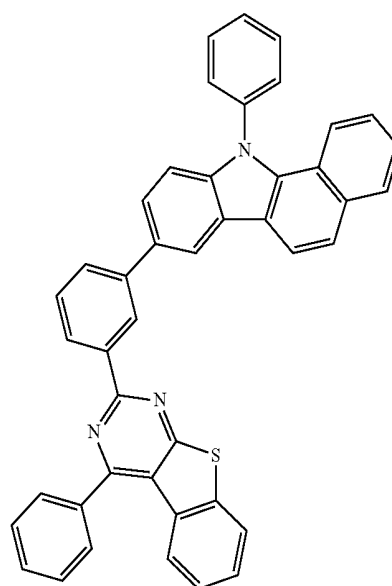


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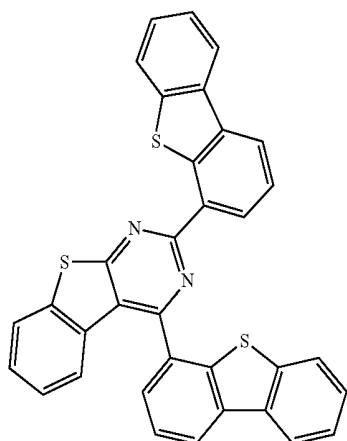
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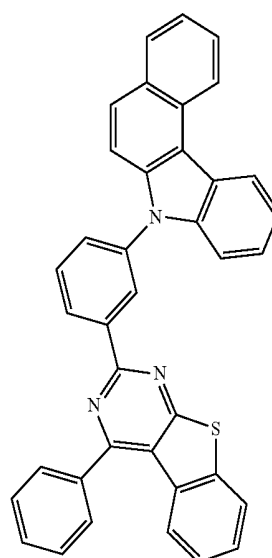
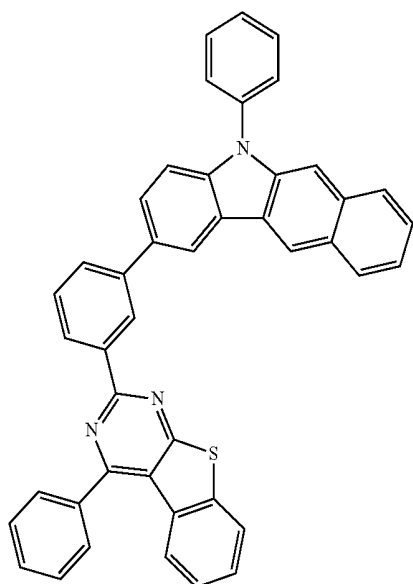
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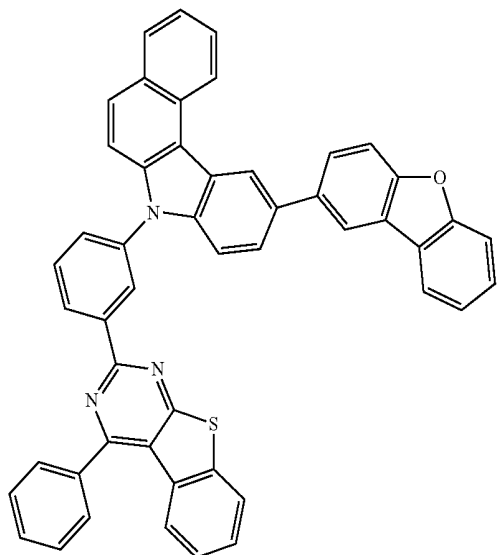
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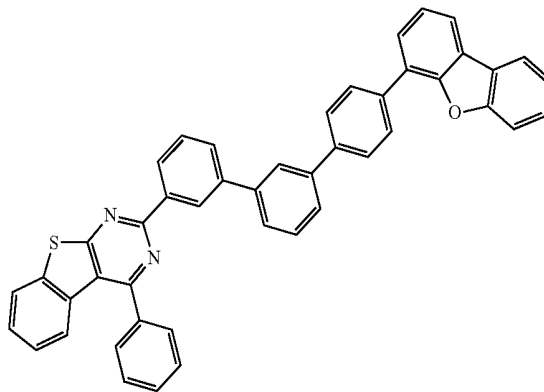
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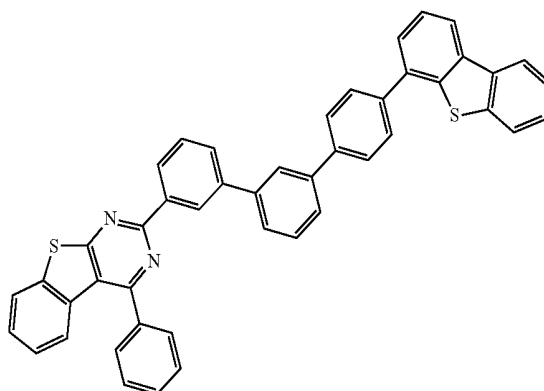


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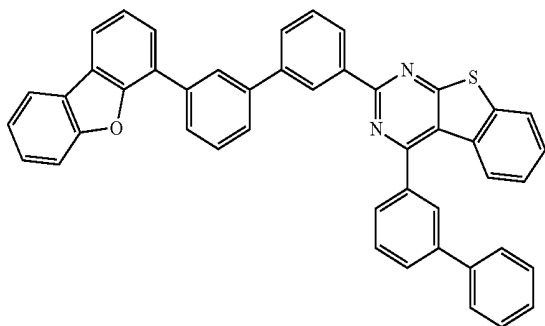
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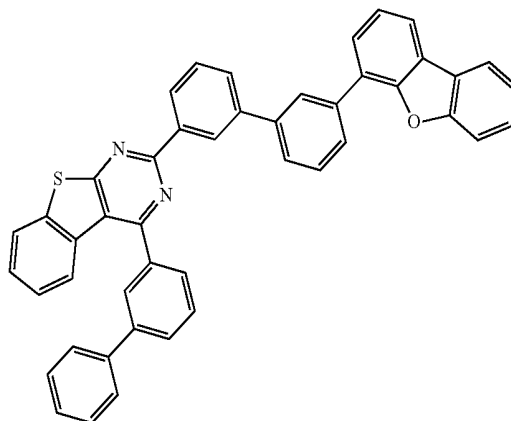
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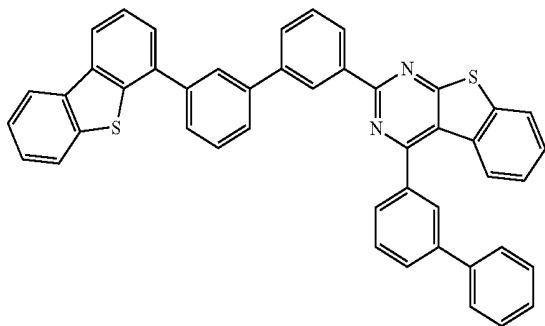
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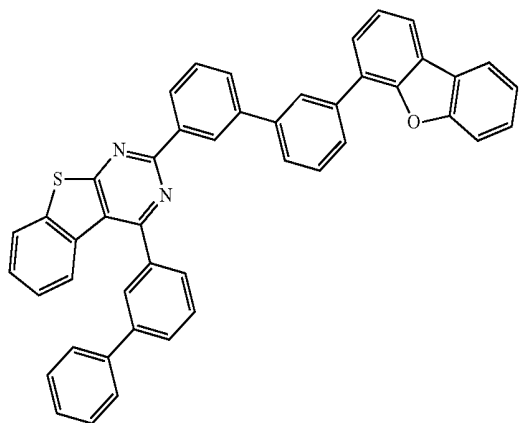


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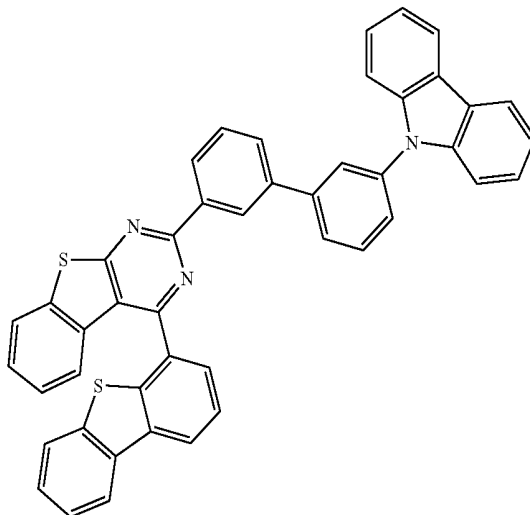
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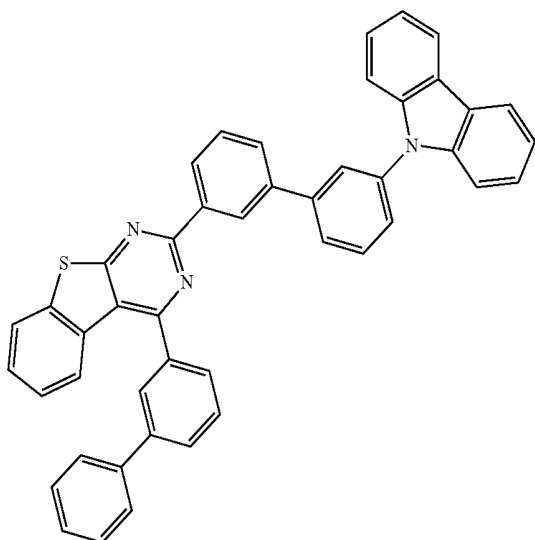


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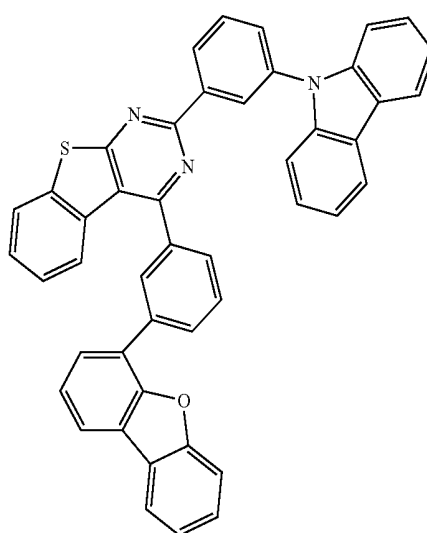
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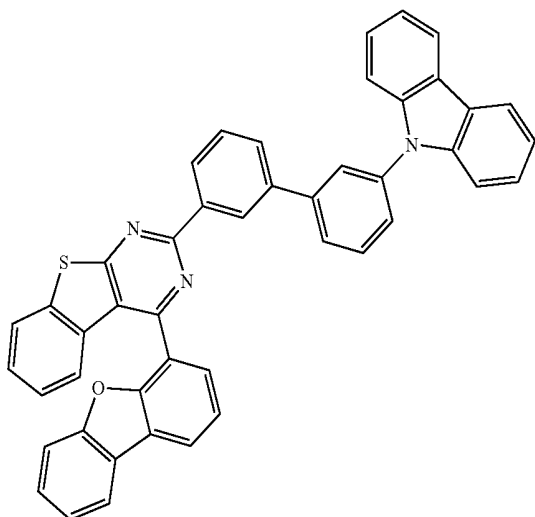
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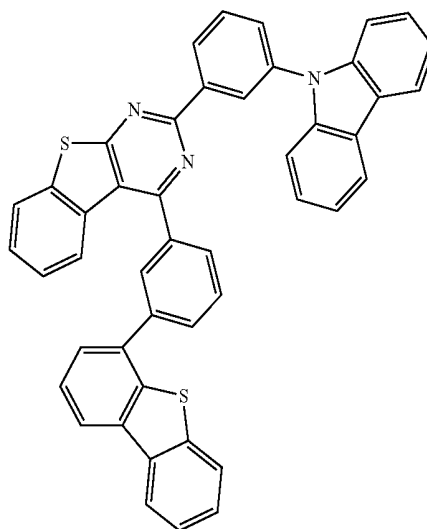
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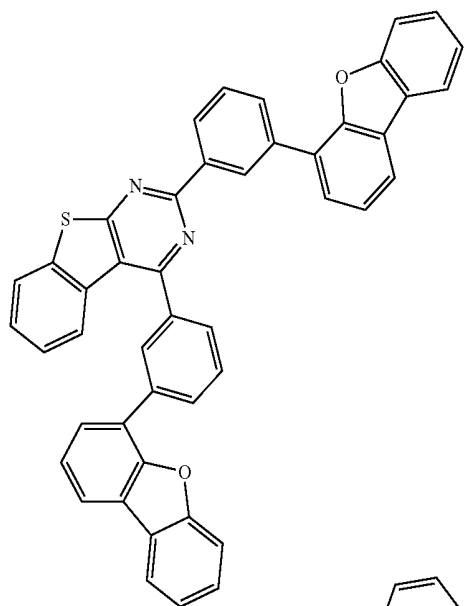
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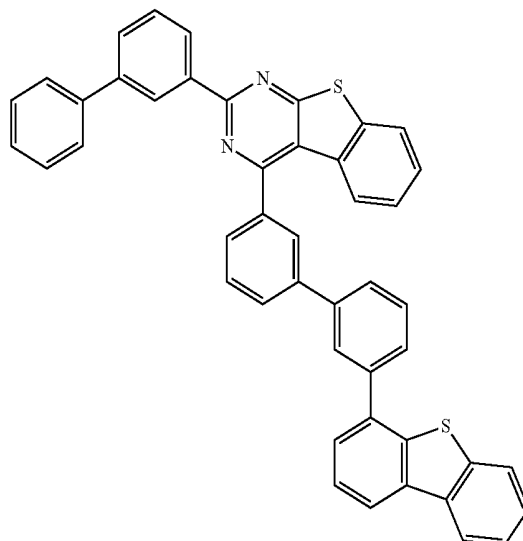


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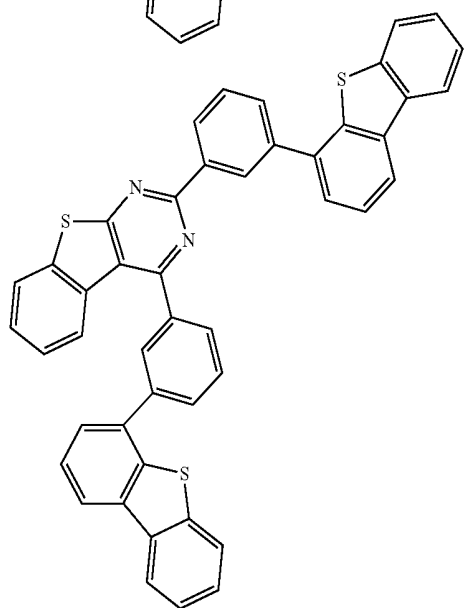


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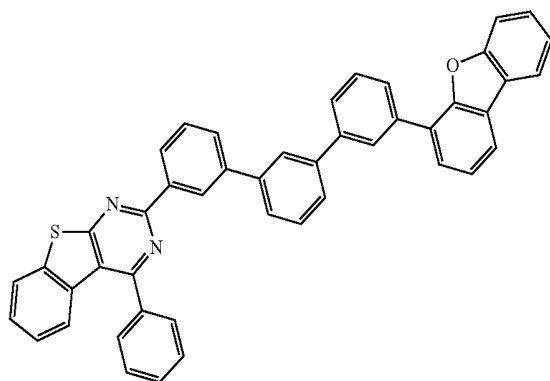
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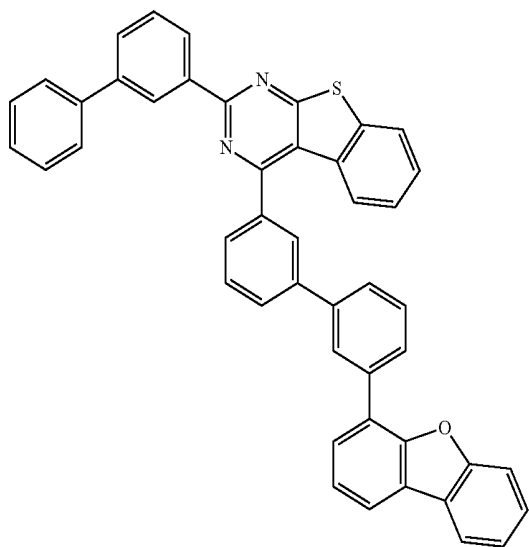
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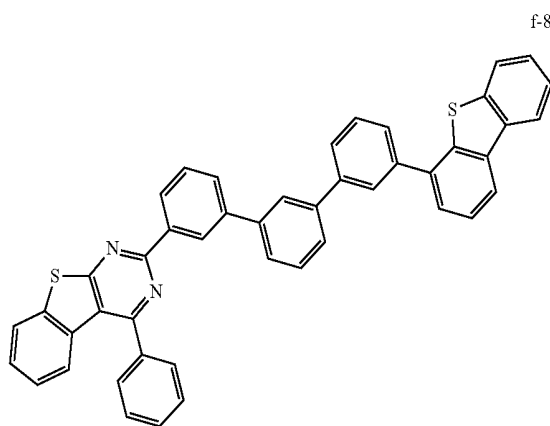
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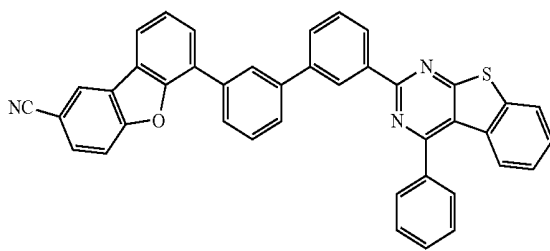
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f-86



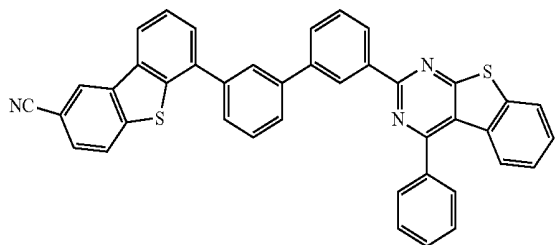
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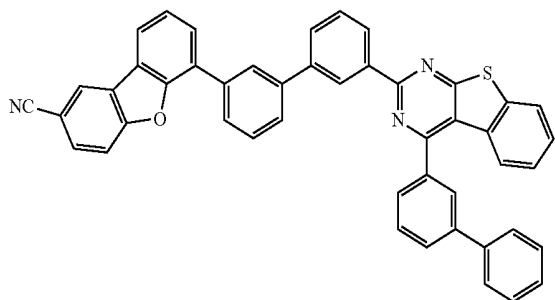
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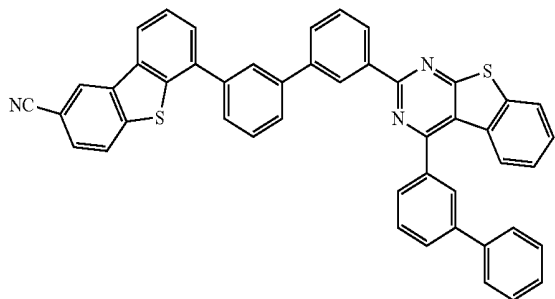
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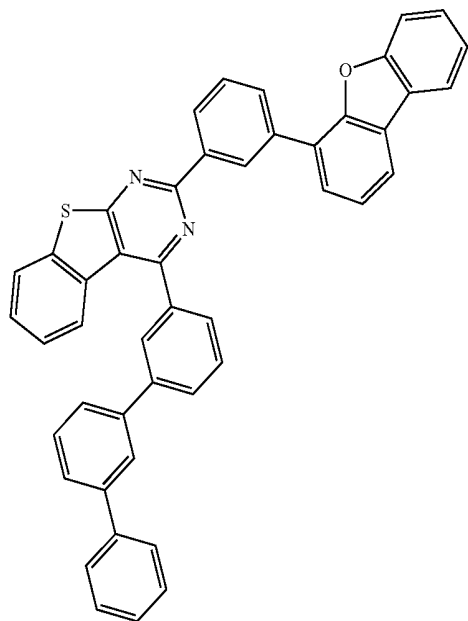
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f-93

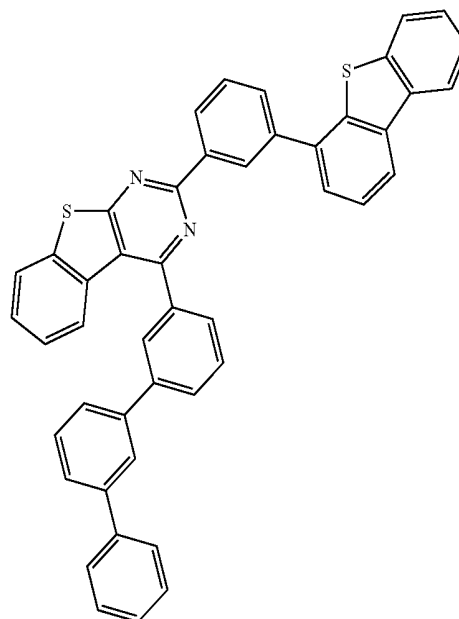


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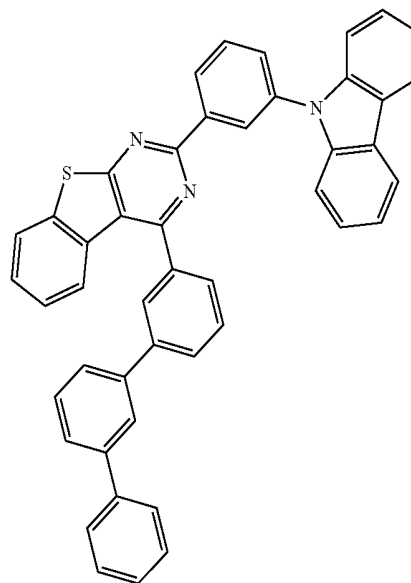


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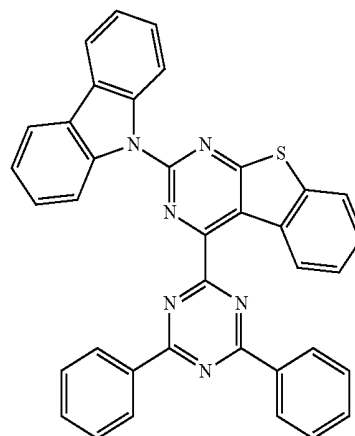
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f-96

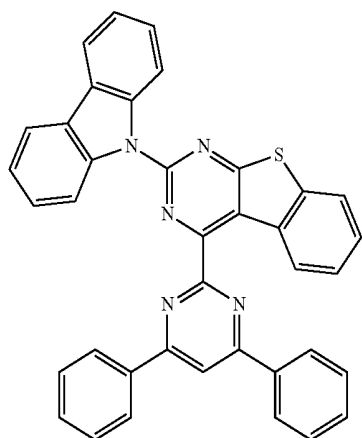


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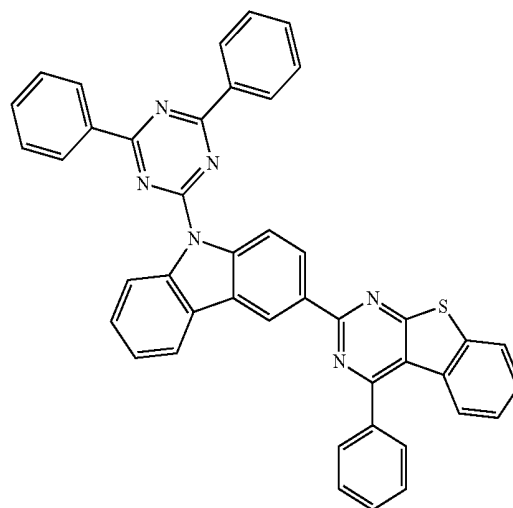
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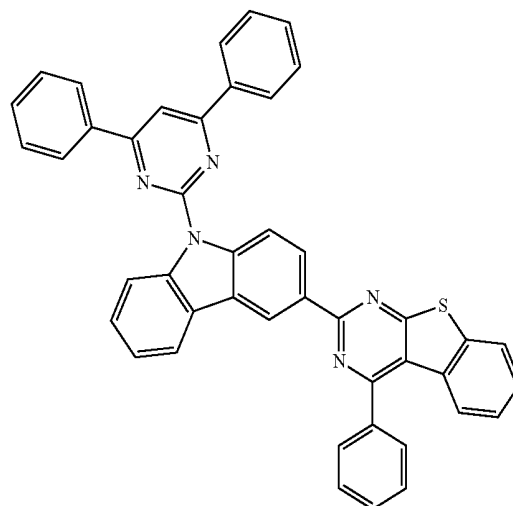
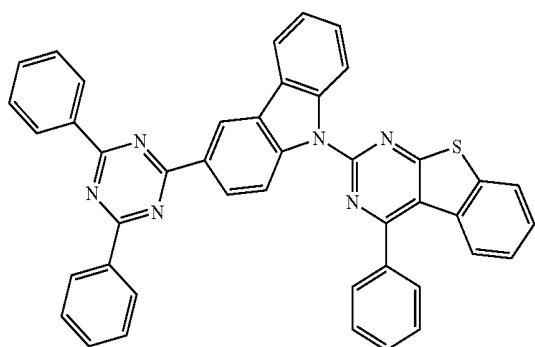
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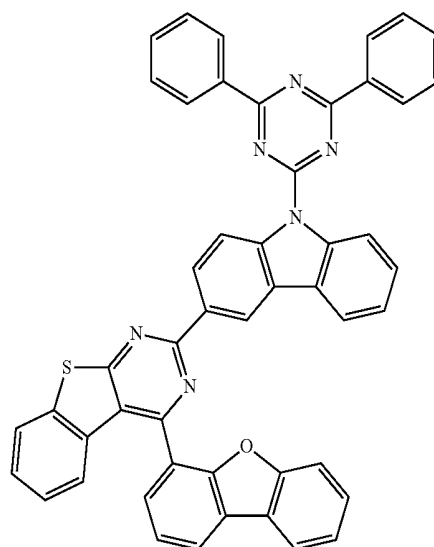
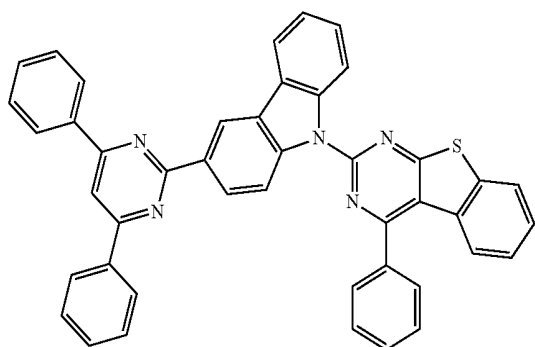
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e-99



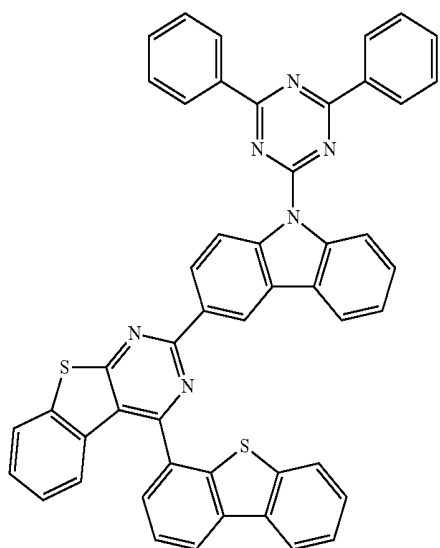
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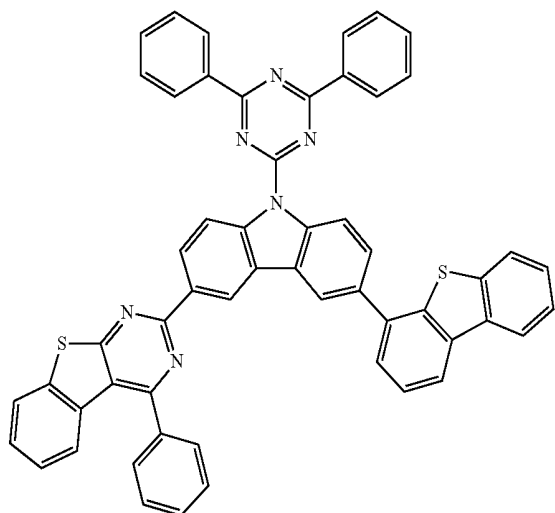


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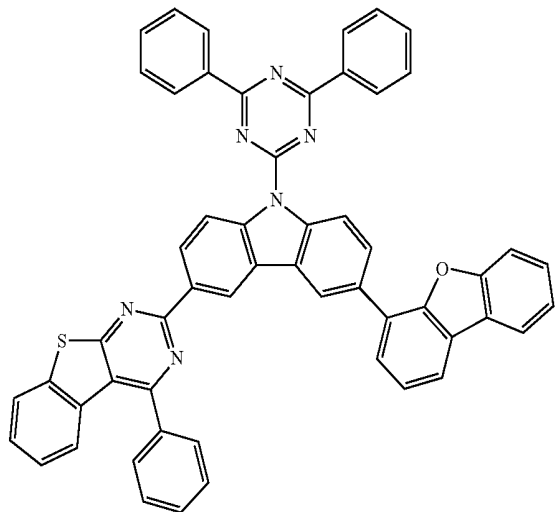
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f-105

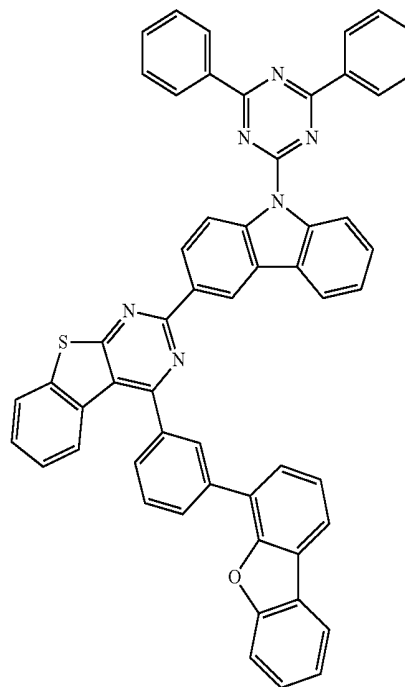


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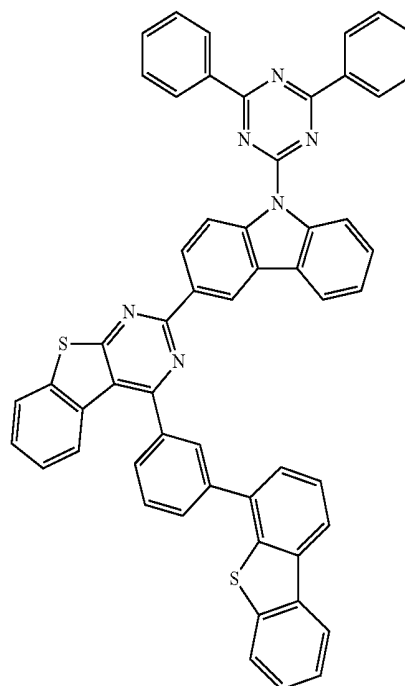


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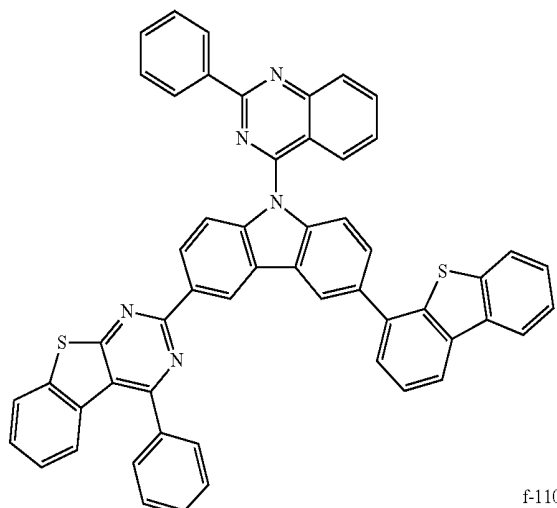


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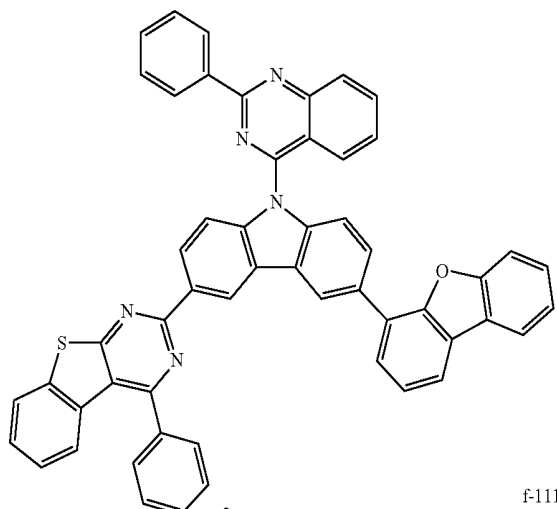


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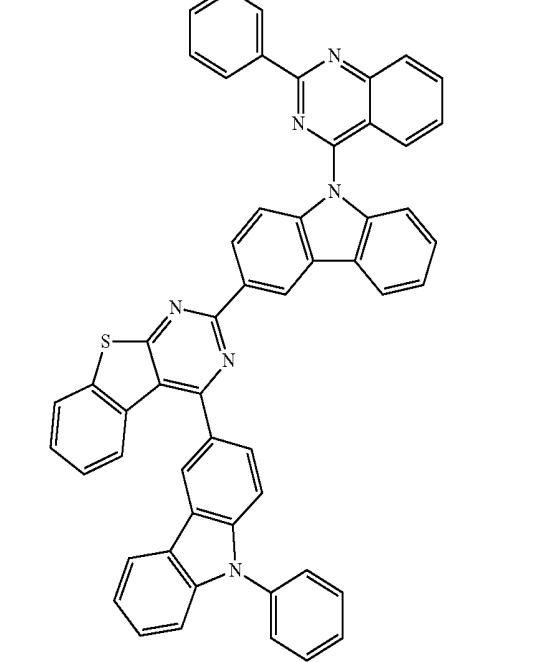
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f-110

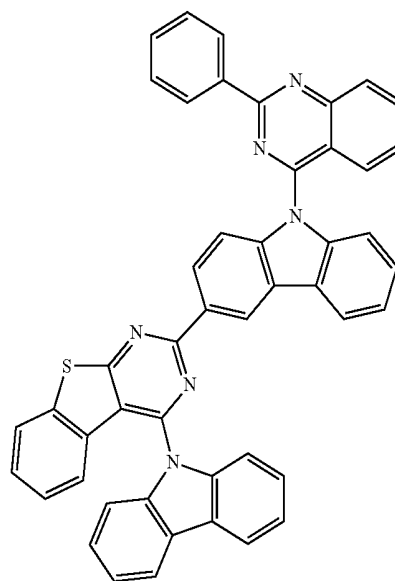


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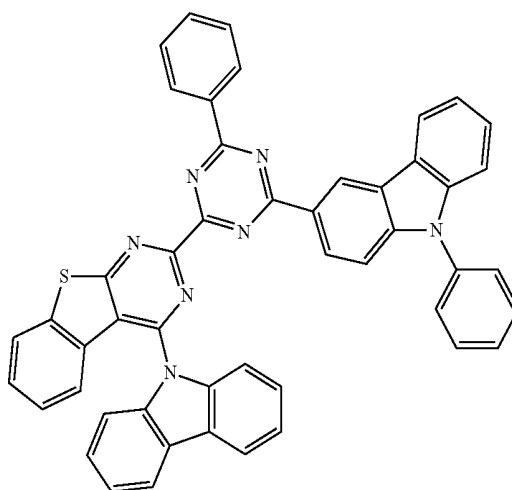


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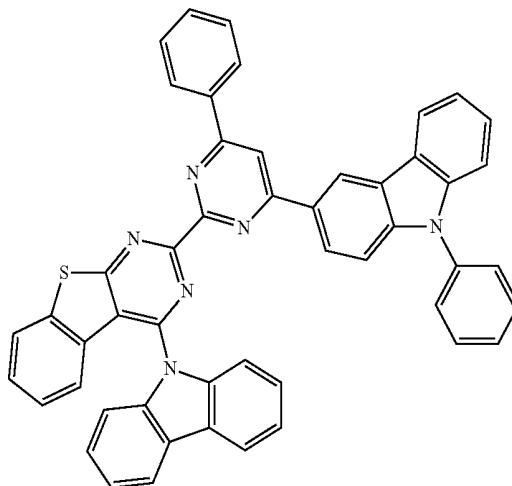
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f-113

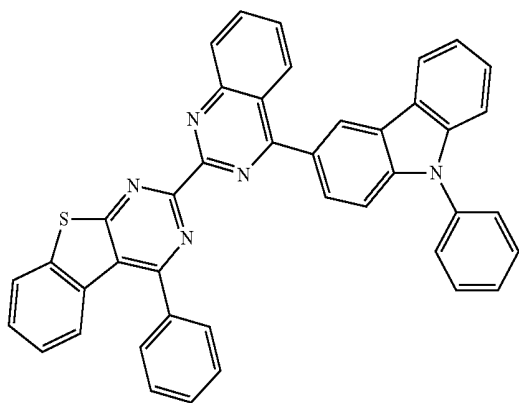


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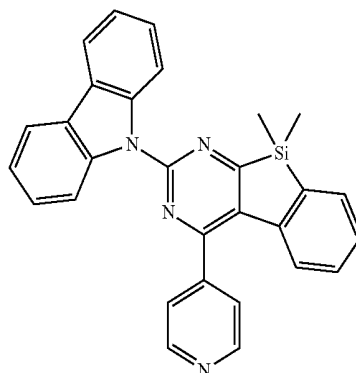
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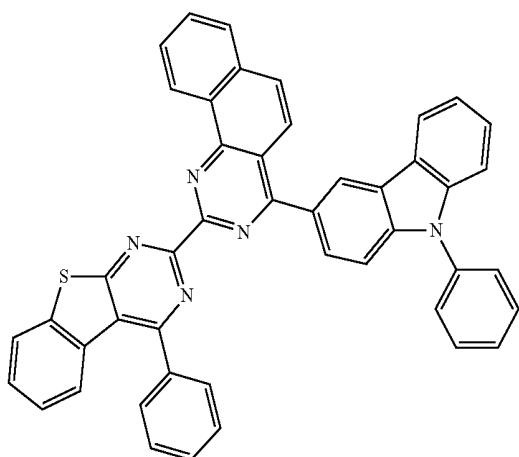


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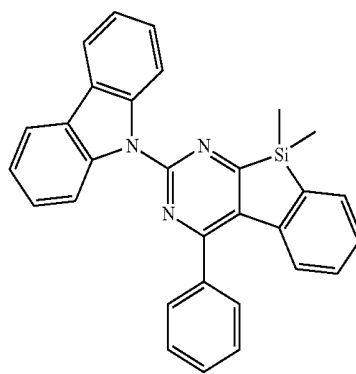
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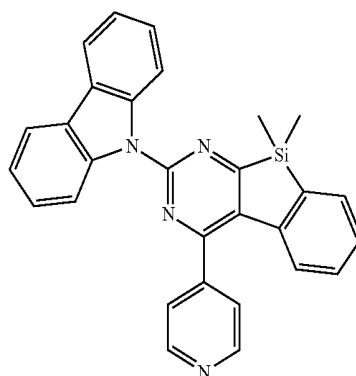
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197



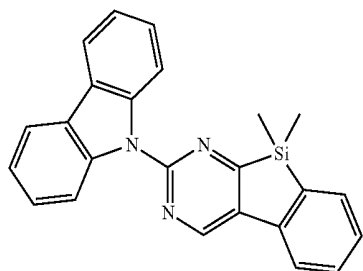
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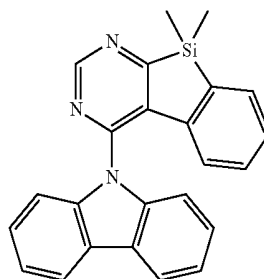
[0162] Group of  $X_1 = \text{Si}(\text{R}_4)(\text{R}_5)$  in Formula 1-2

[0163] ( $\text{R}_4$  and  $\text{R}_5$  are Described in the Above Specification)

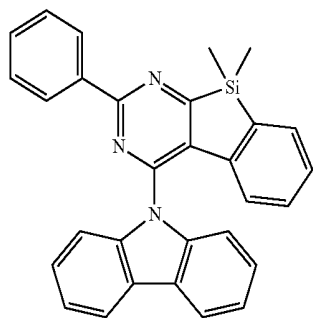
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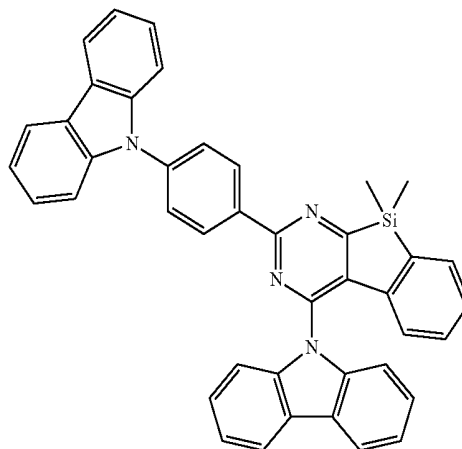
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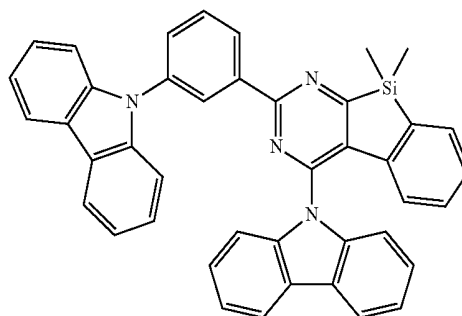
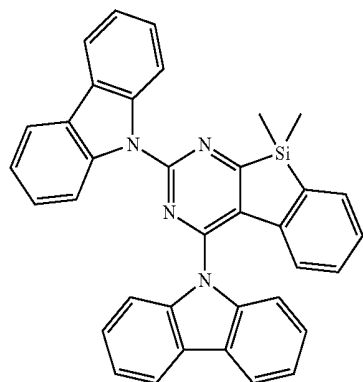
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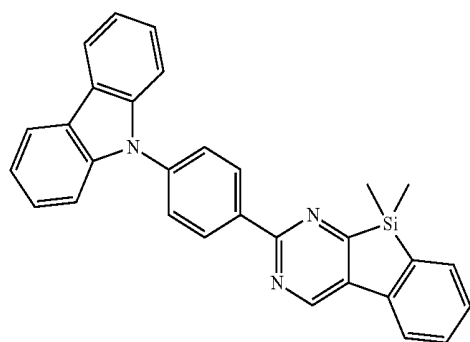
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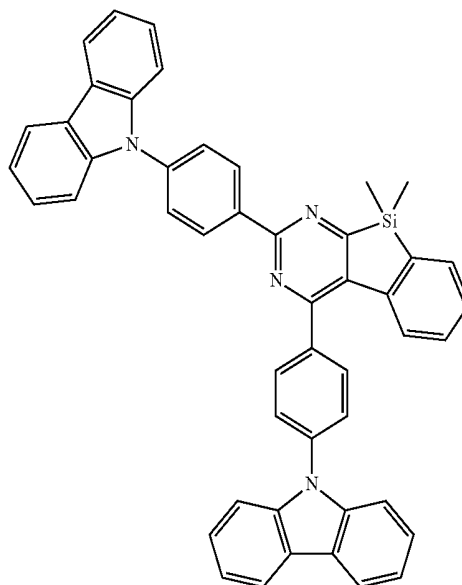
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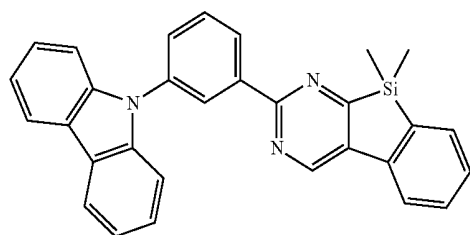
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206

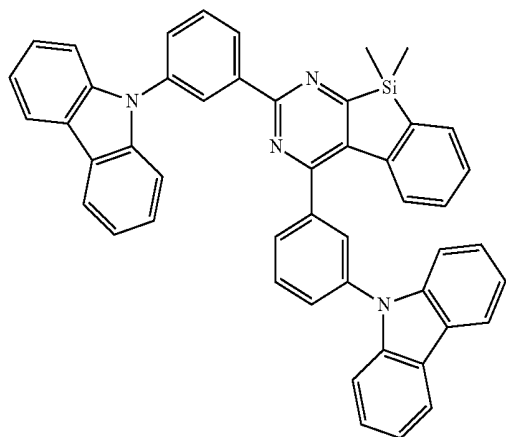


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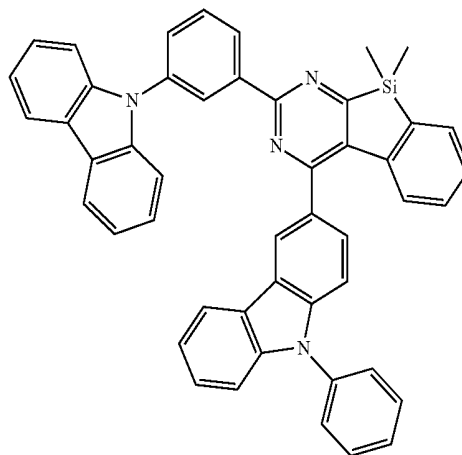
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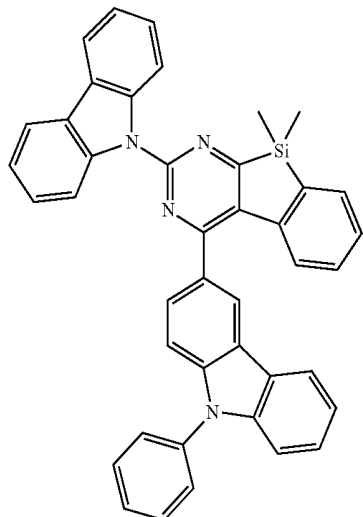


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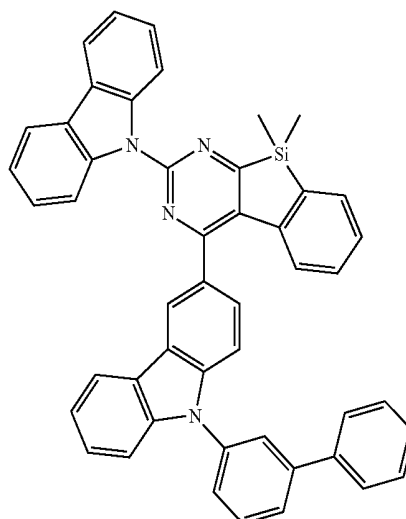
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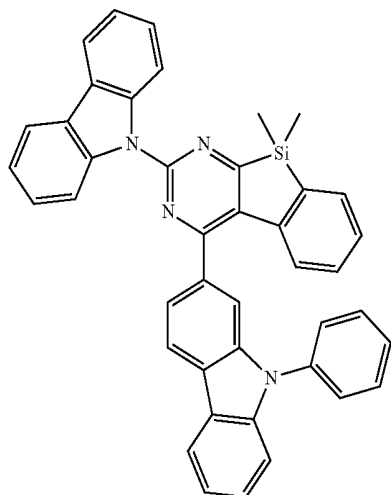
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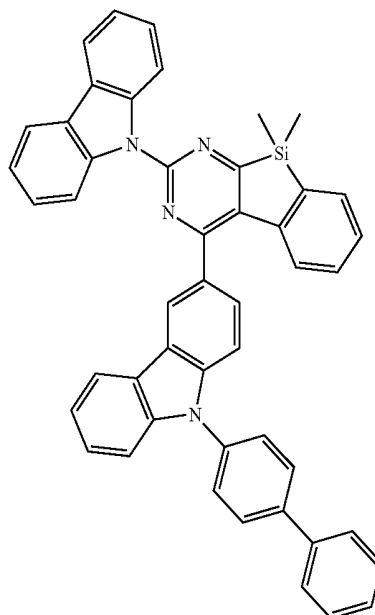
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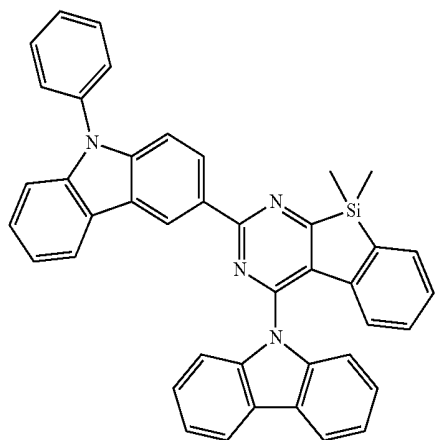


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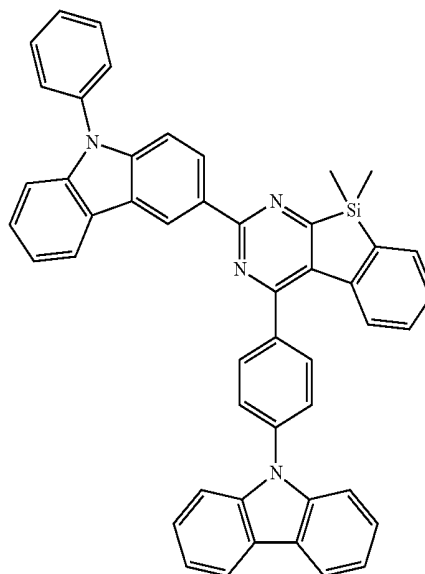
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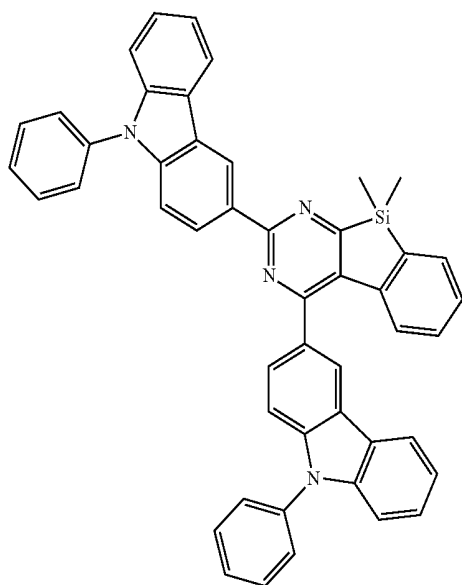


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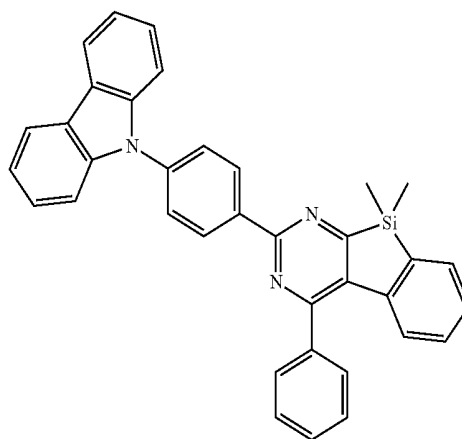
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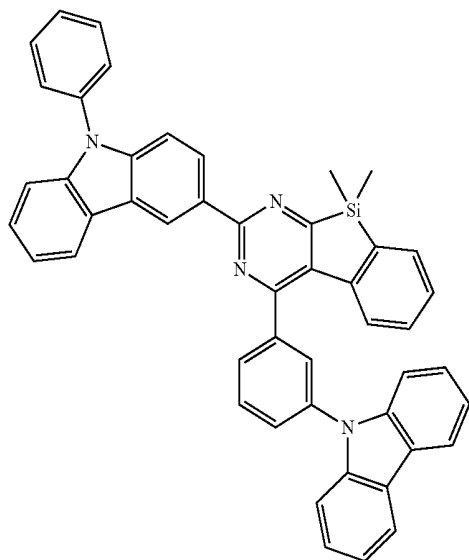
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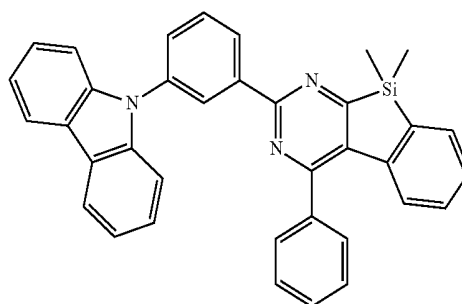
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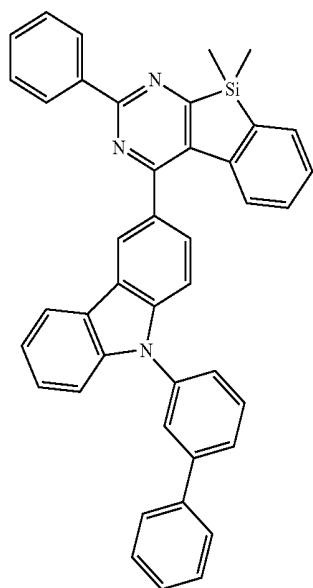
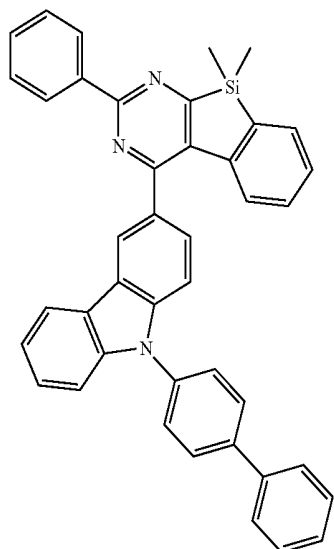
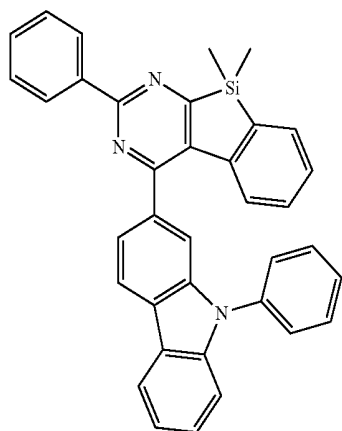
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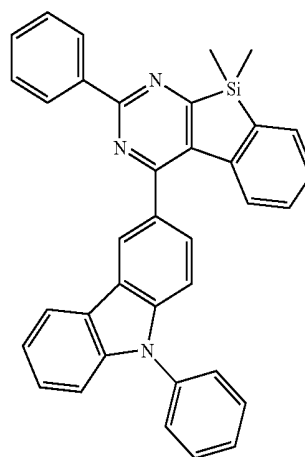
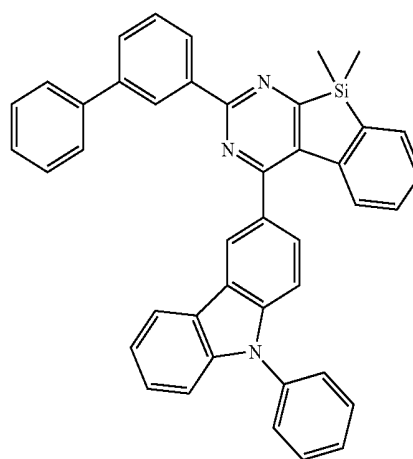
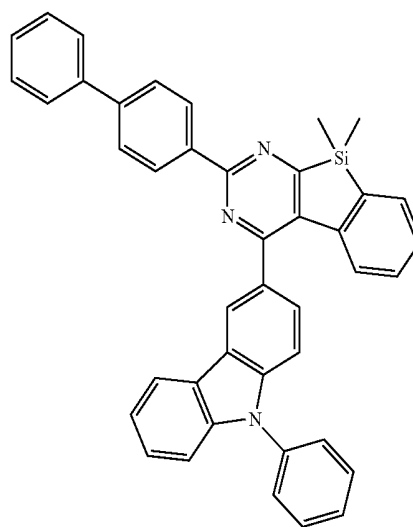
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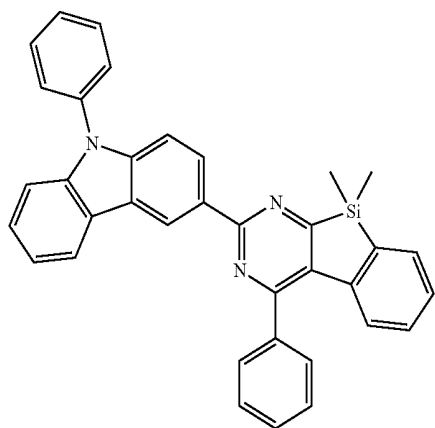
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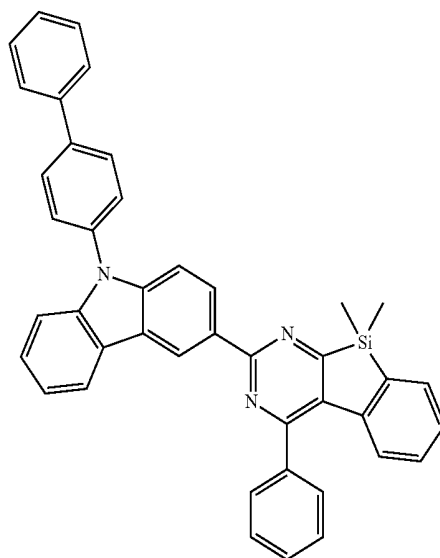


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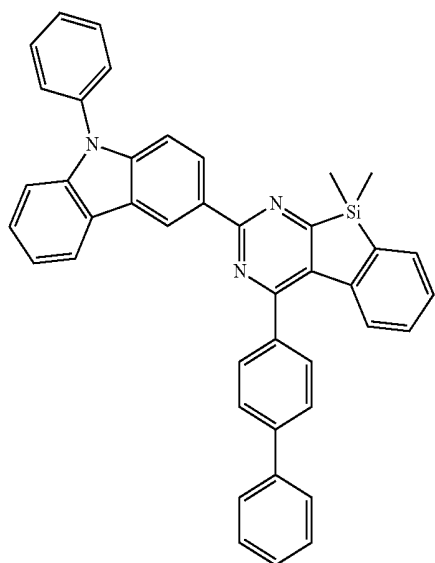
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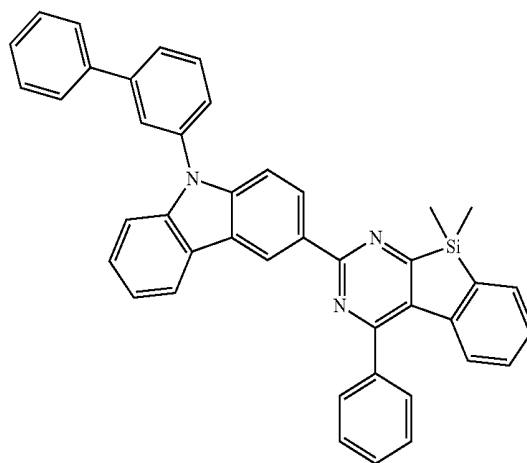


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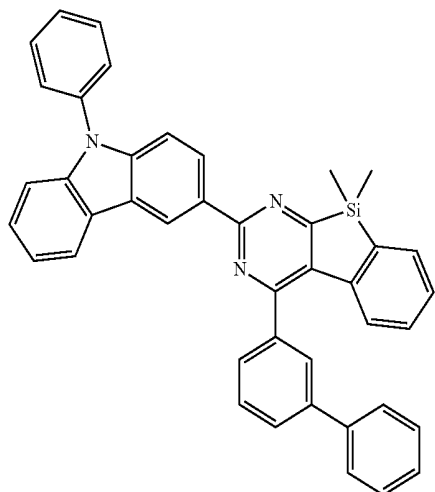
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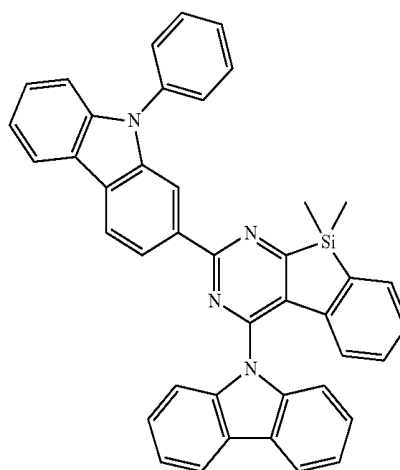
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g-3

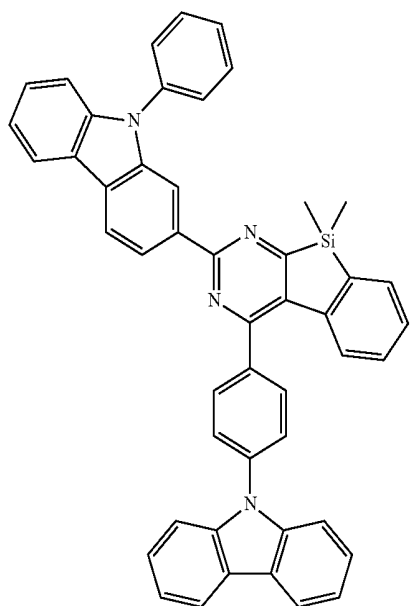


g-6



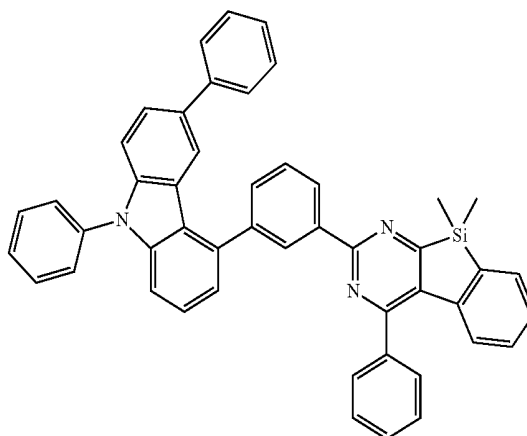
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g-7



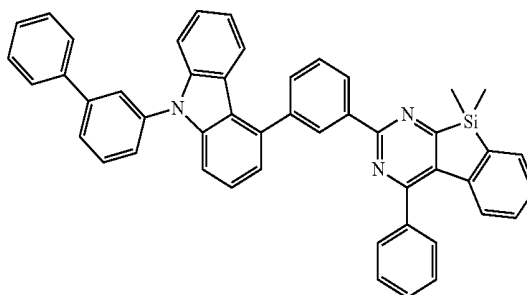
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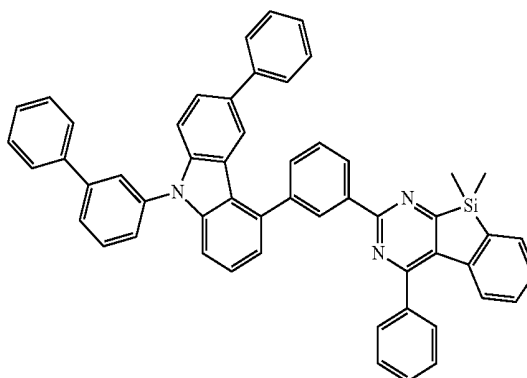
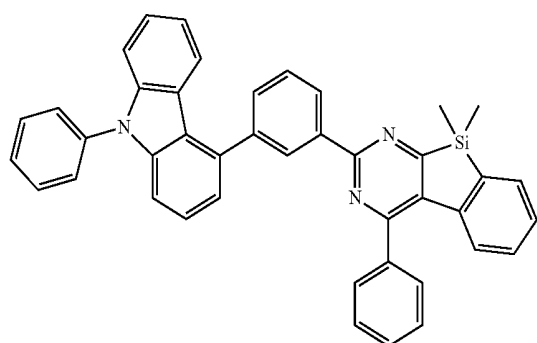
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g-8



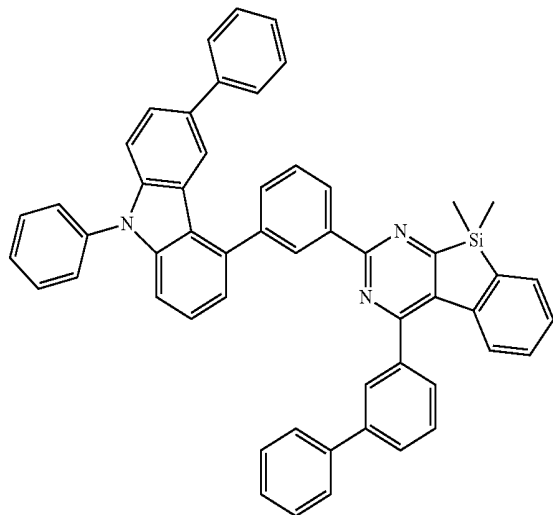
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g-9



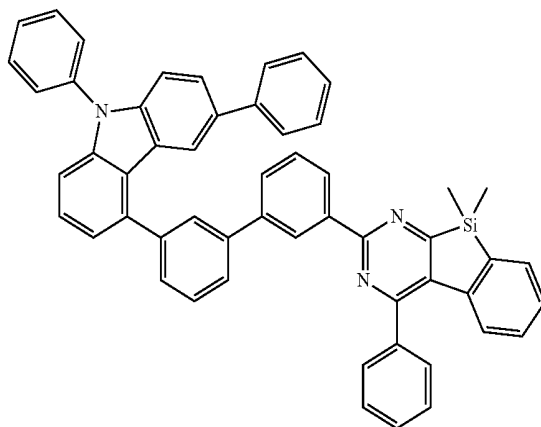
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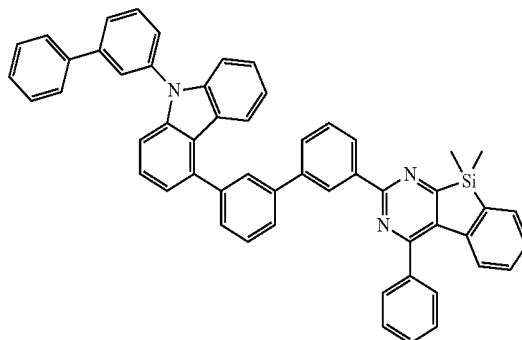
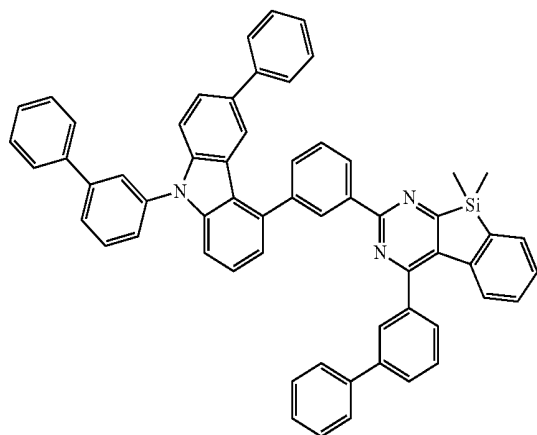
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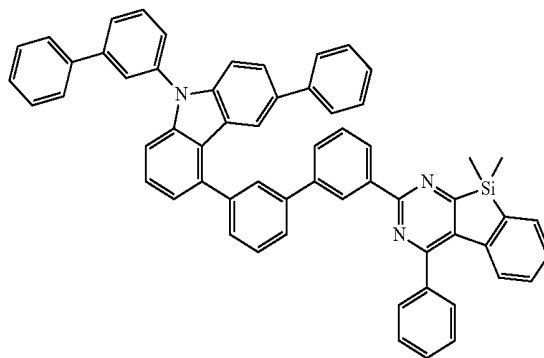
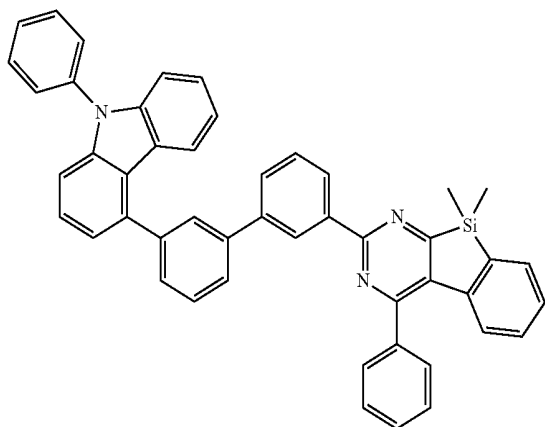
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g-14



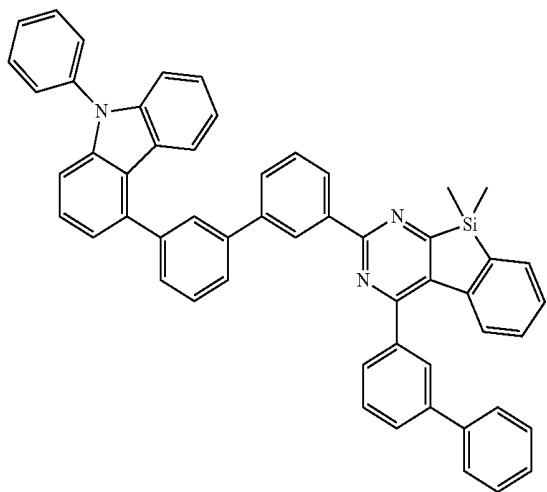
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g-18



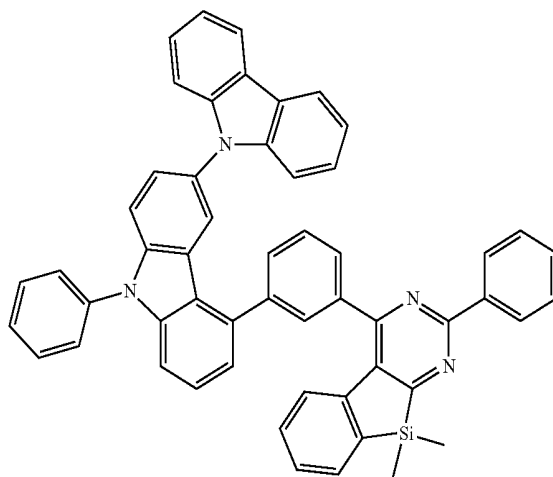
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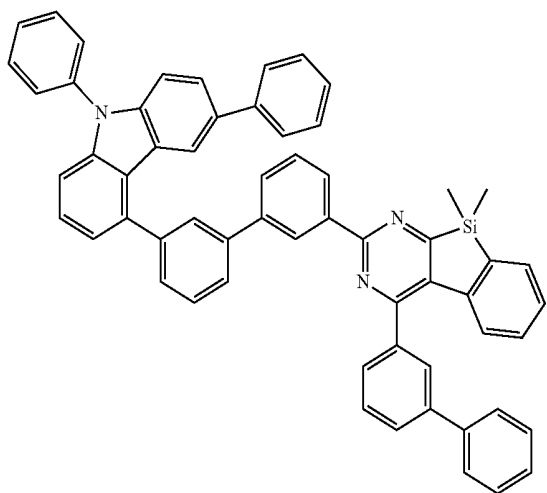


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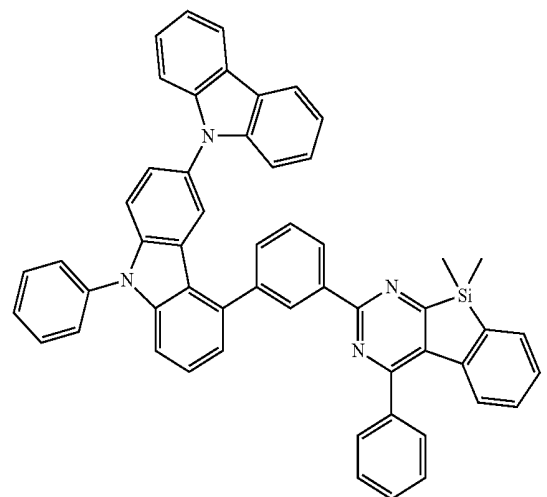
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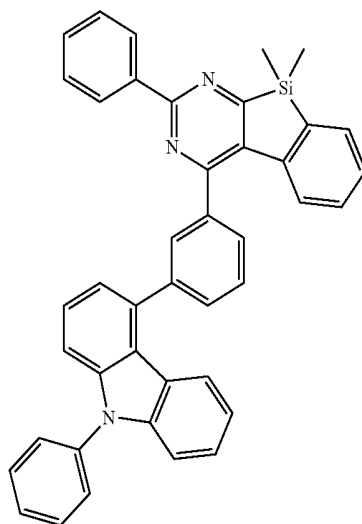
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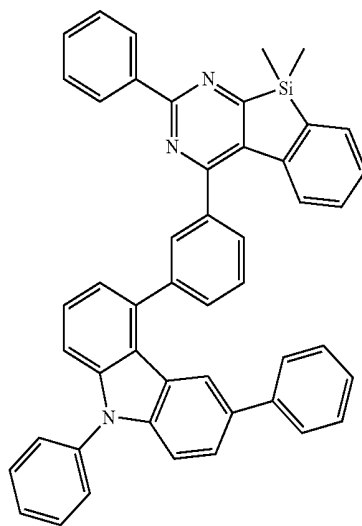
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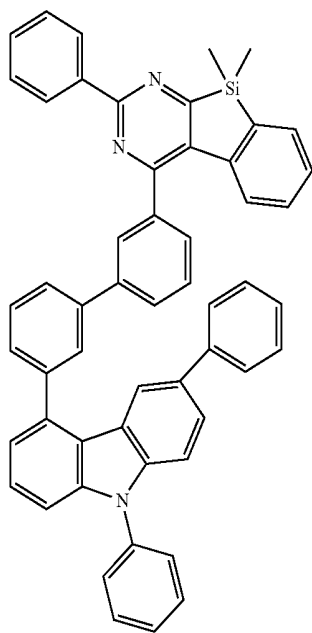
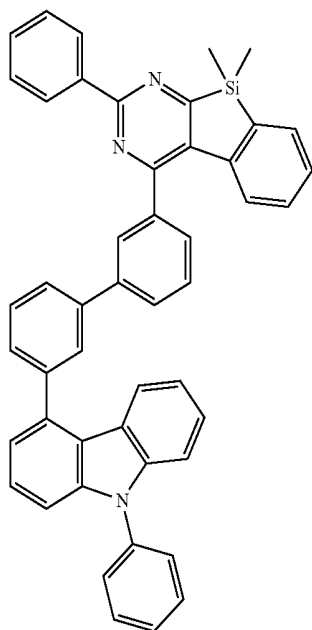
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g-24

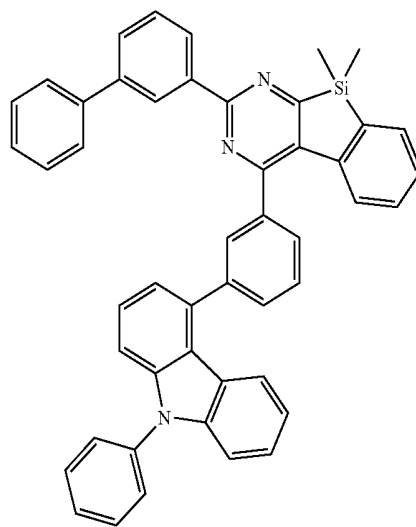


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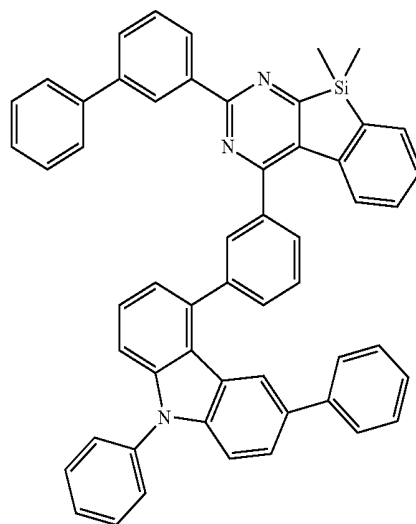


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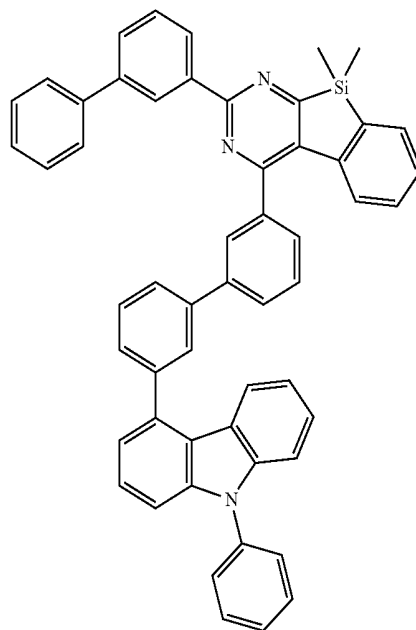


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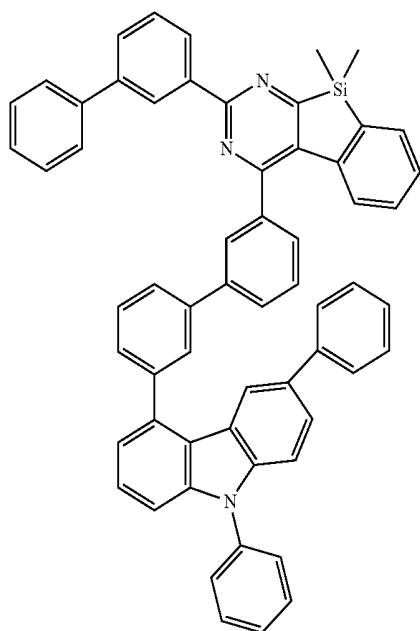
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g-26



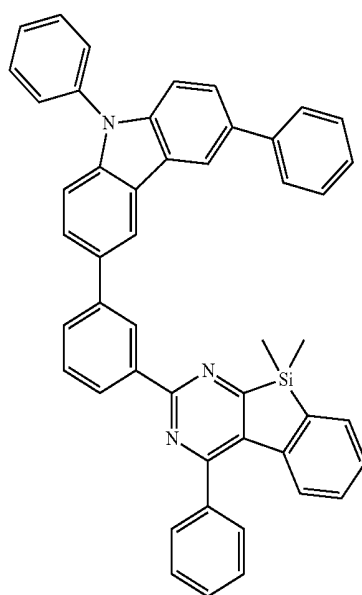
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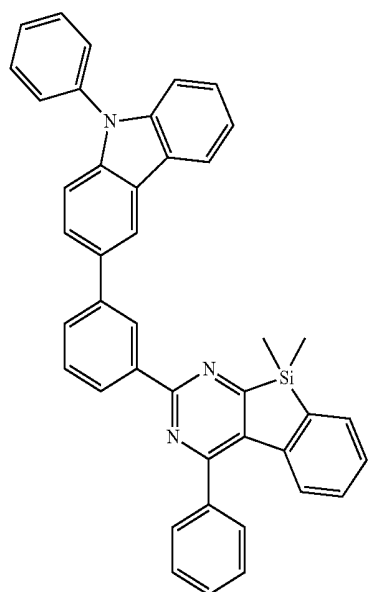
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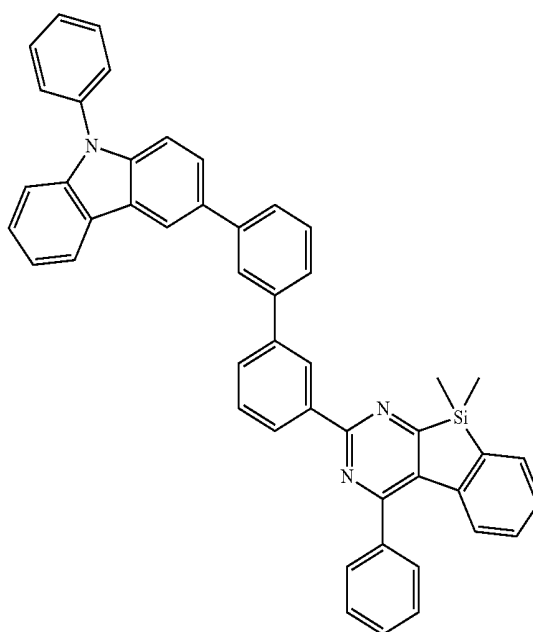


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g-31

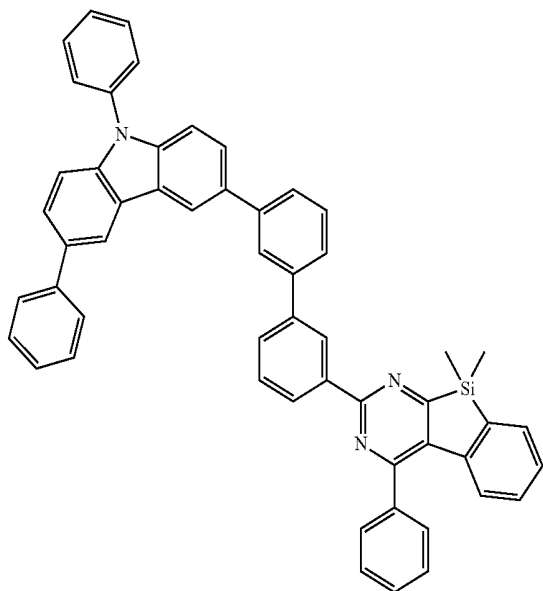


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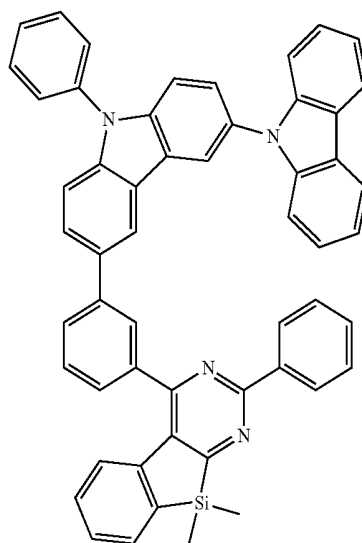
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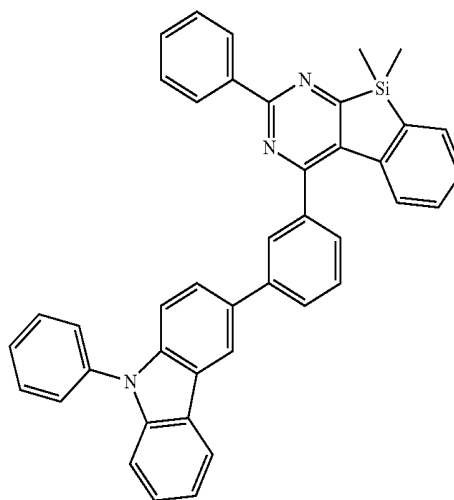


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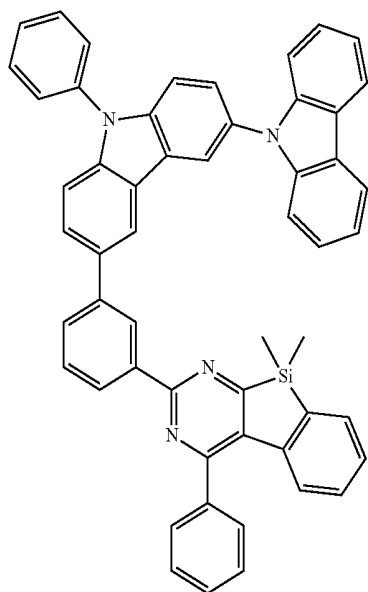
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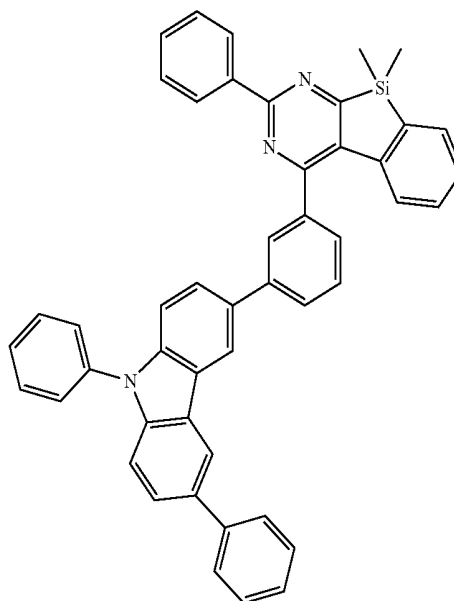
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g-35

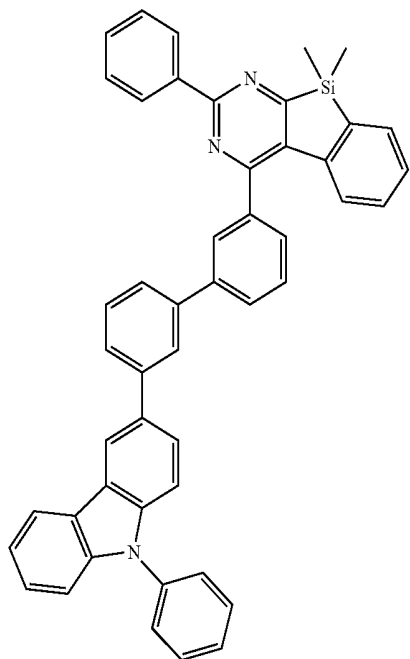


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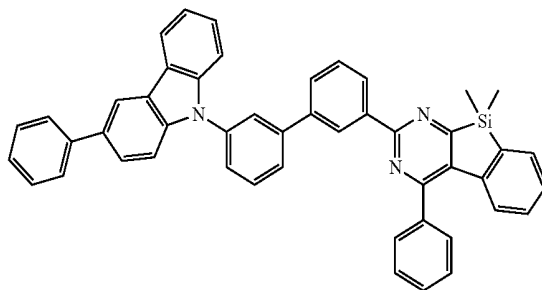
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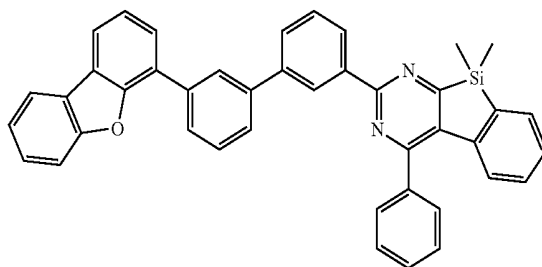


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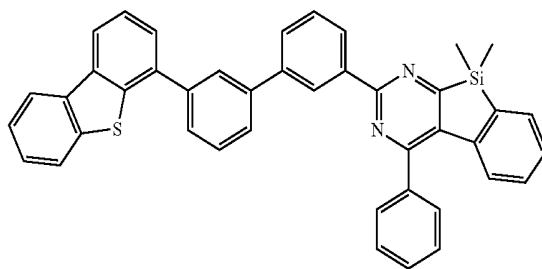
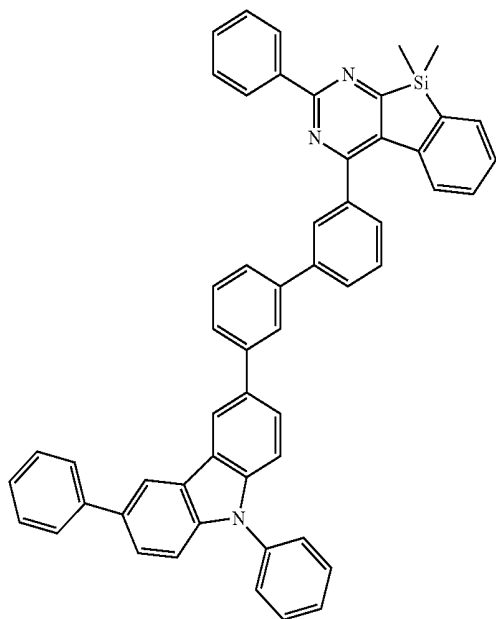


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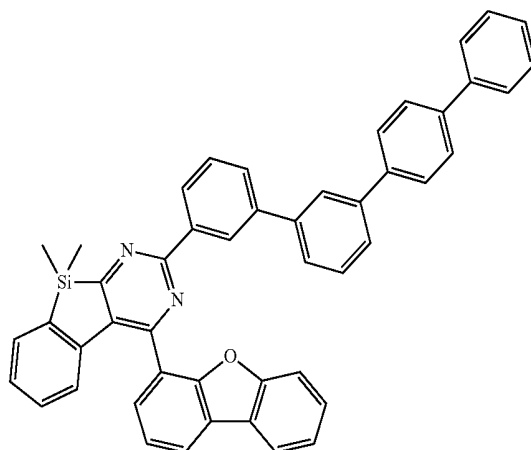
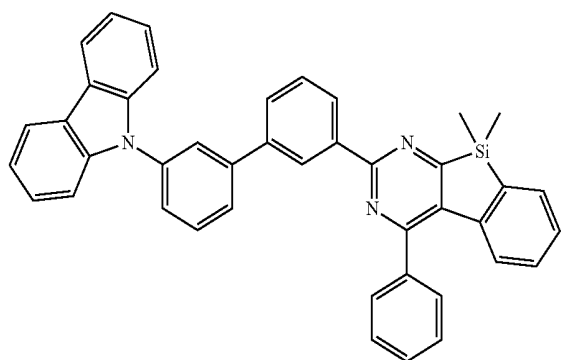
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g-44



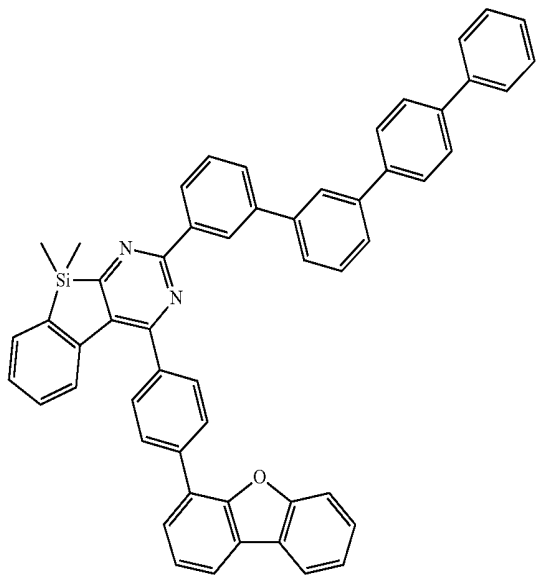
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g-41



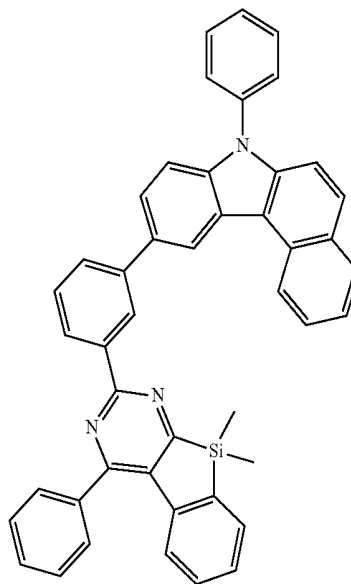
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g-46

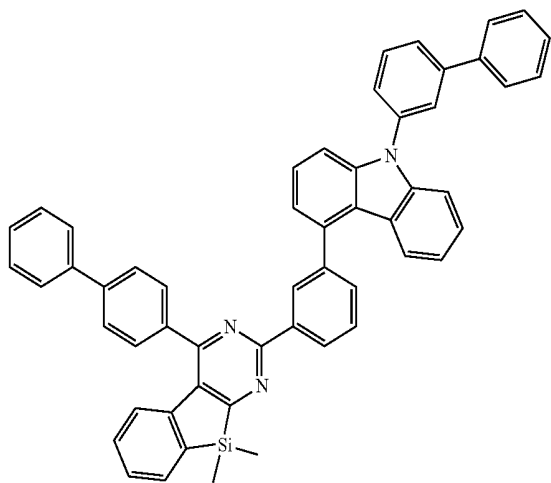


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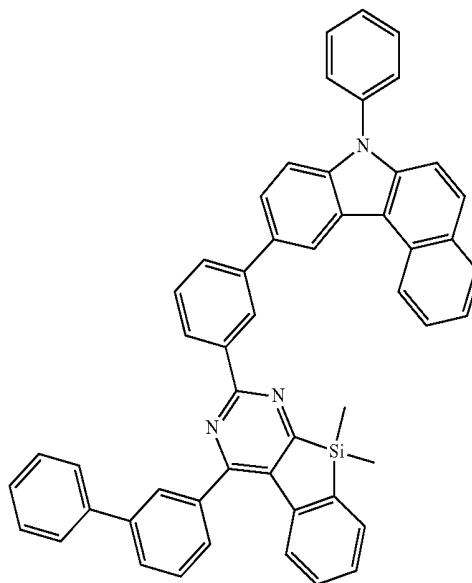
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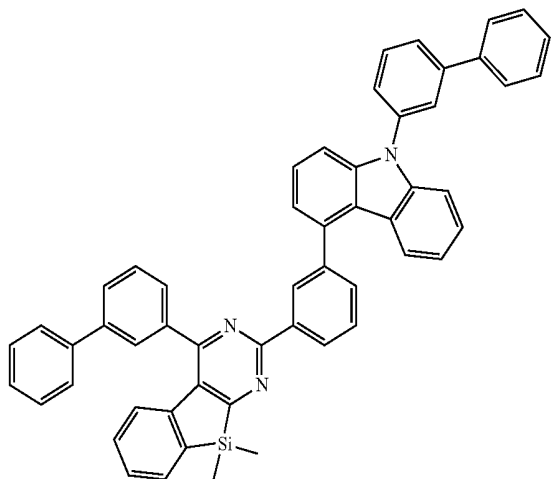
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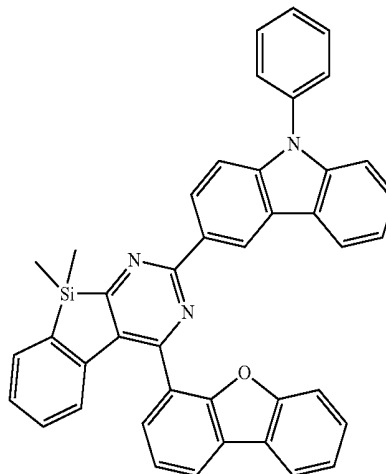
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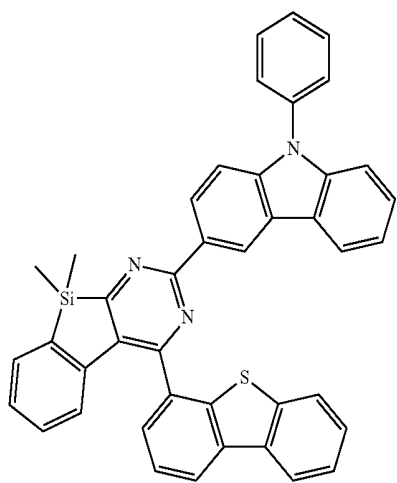
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g-51

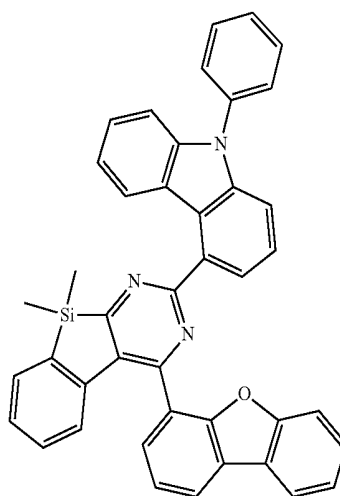


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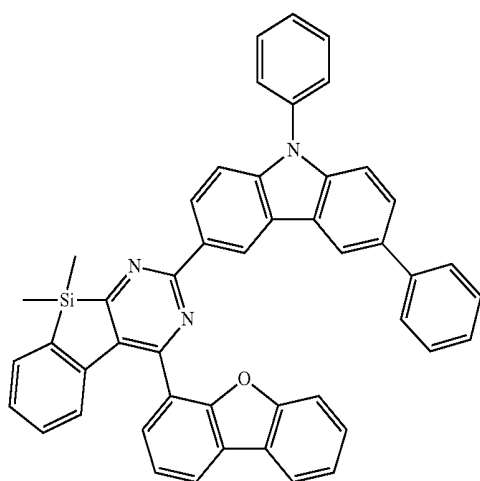
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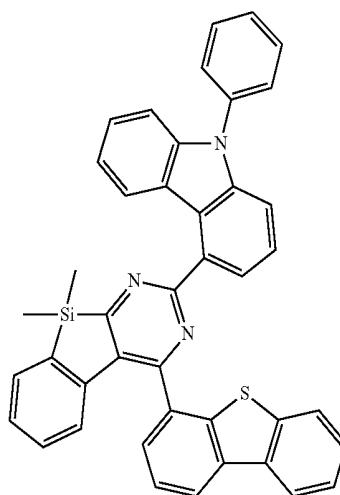


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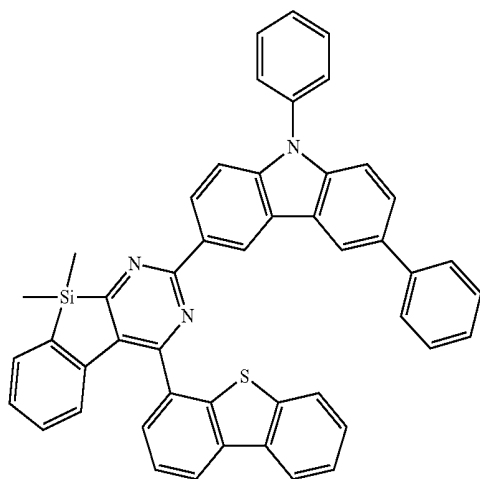
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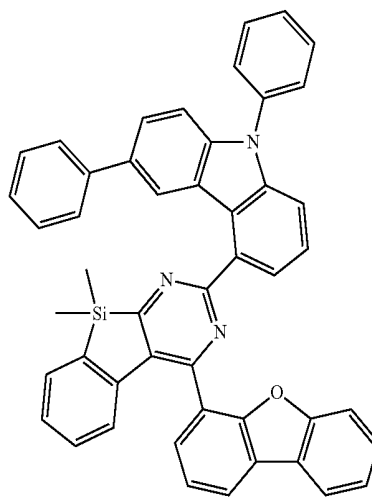
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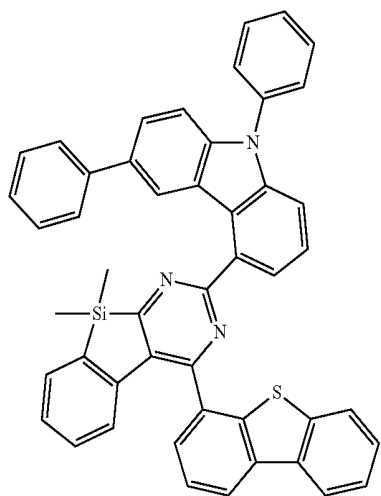
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g-57

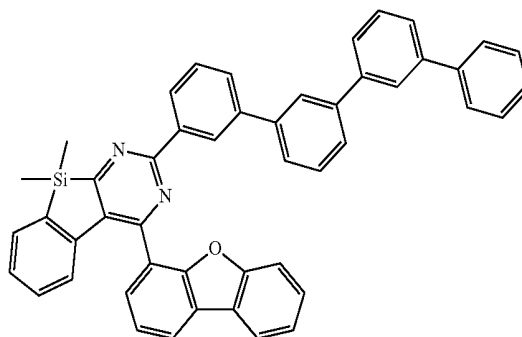


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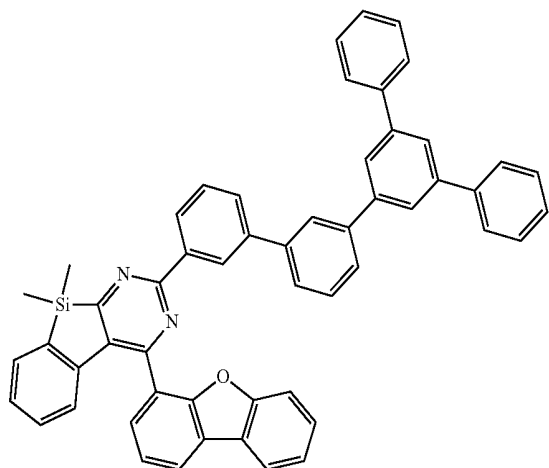
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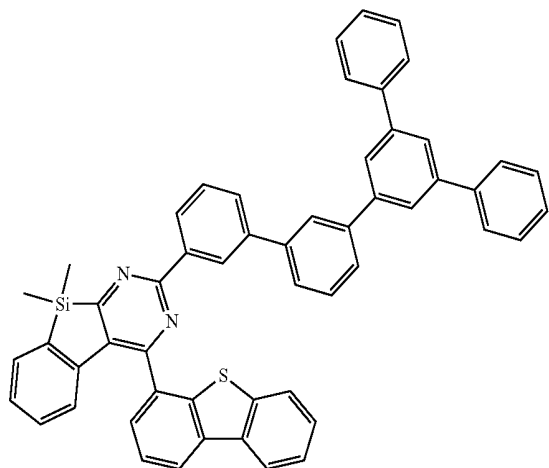


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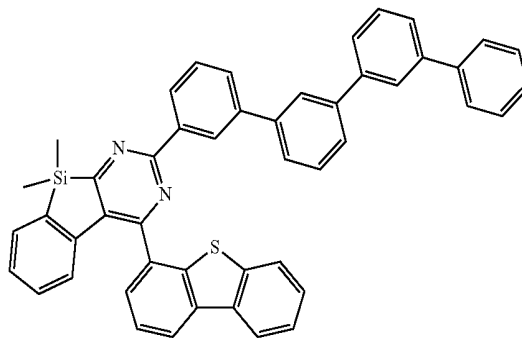
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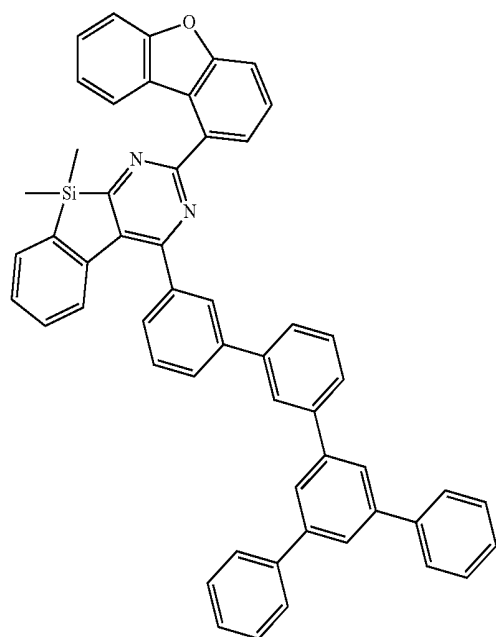
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g-62

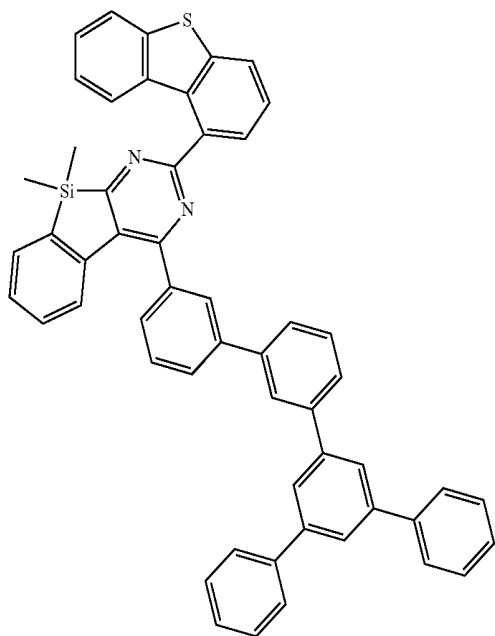


g-63



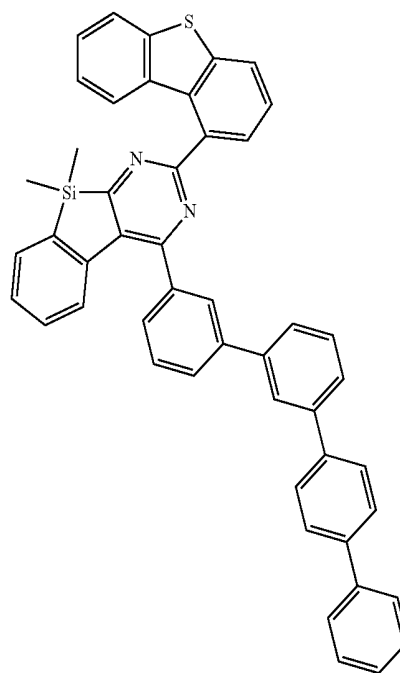
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g-64



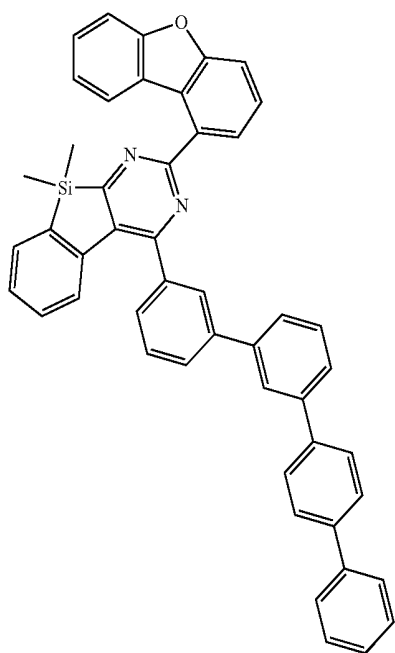
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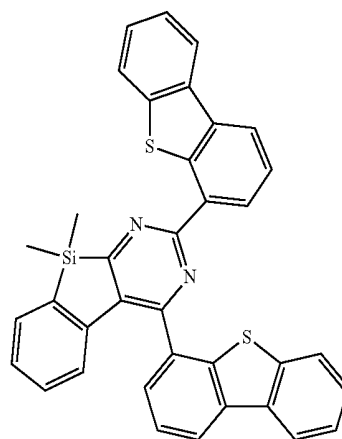


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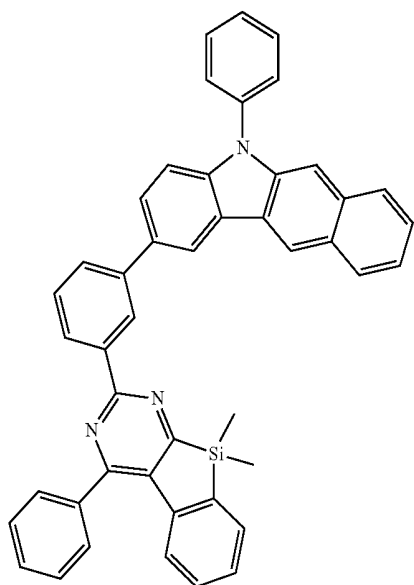
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g-68

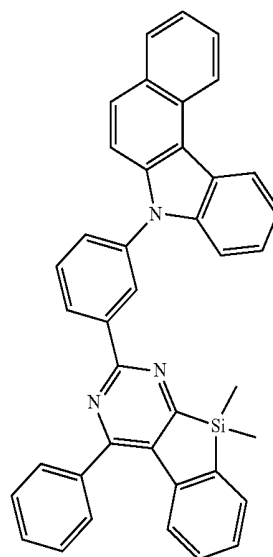


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g-69

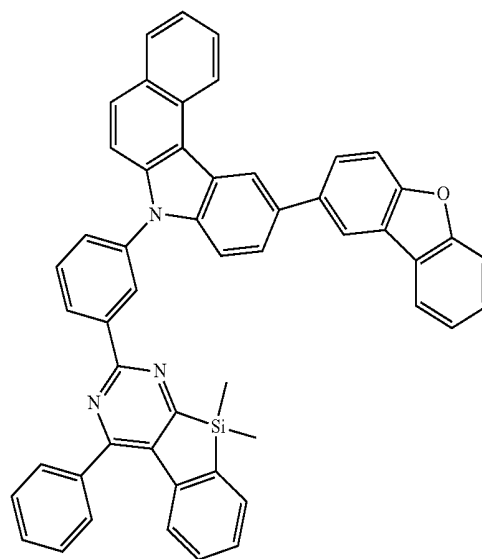
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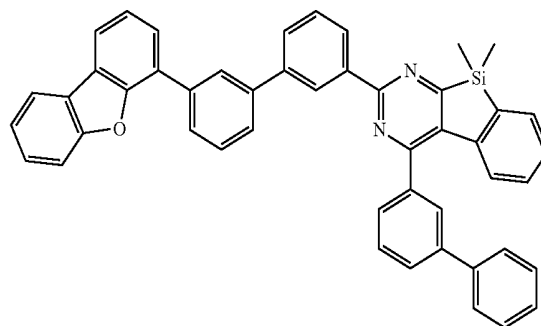
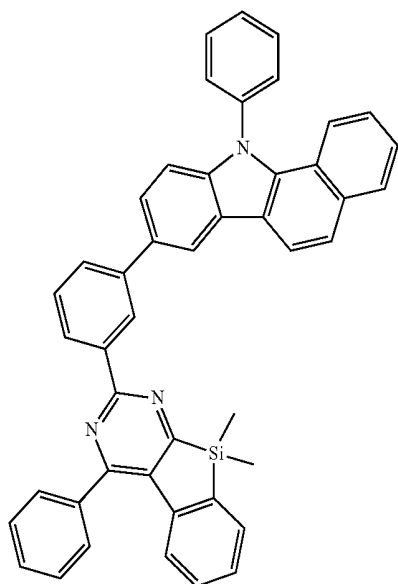
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g-72

g-70

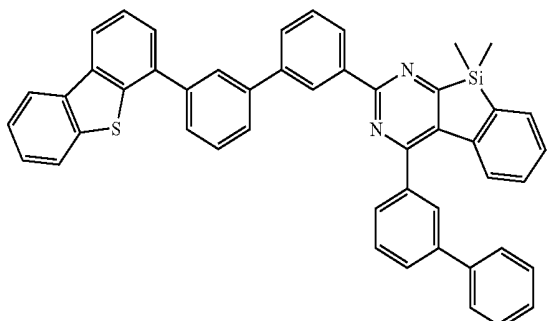


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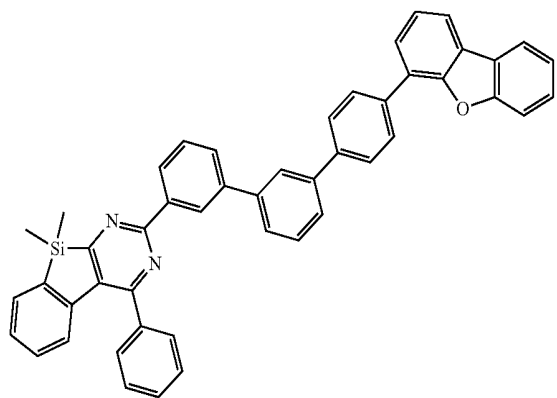


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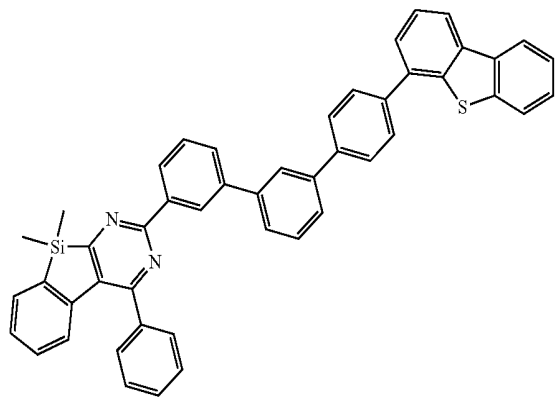
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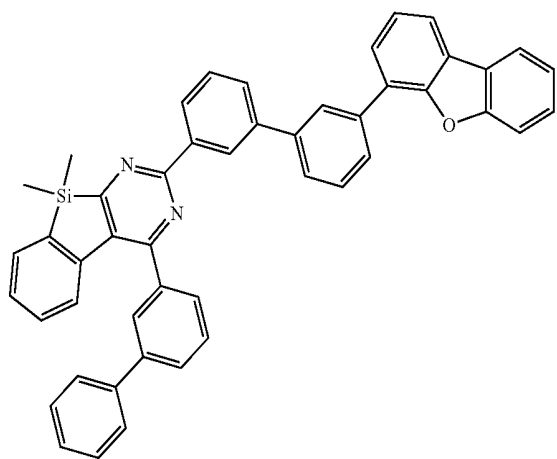
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g-76

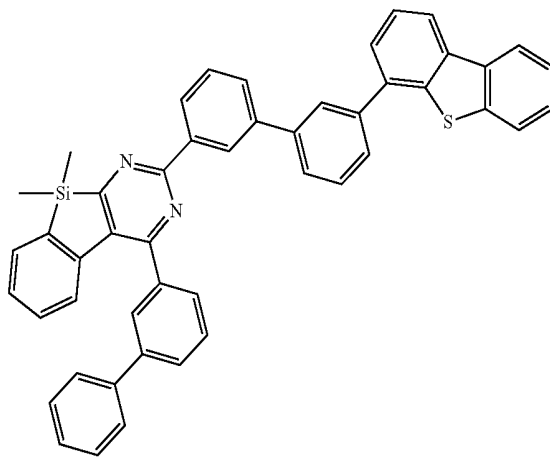


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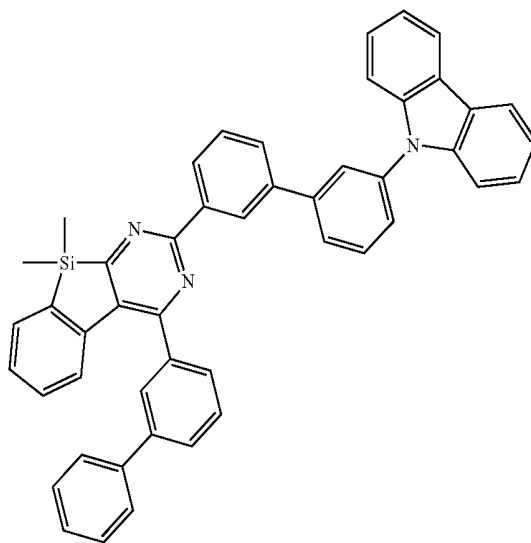


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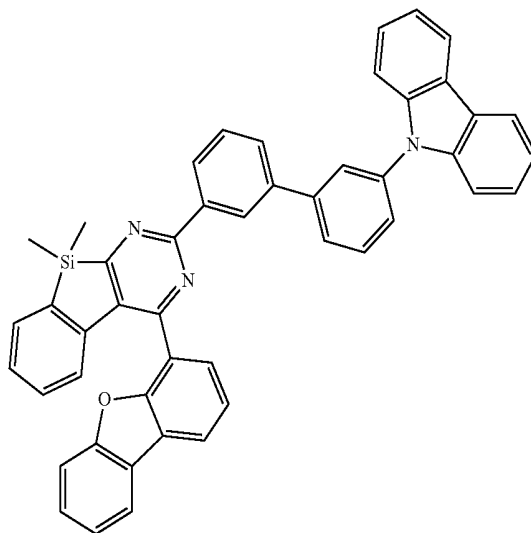
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g-79

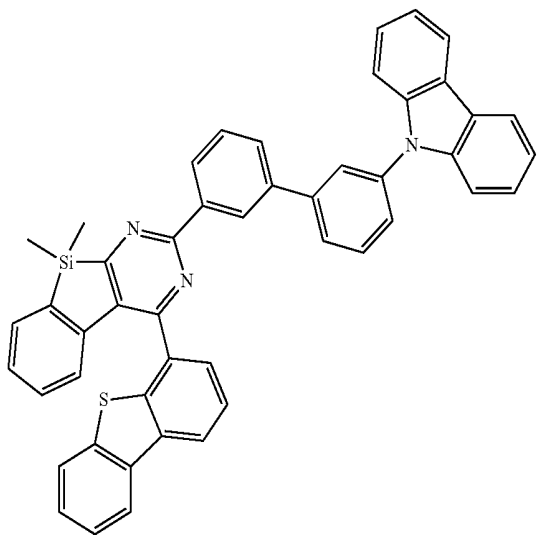


g-80



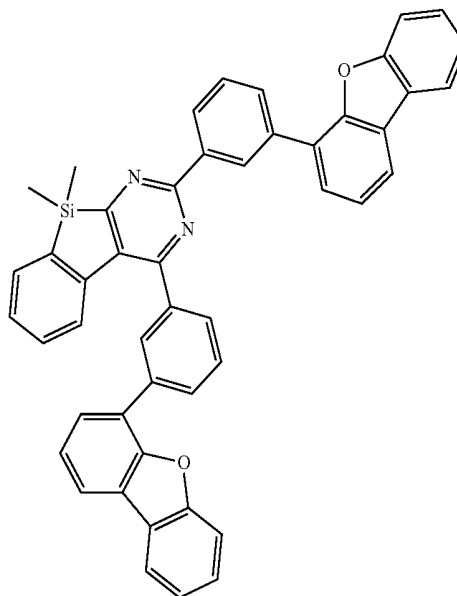
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g-81

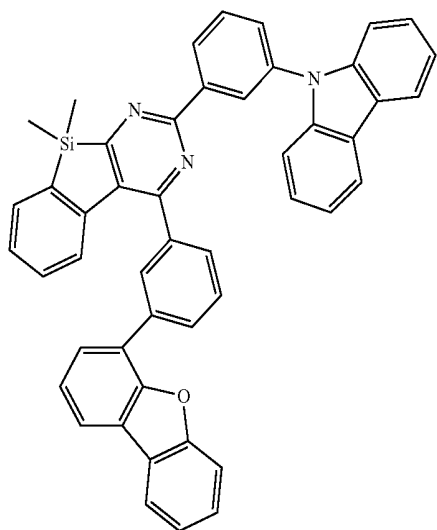


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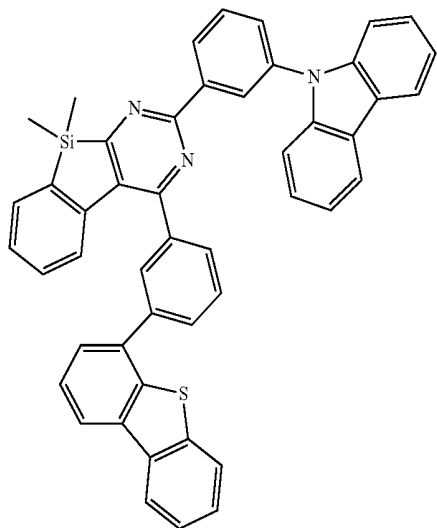
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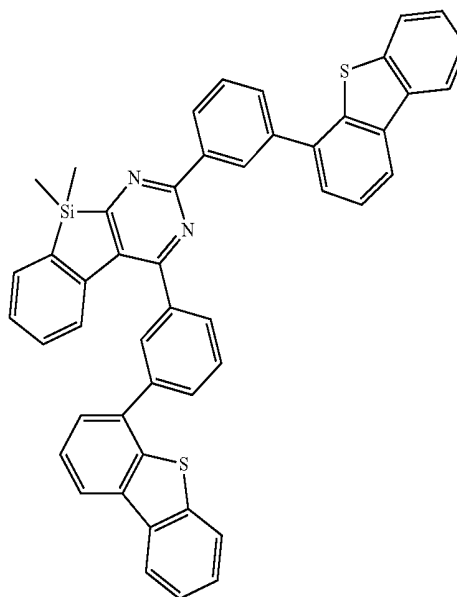
g-82



g-83

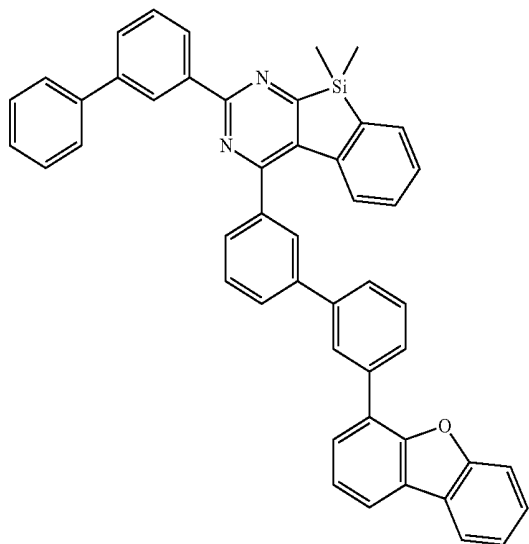


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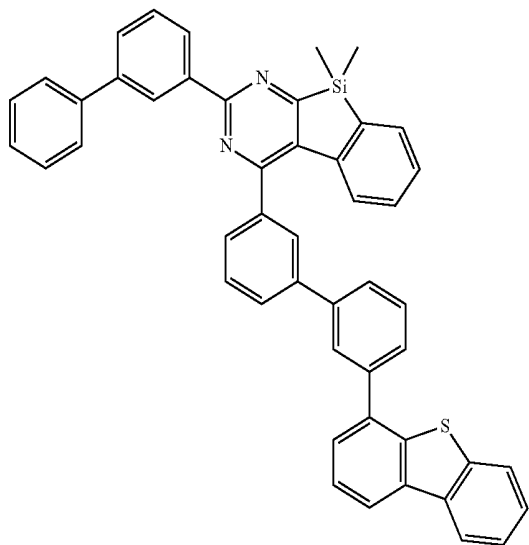


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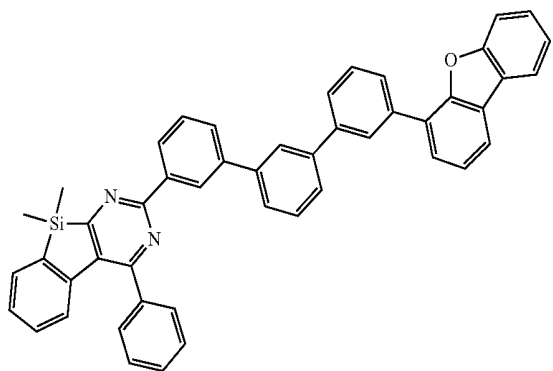
g-86



g-87

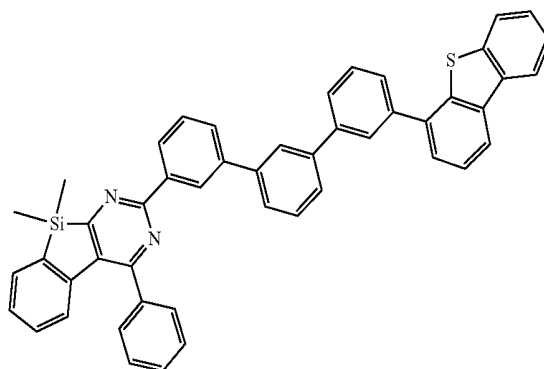


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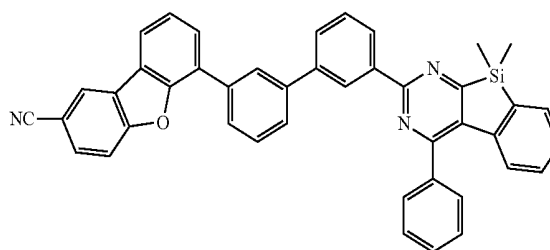


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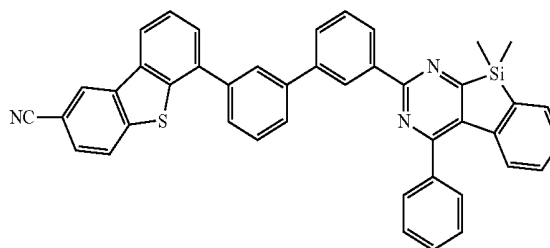
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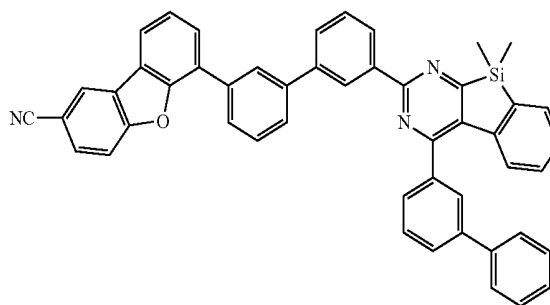
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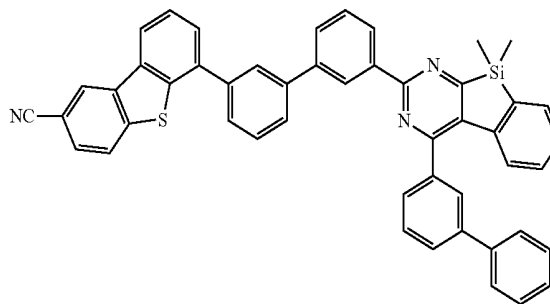
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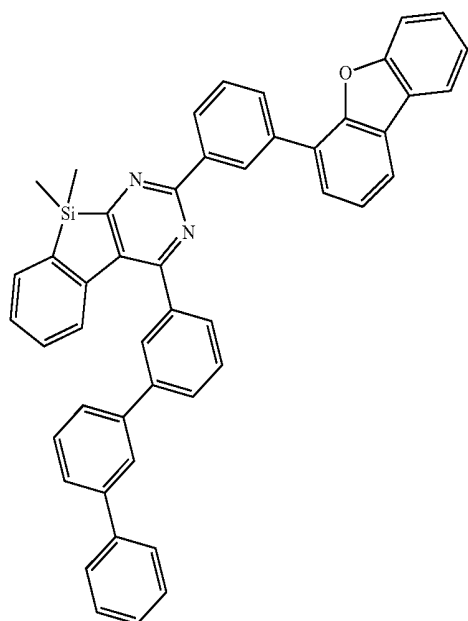
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g-93

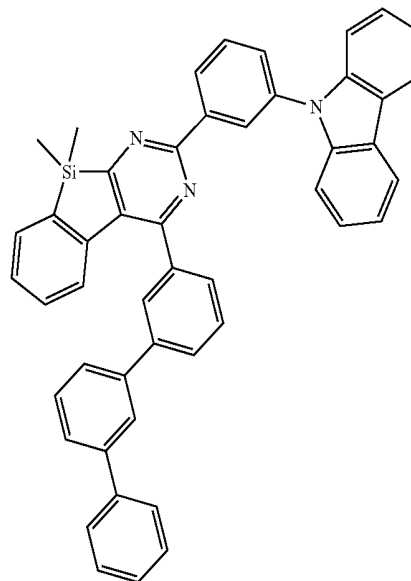


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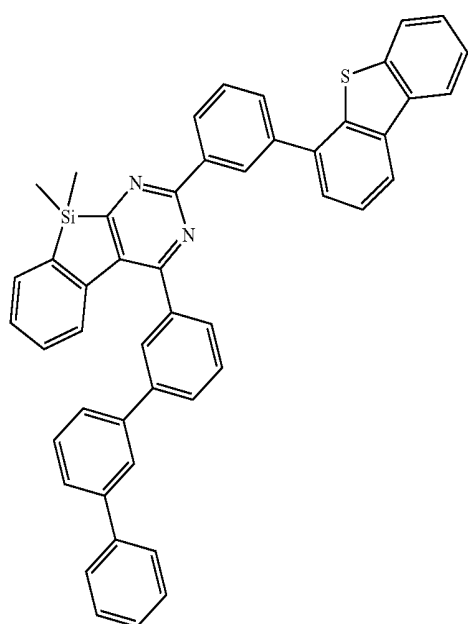


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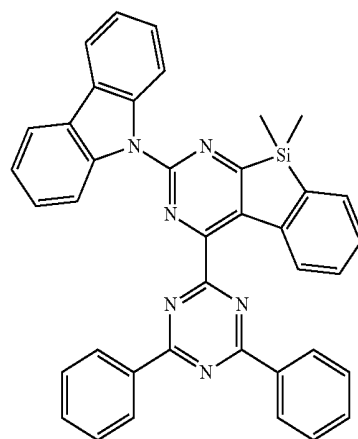
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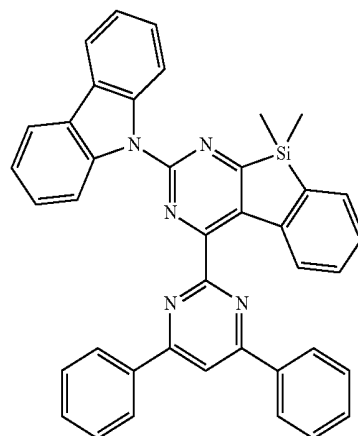
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g-95



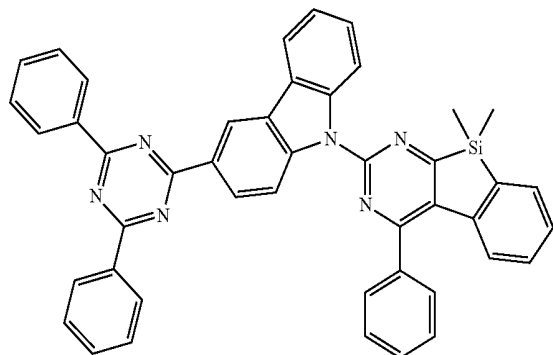
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g-98

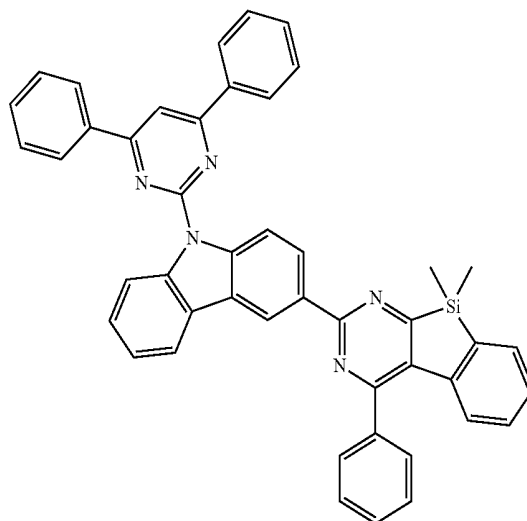
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g-99

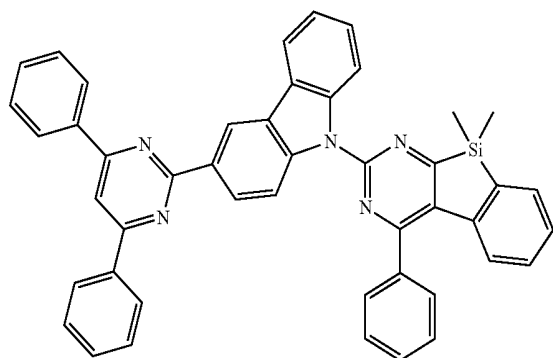


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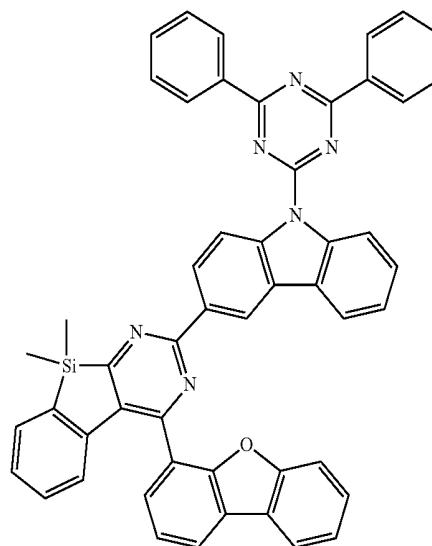
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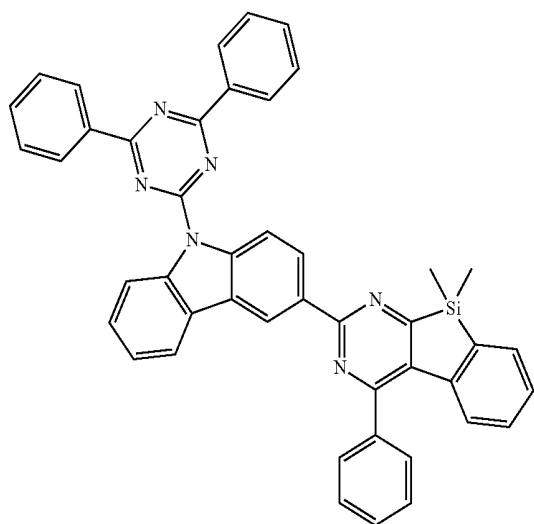
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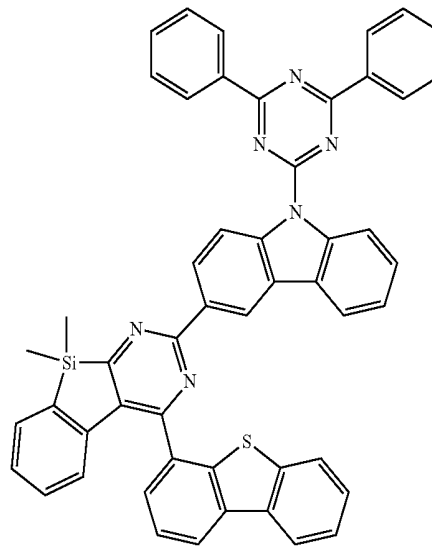
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g-101

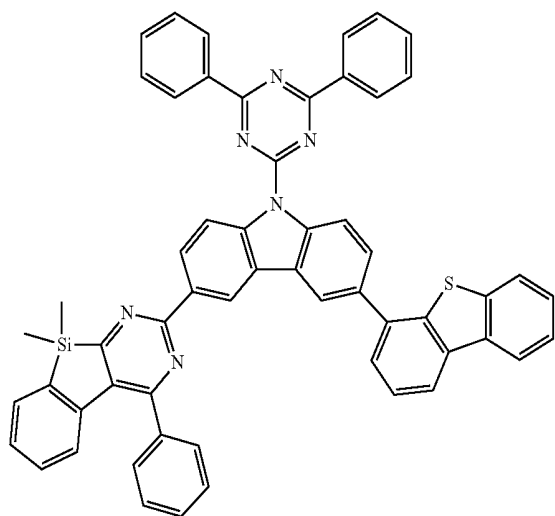


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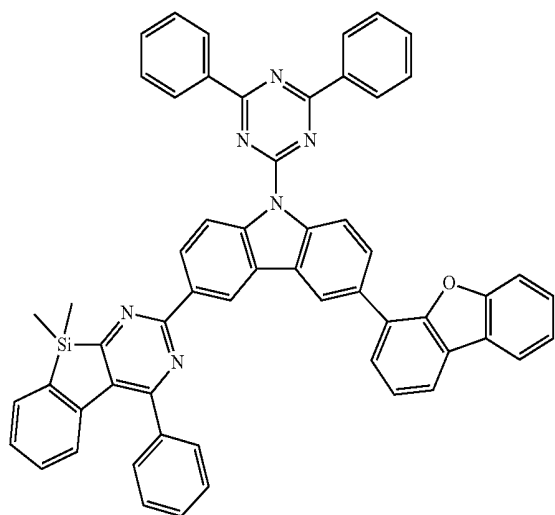


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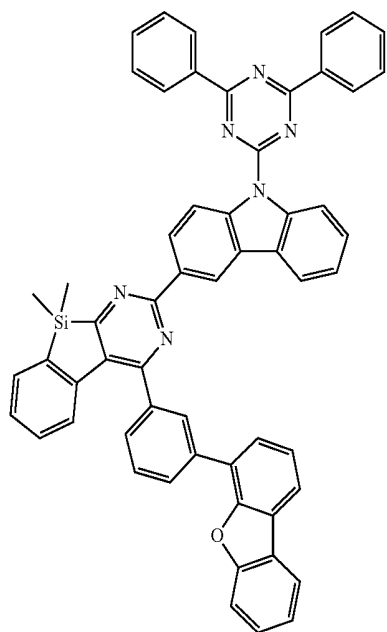
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g-106

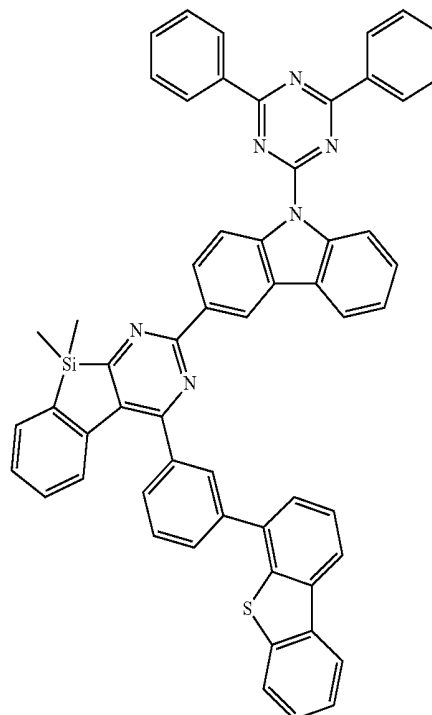


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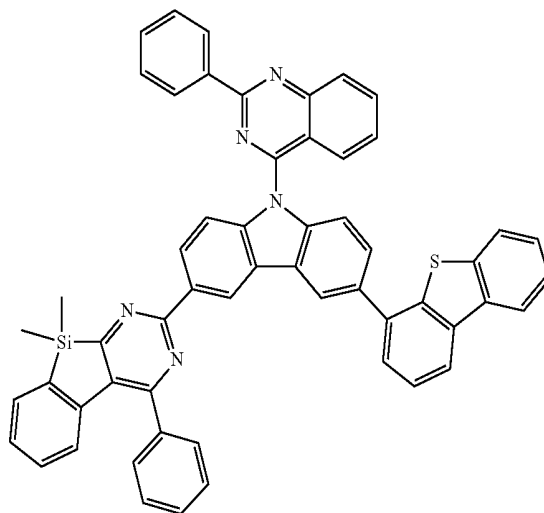


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g-108

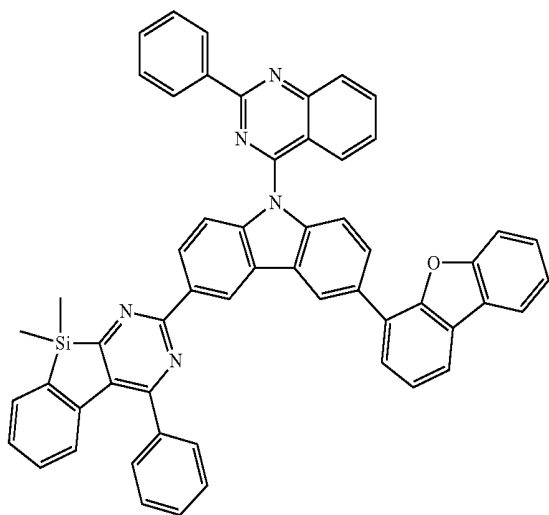


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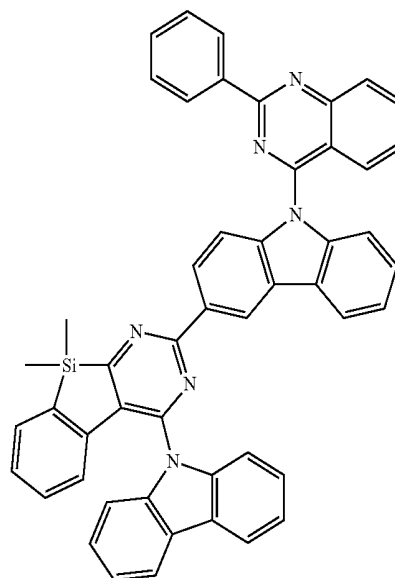
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g-110



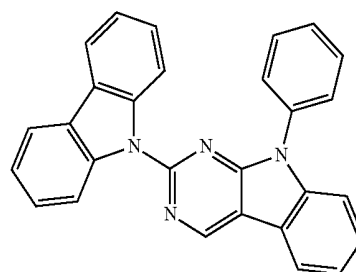
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g-112

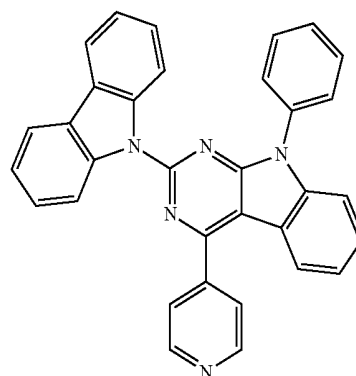
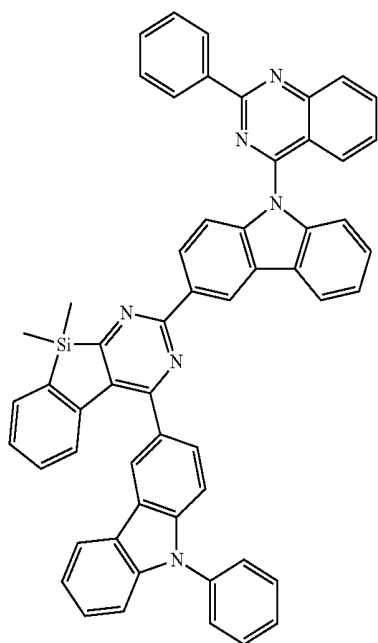
[0164] Group of  $X1=N-[(L_1)a1-(R_1)b1]$  in Formula 1-2[0165] ( $L_1$ ,  $a1$ ,  $R_1$  and  $b1$  are Described in the Above Specification)

227

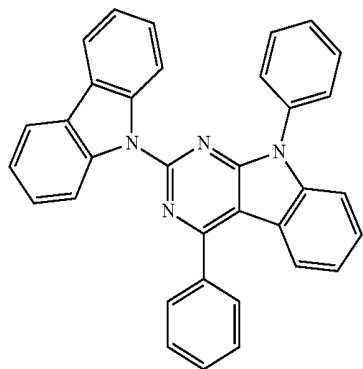
g-111



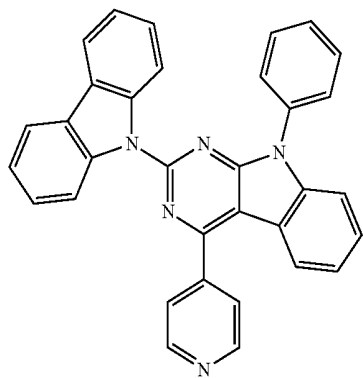
228



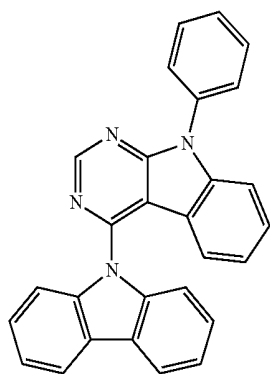
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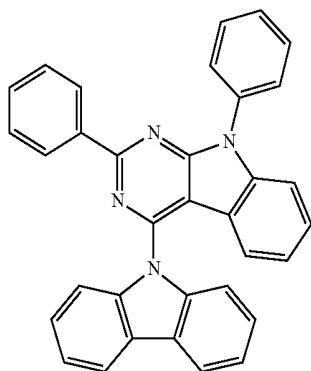
229



230

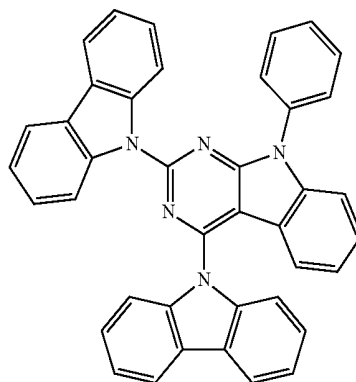


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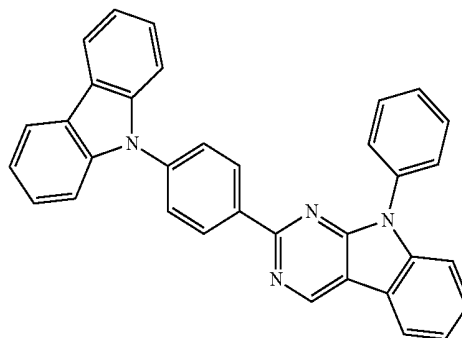


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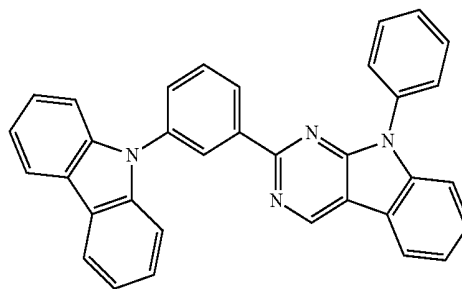
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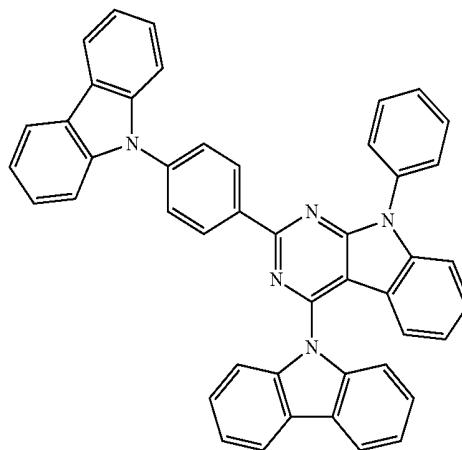
233



234



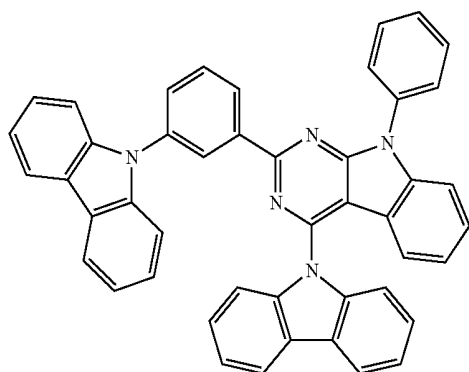
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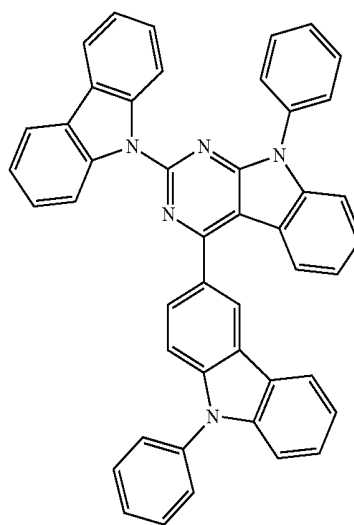
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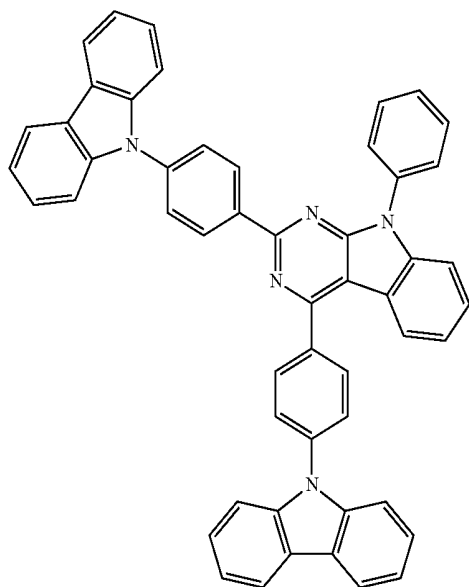


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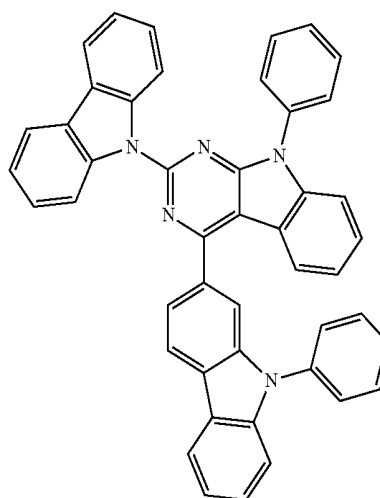
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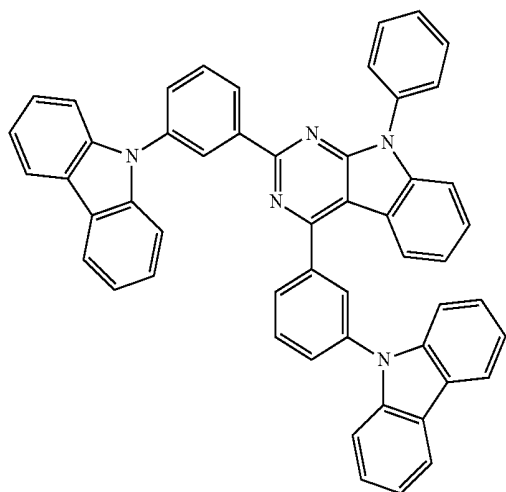
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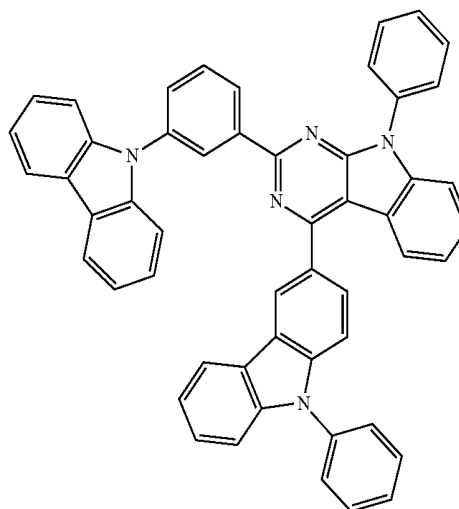
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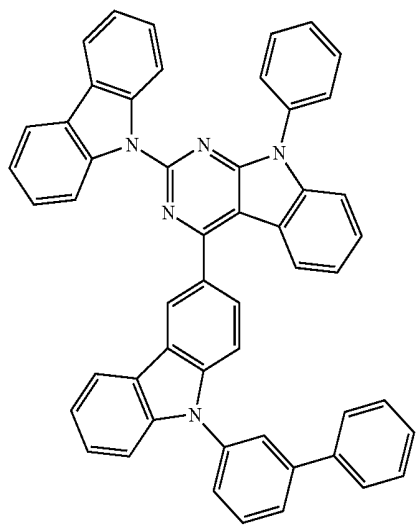
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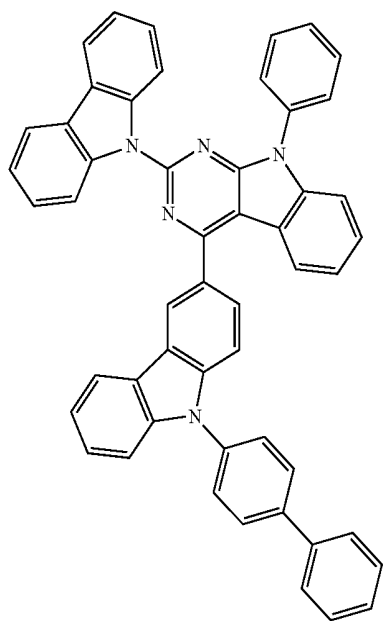
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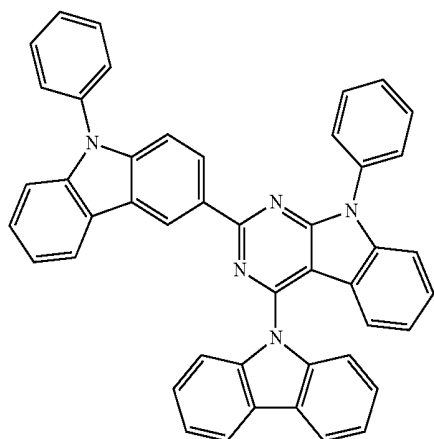
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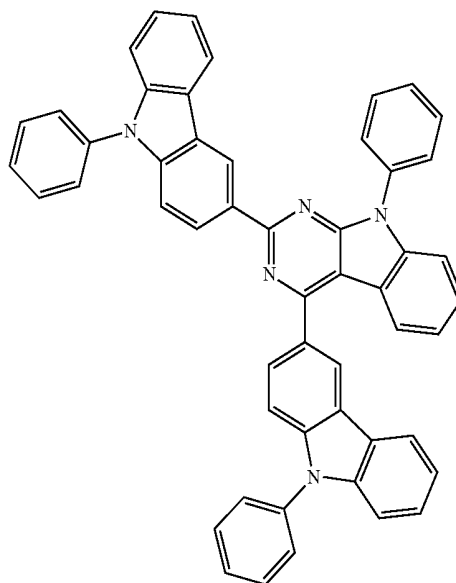


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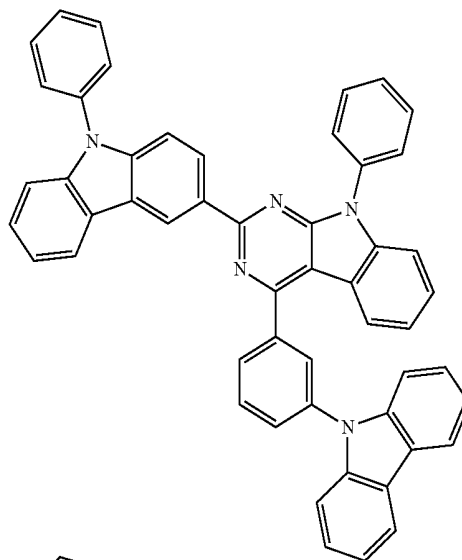


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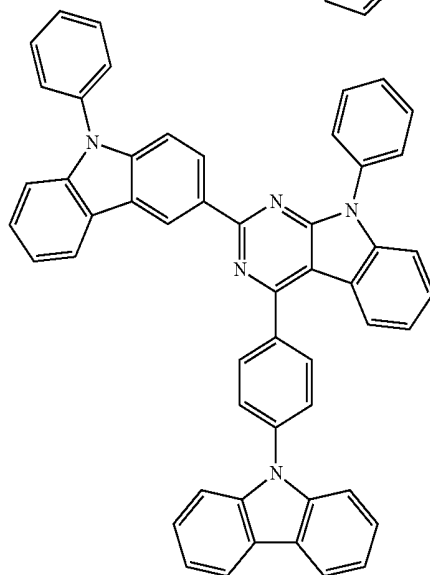
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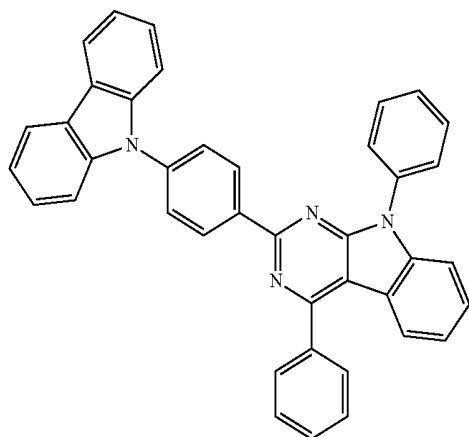
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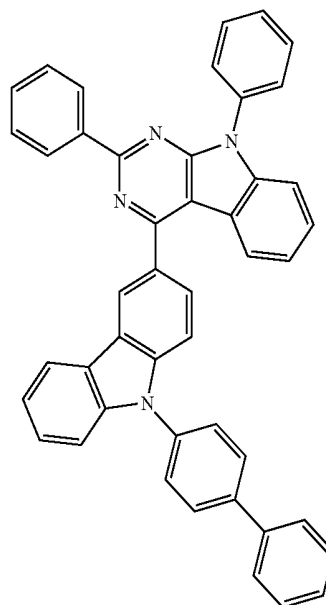
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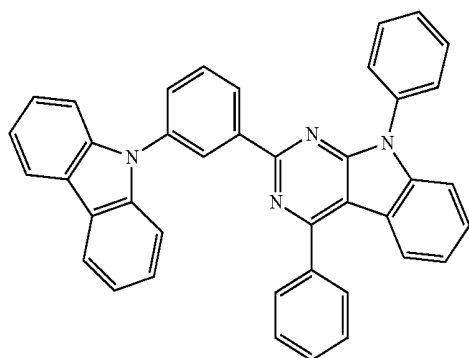


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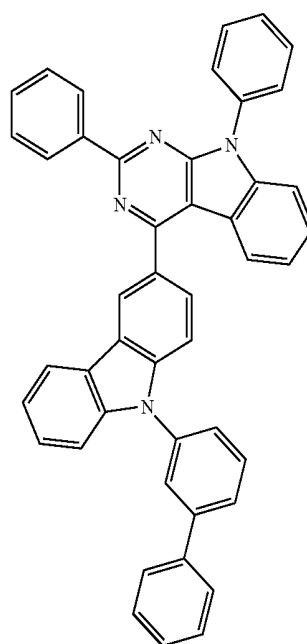
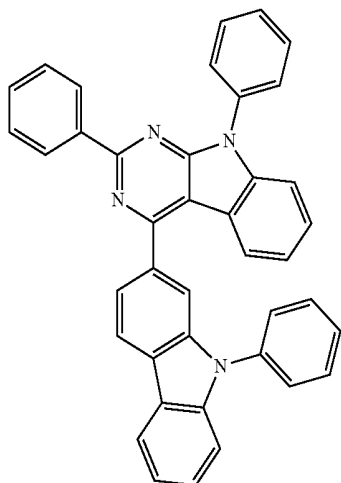


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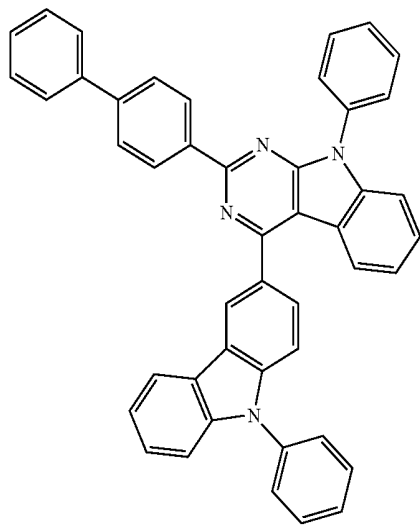


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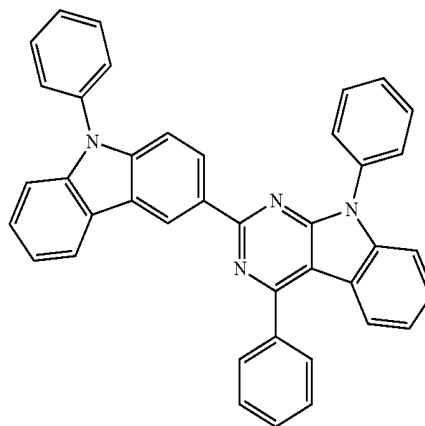


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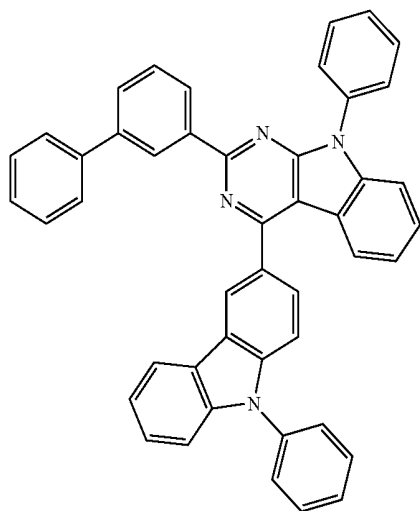
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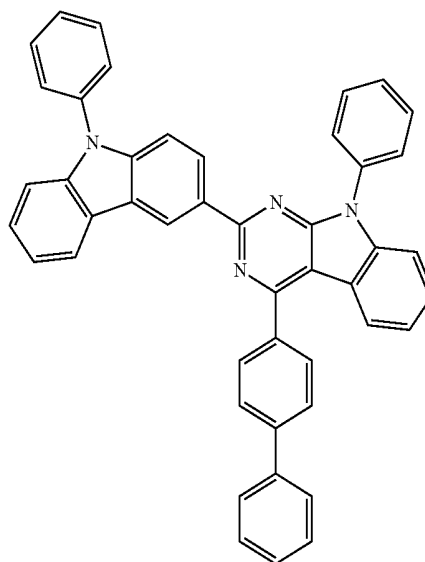


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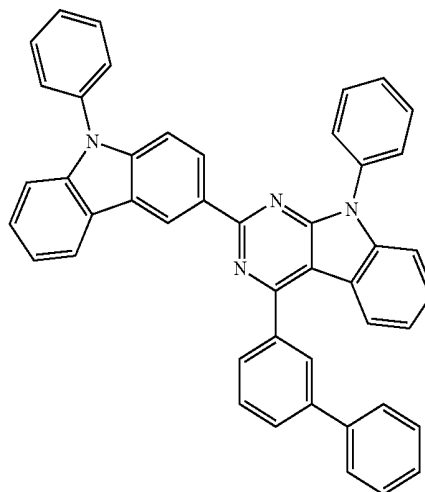
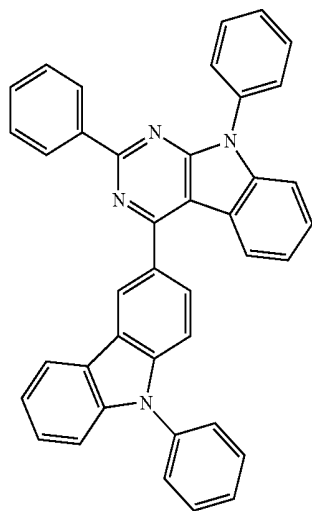


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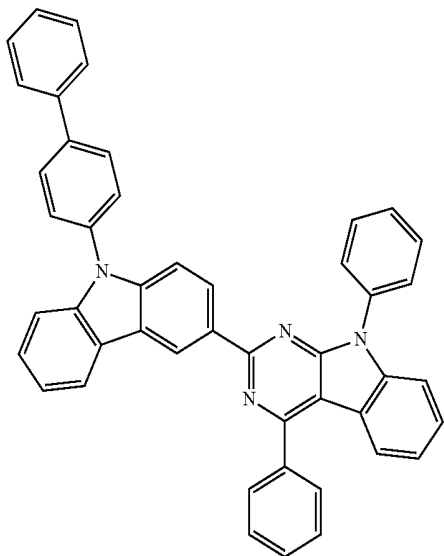
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h-3



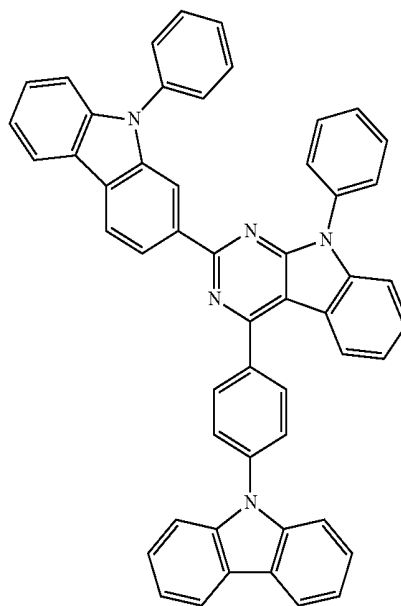
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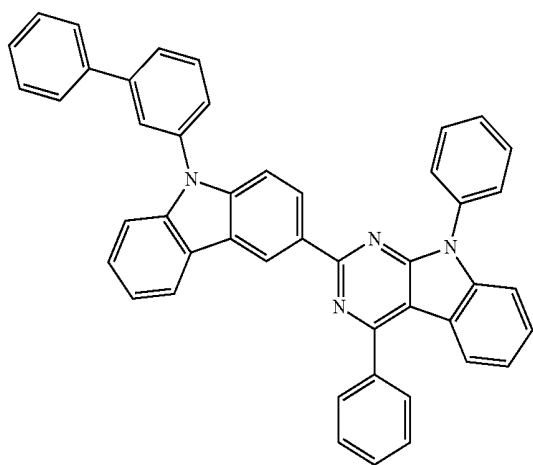


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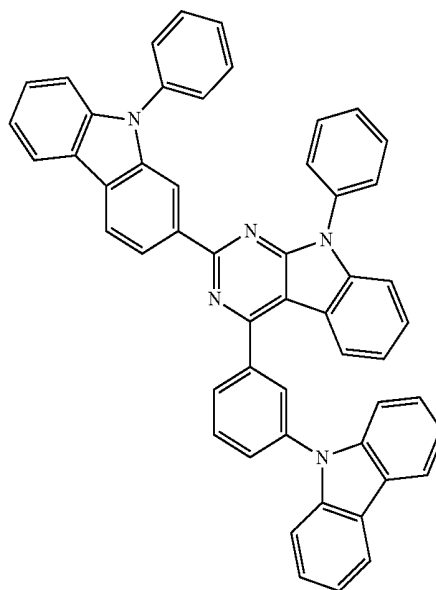
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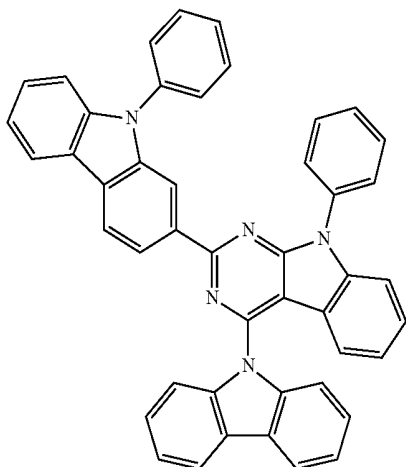
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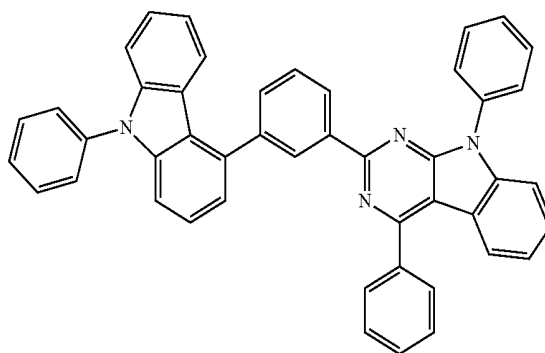
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h-6

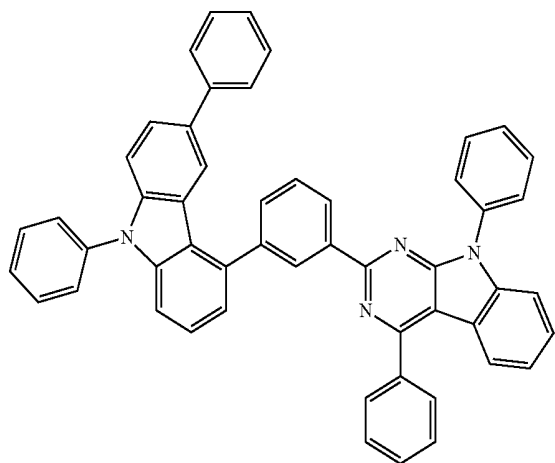


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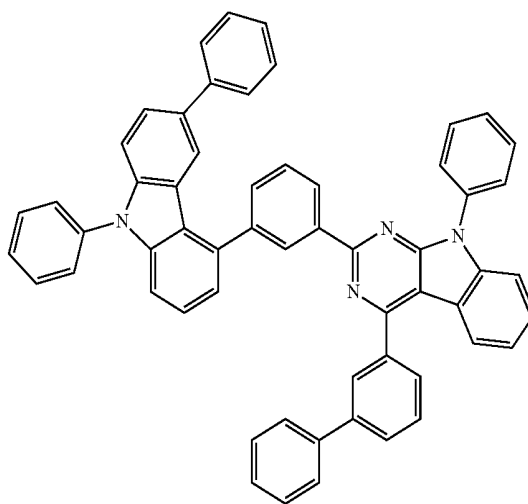
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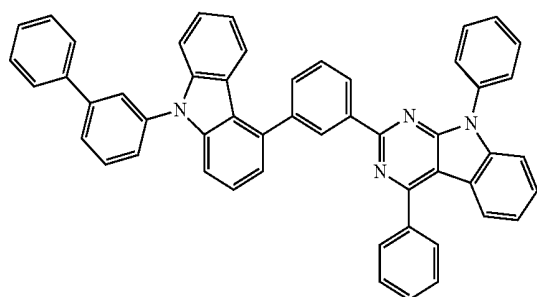


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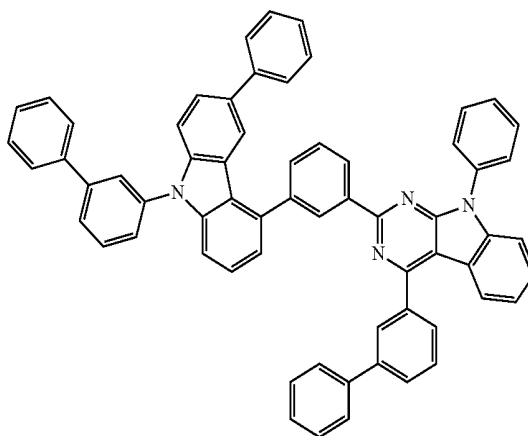
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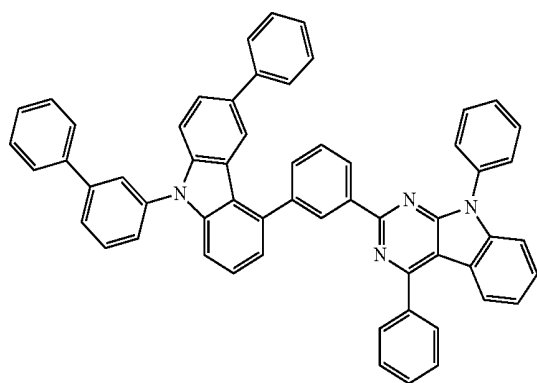
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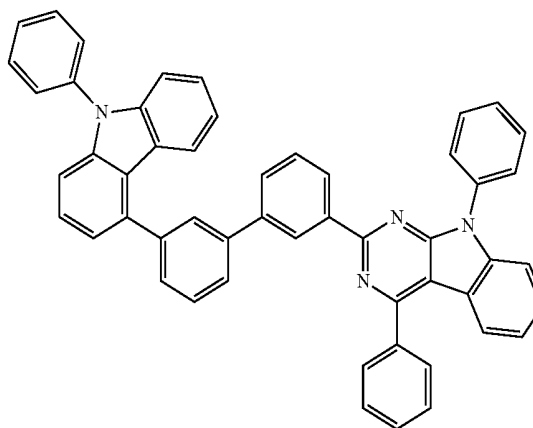
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h-12

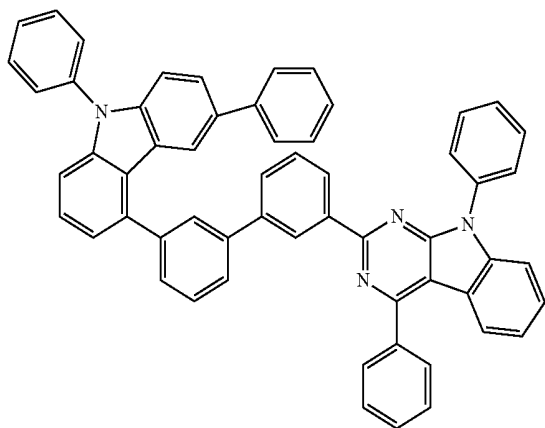


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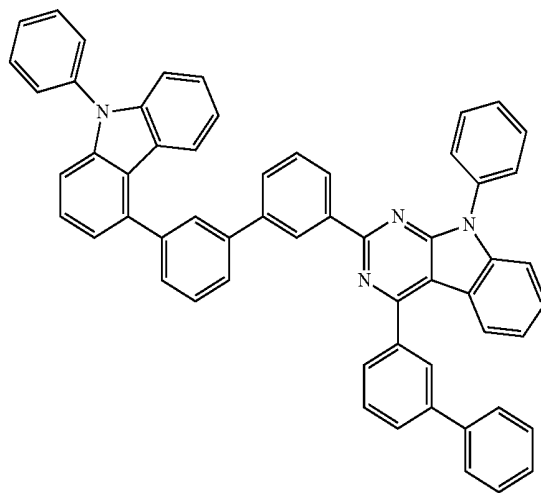
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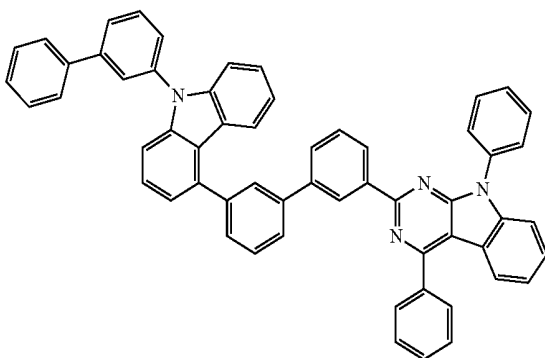


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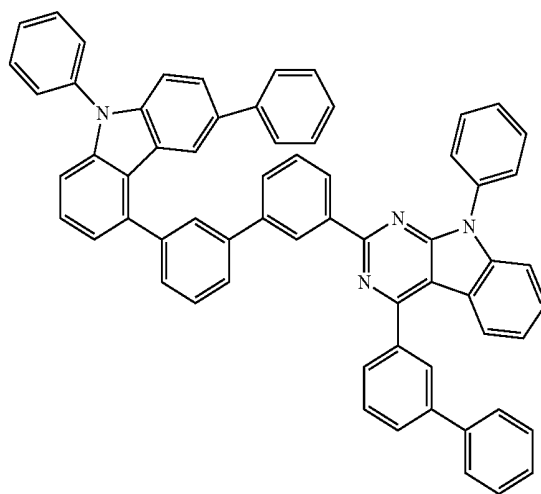
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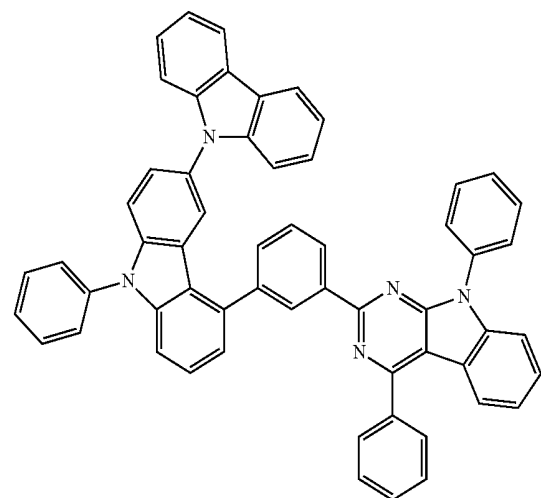
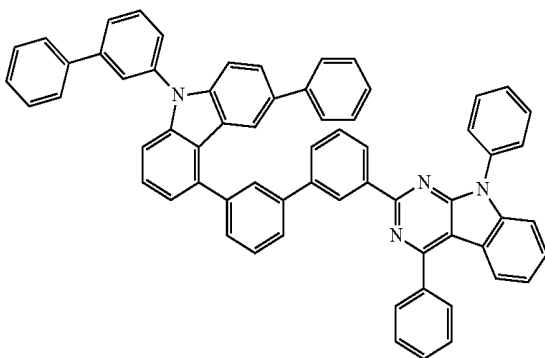


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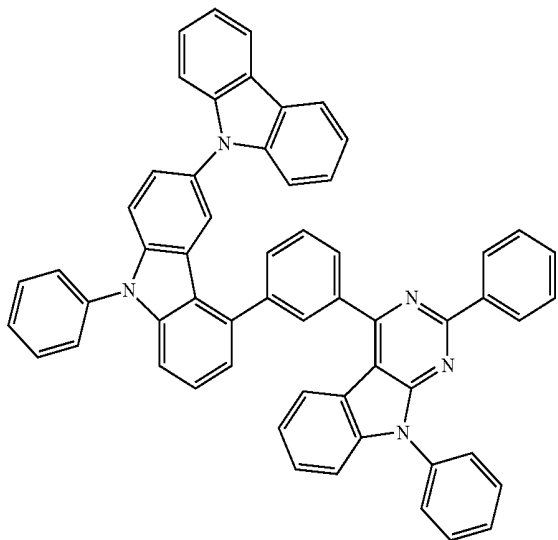
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h-18



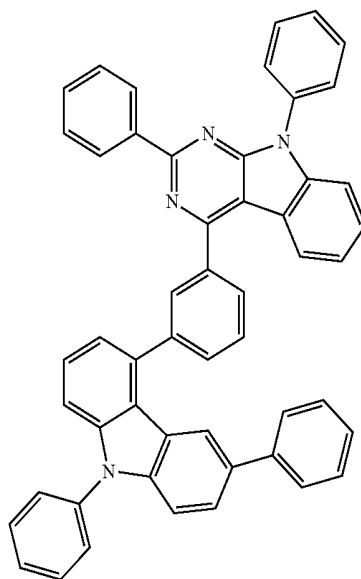
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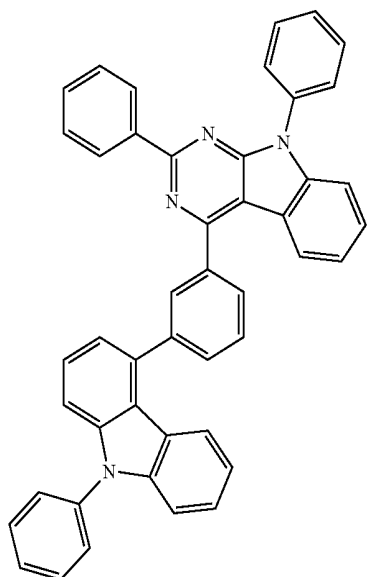


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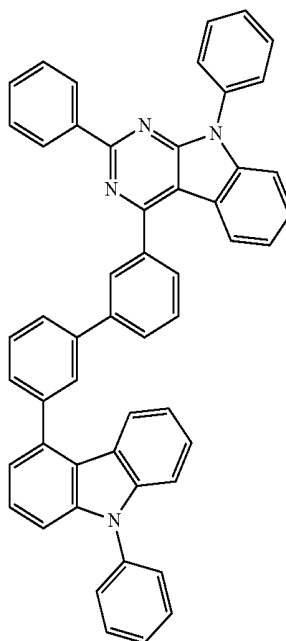
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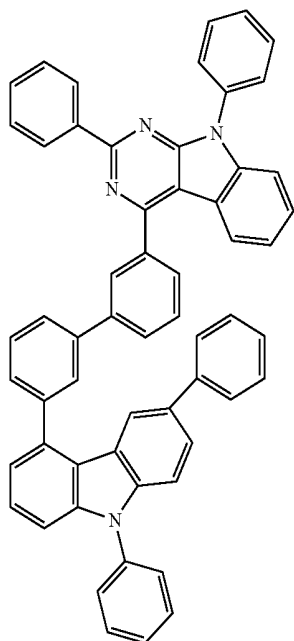
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h-25

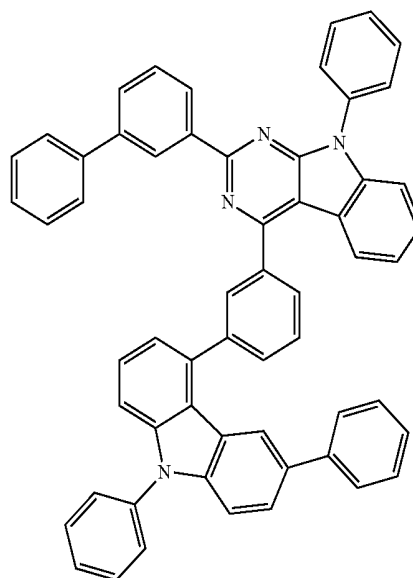


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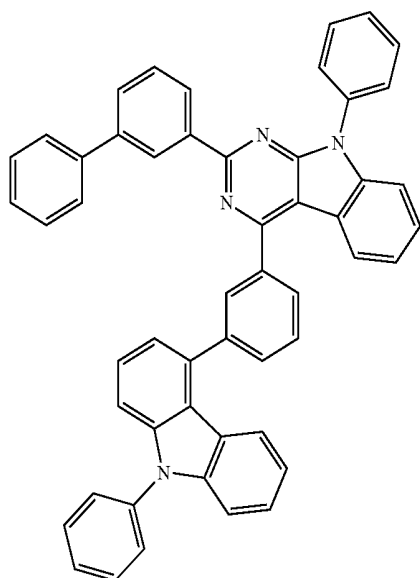


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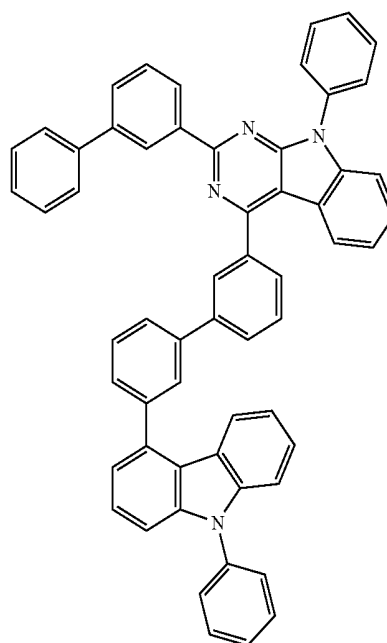
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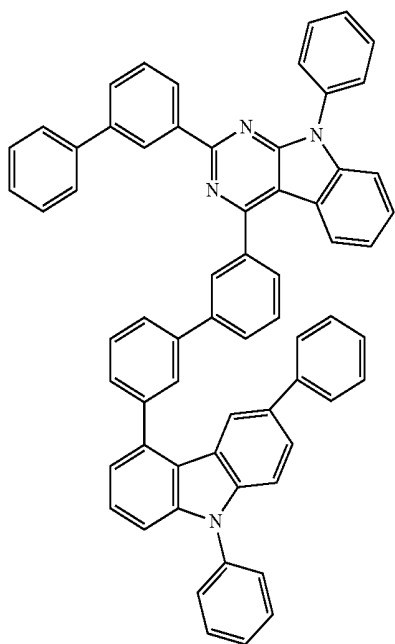


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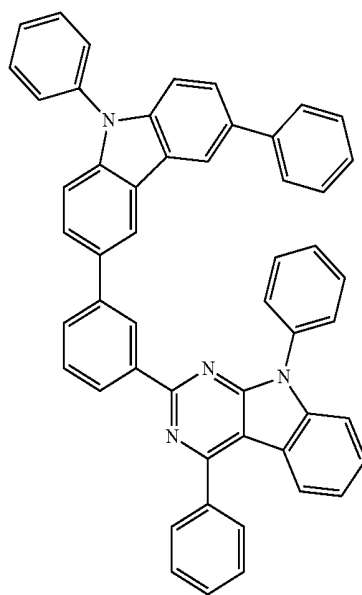
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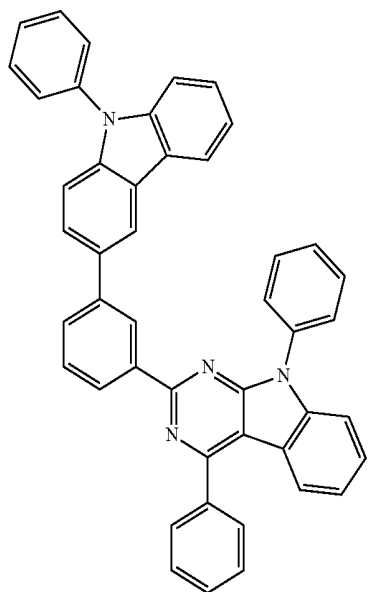


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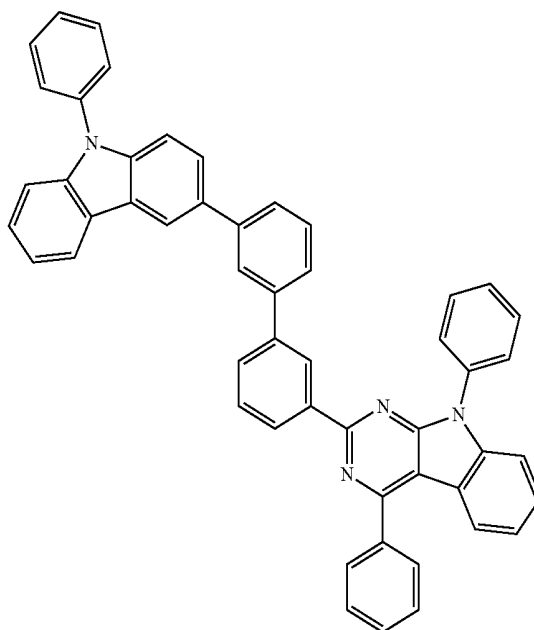
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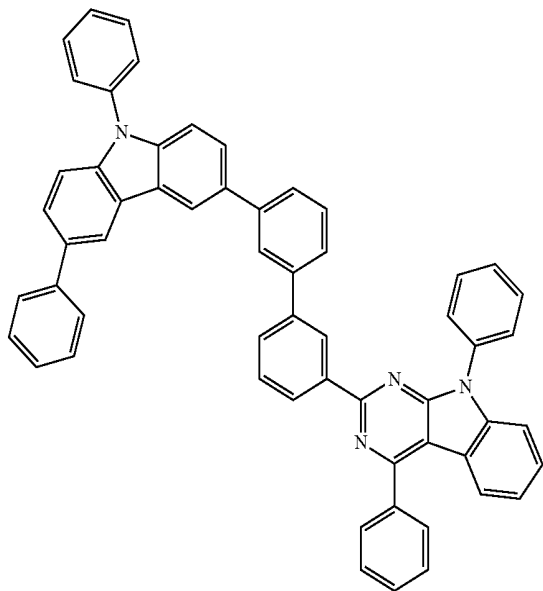
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h-33

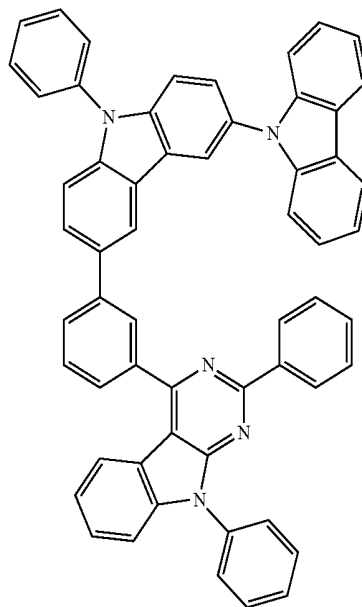
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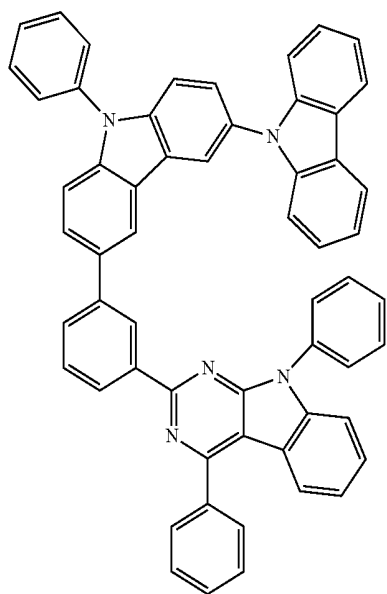


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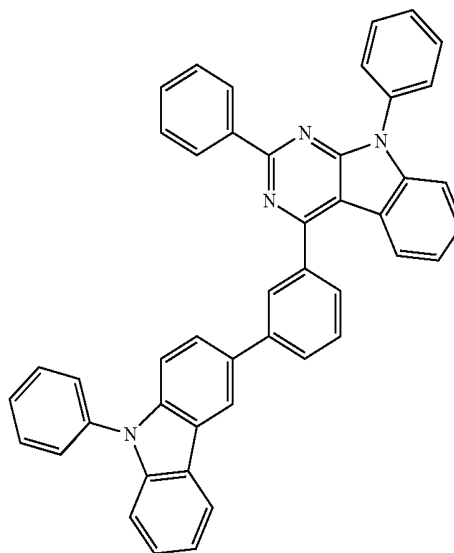
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h-35

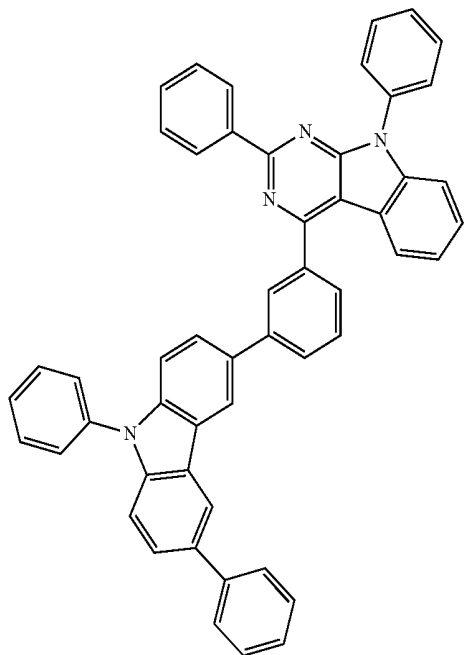


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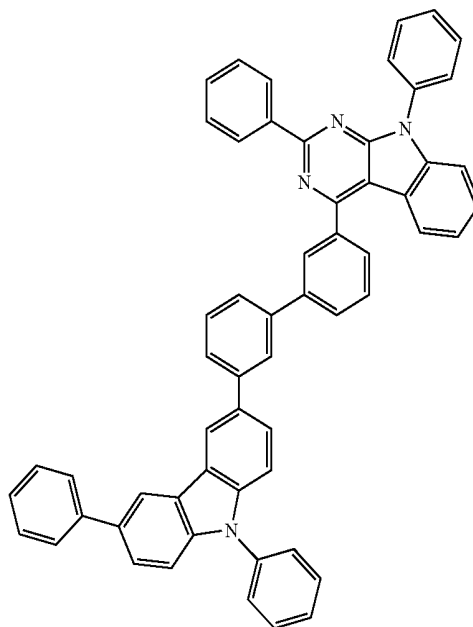
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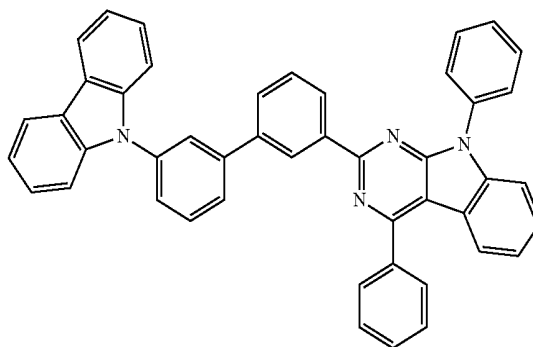


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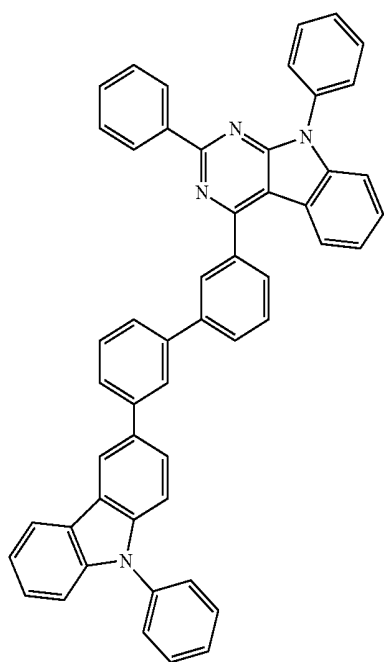
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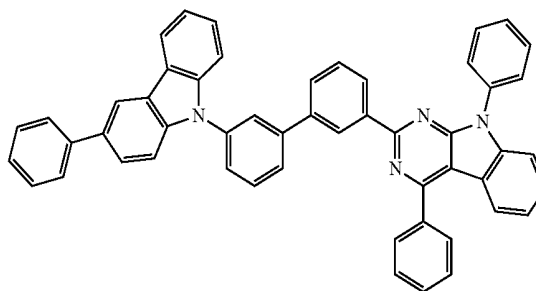
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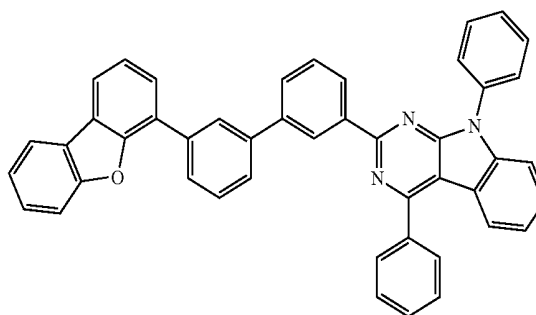
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h-42

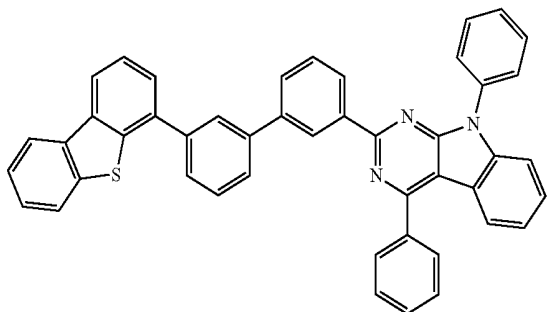


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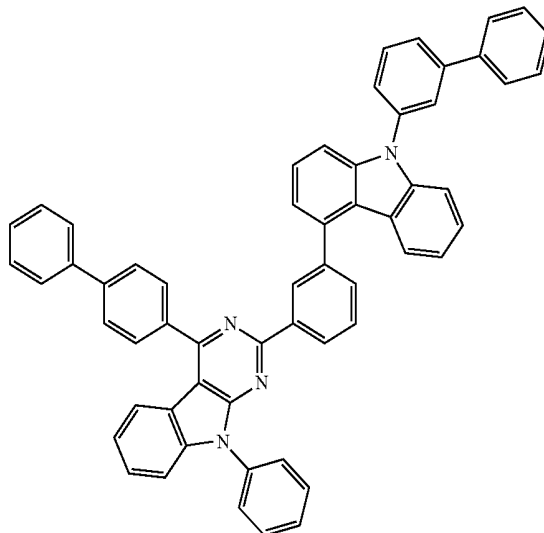
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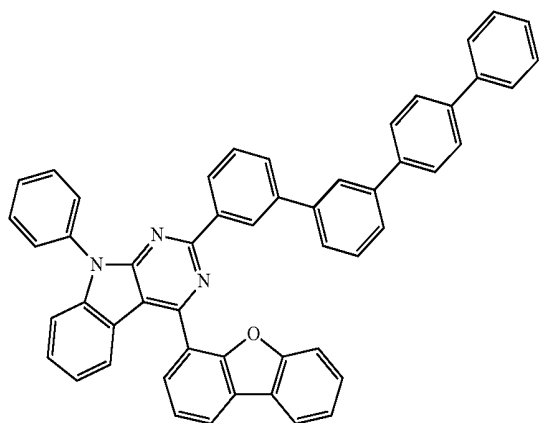


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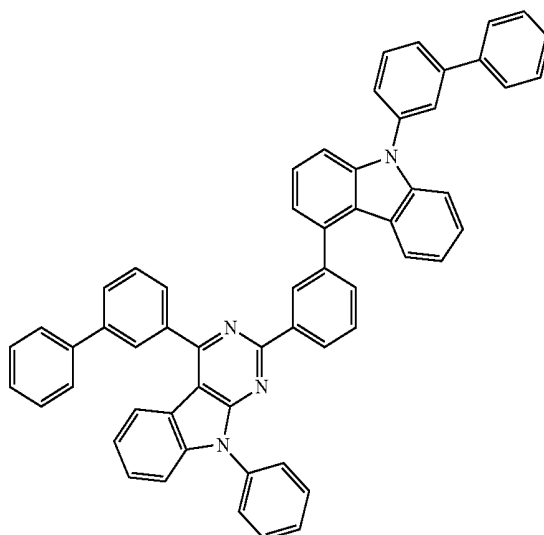
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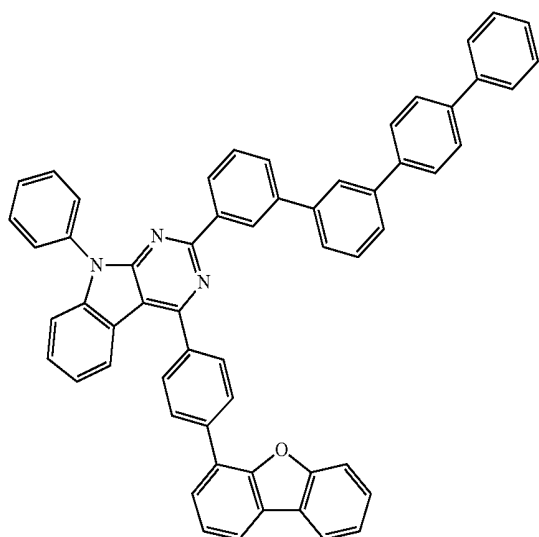
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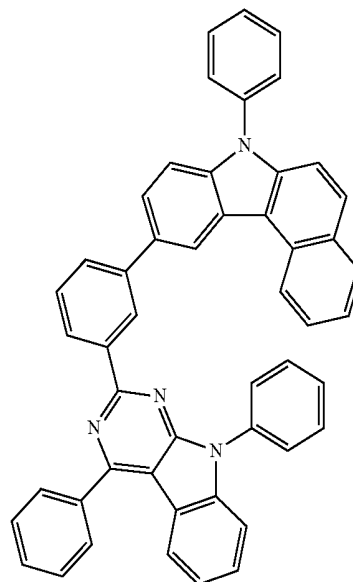
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h-46

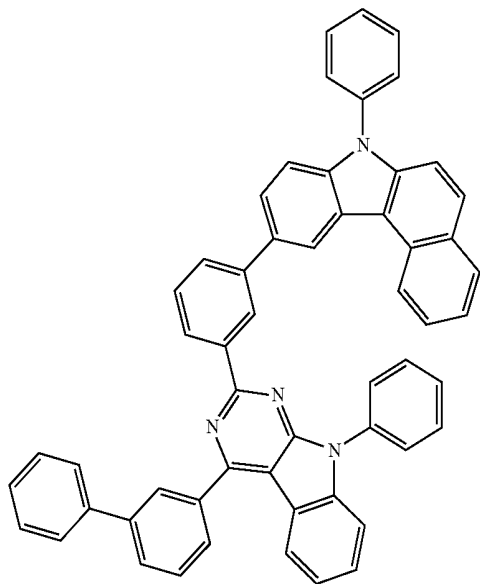


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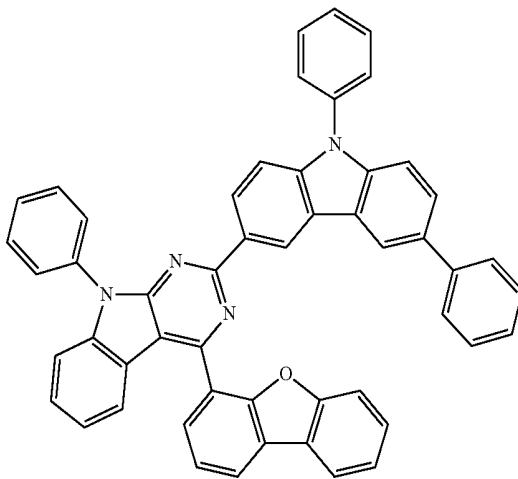
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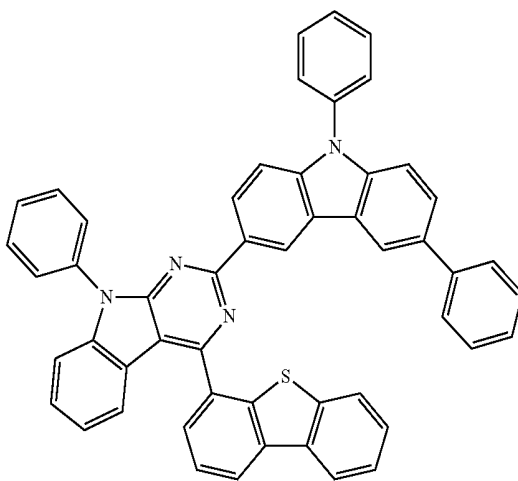
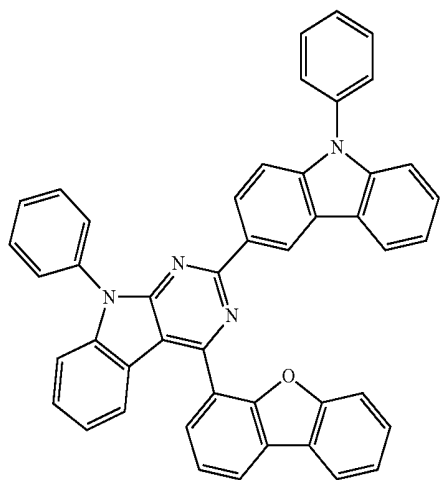
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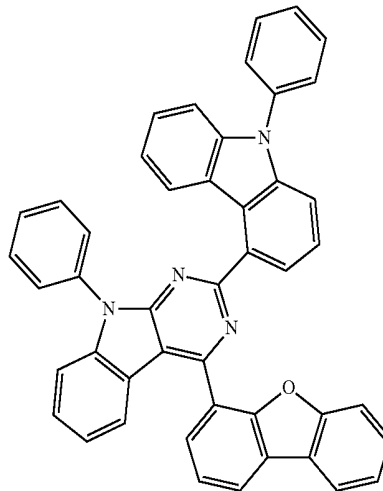
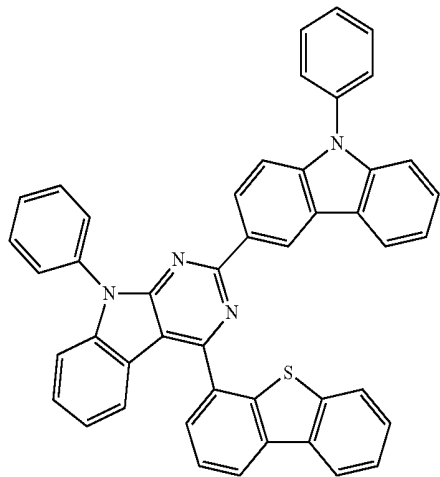
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h-51

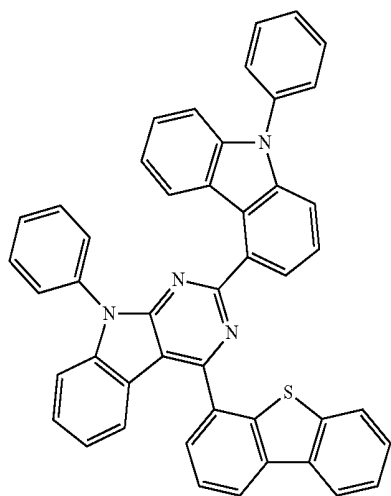


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h-52

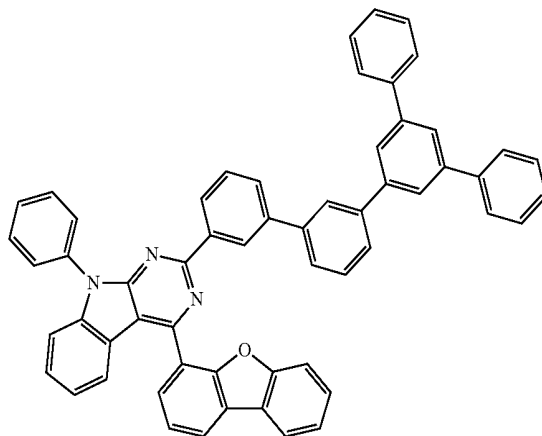


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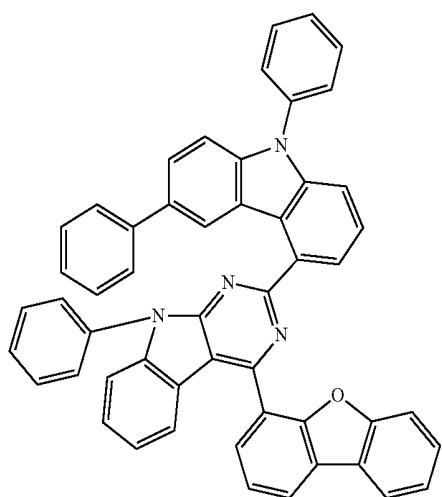


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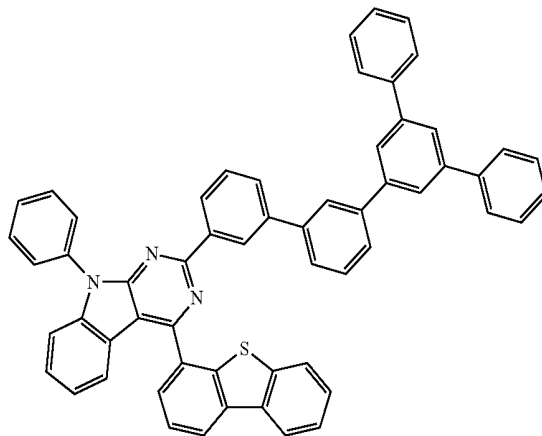
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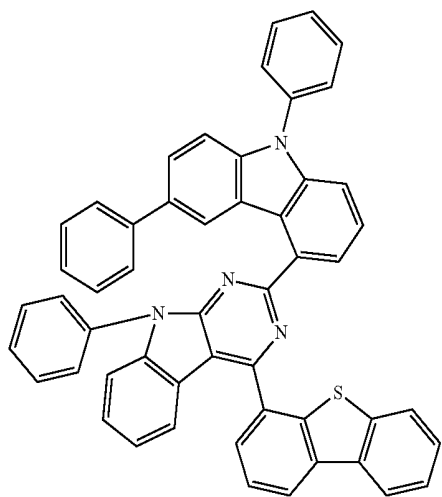
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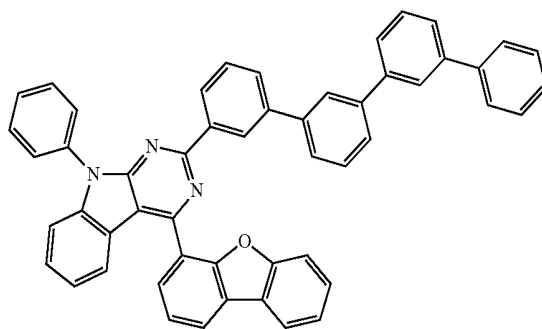
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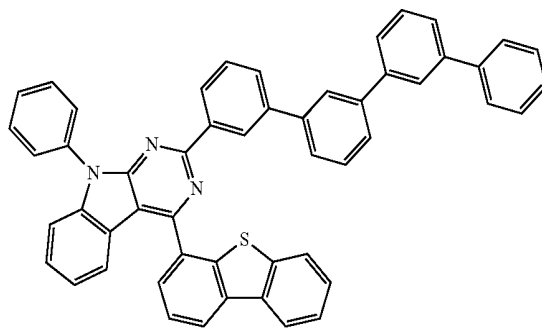
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h-58



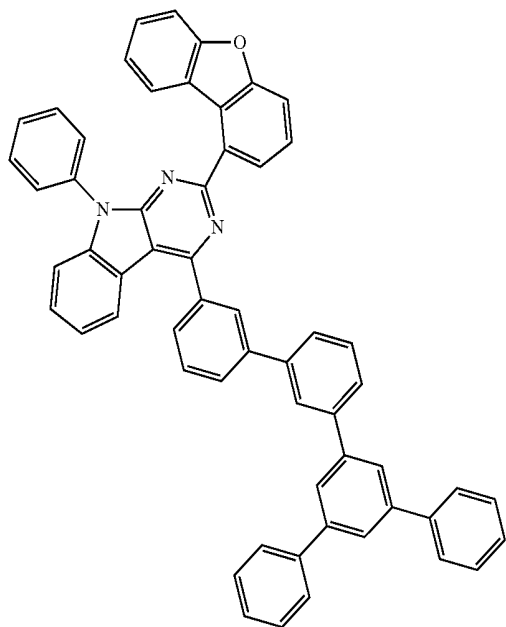
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h-62

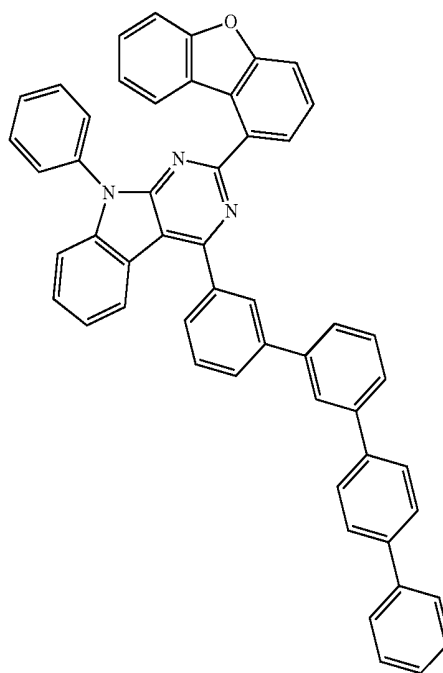
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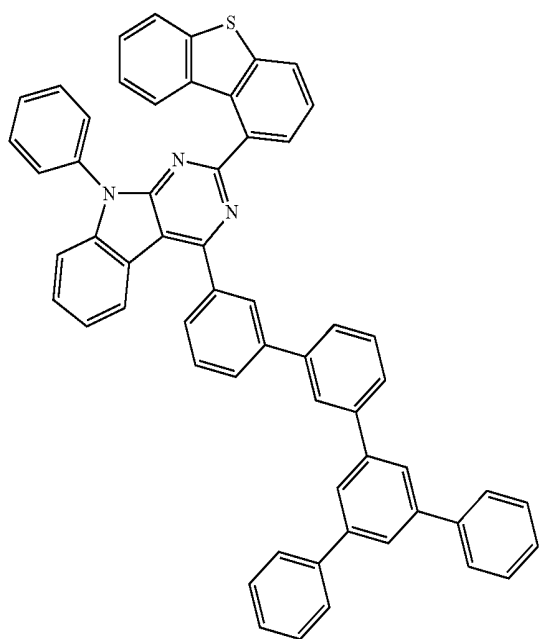


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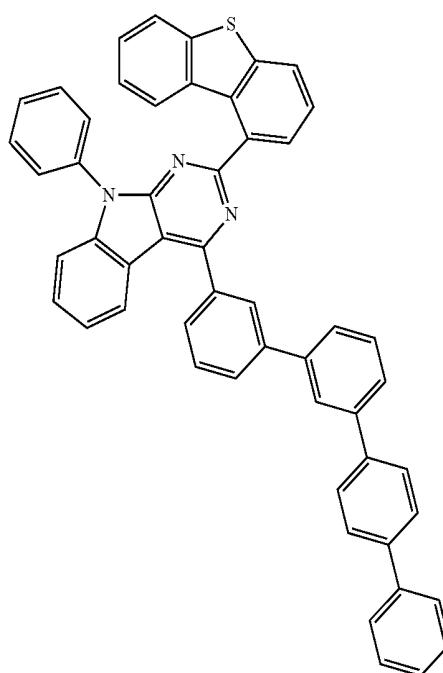
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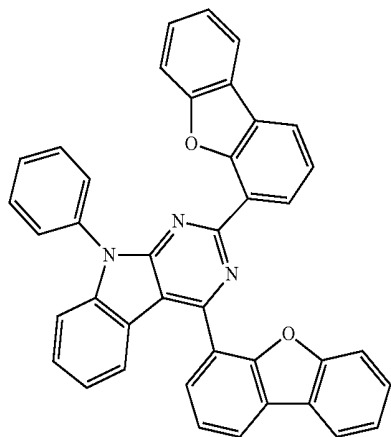
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h-66

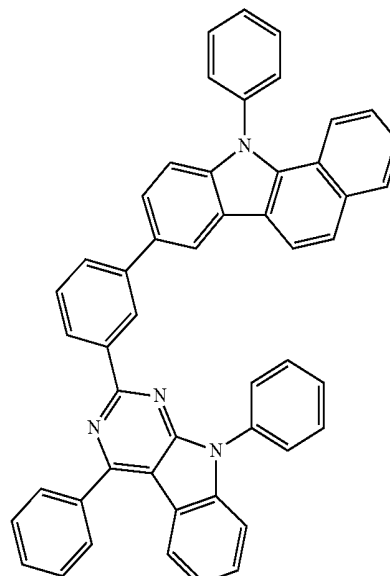


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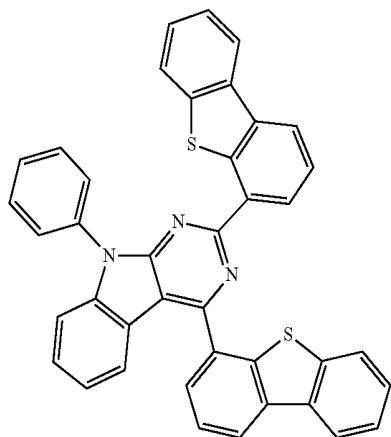
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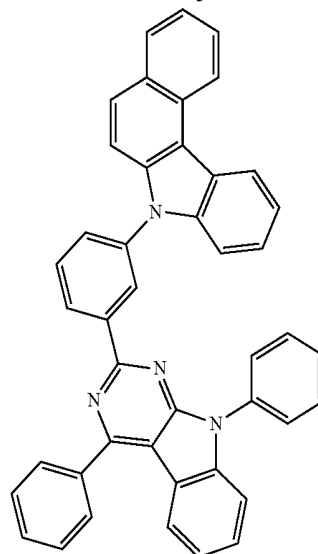


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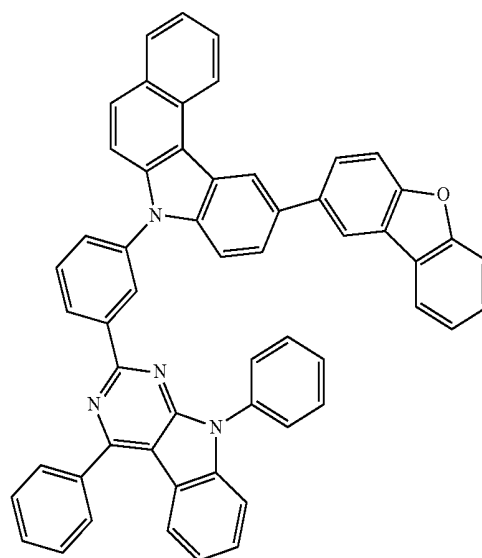
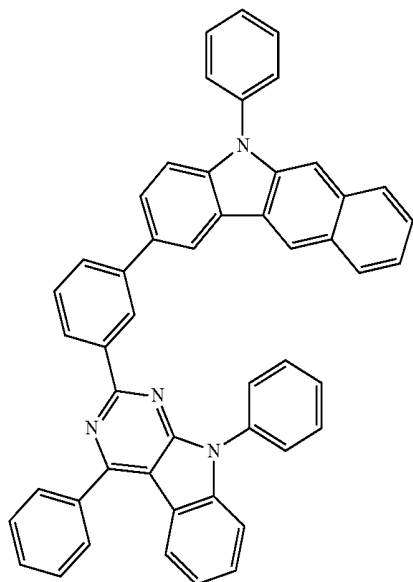
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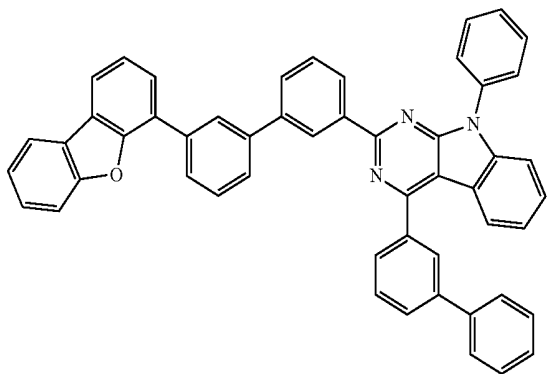
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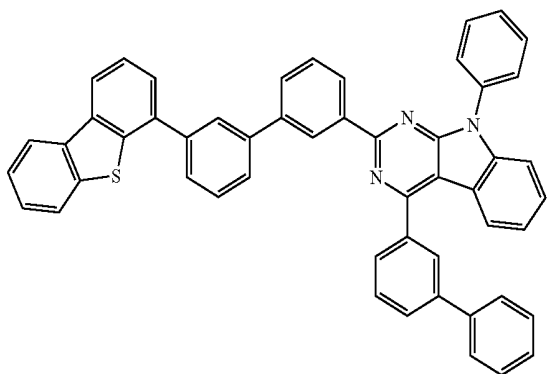
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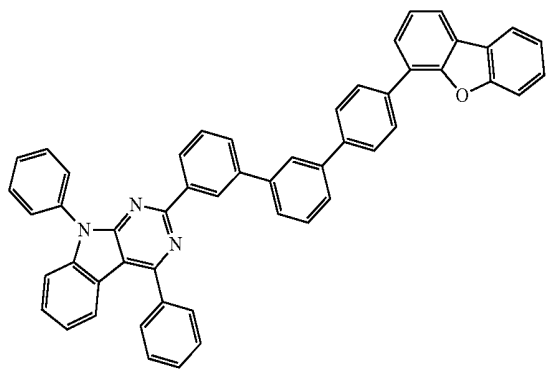
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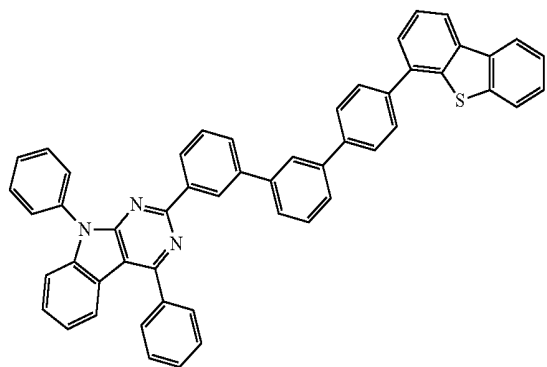
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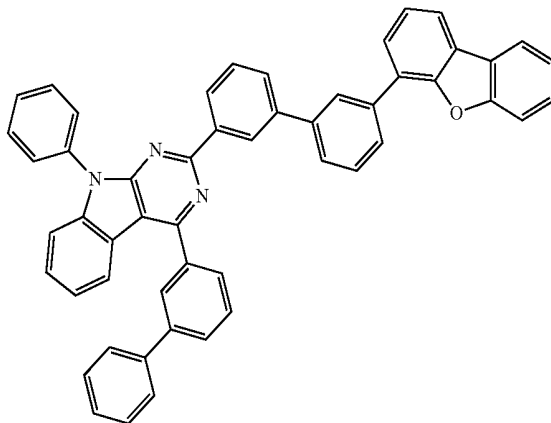


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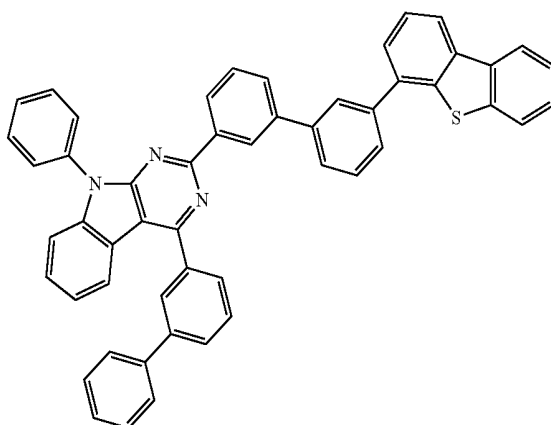


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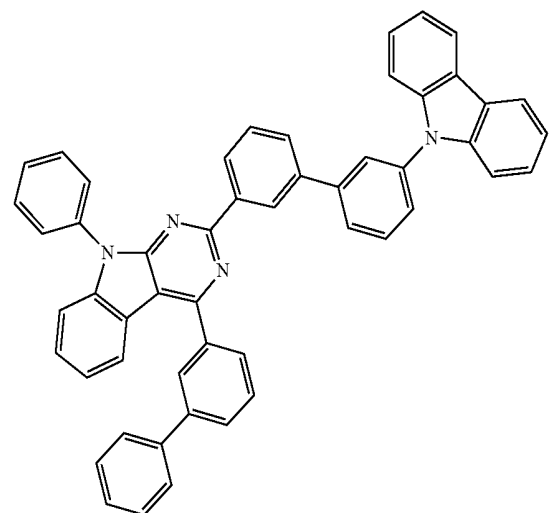
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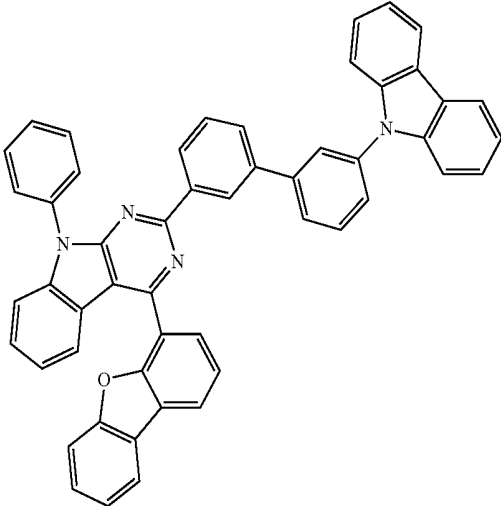


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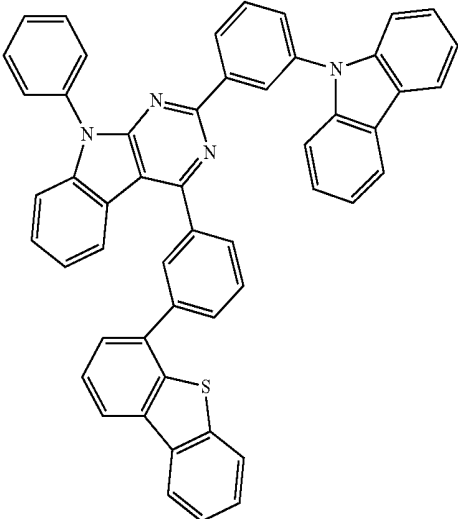
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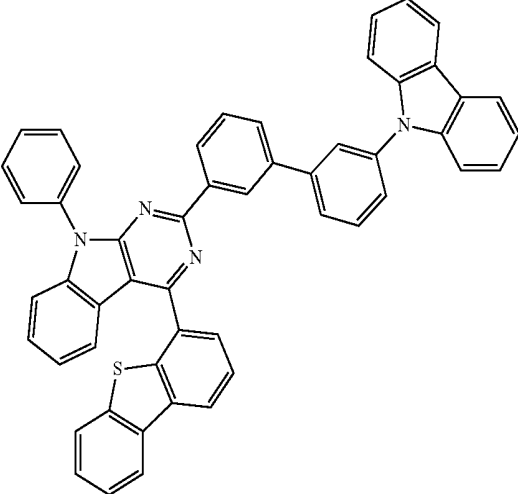


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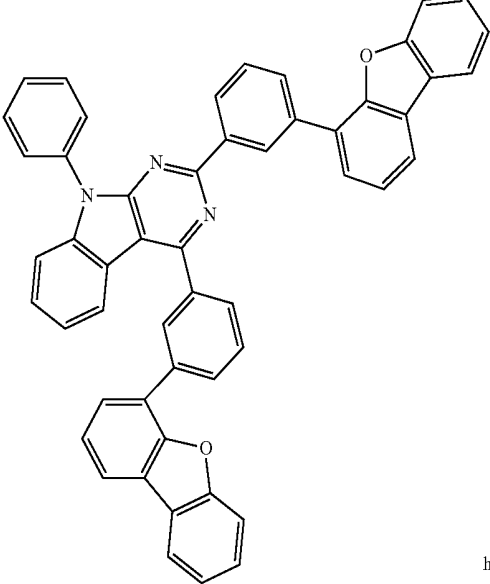
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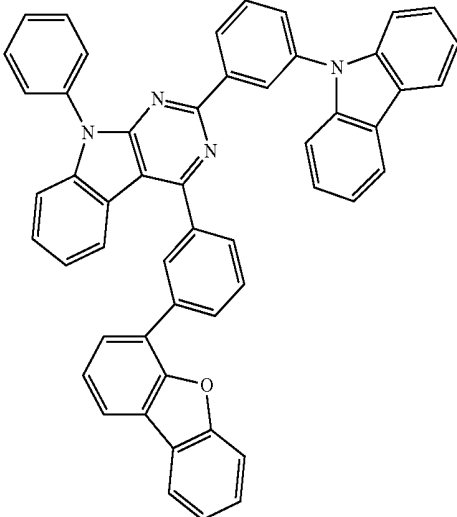
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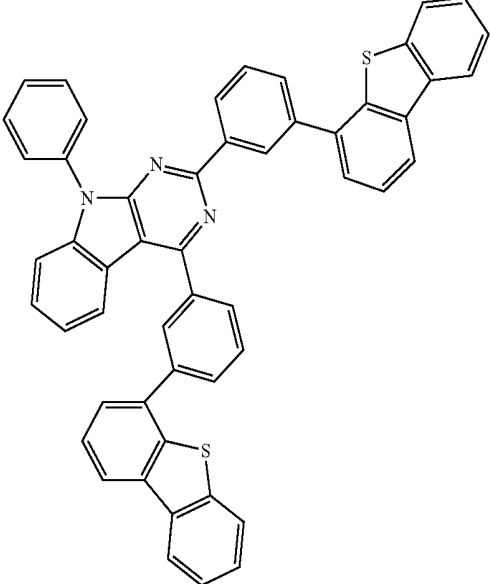
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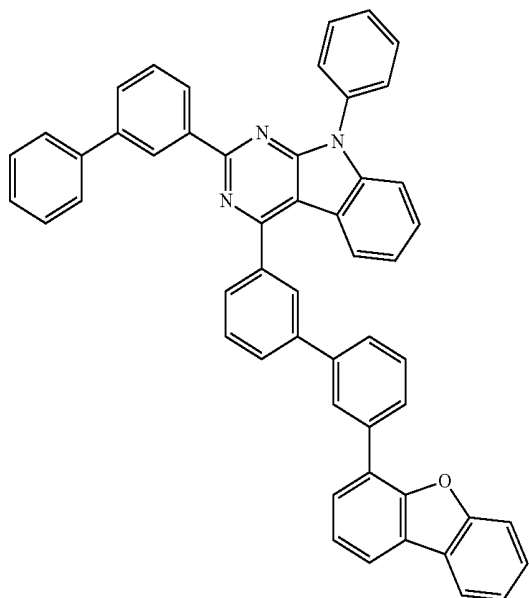


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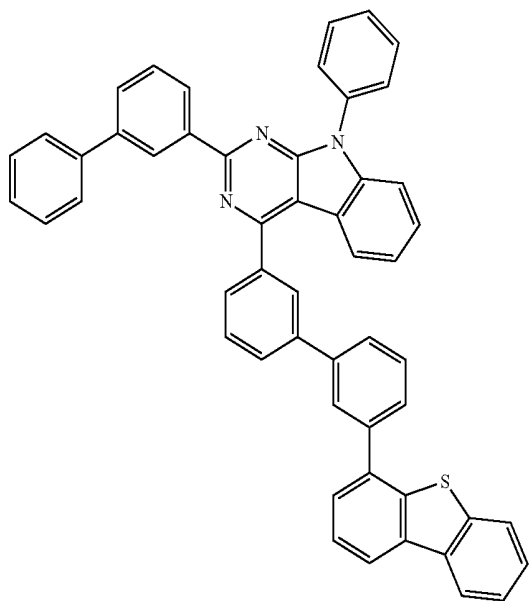


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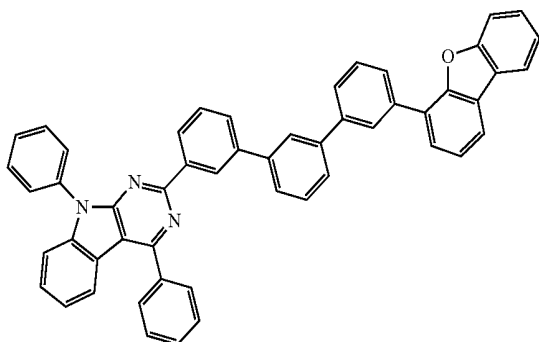
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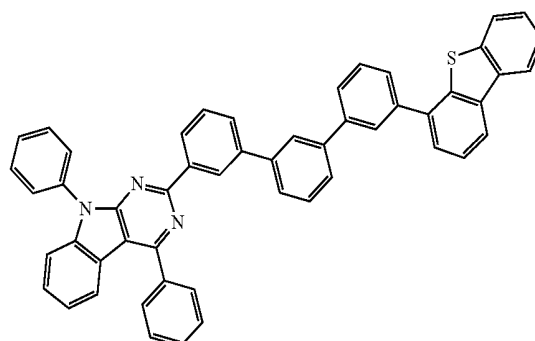


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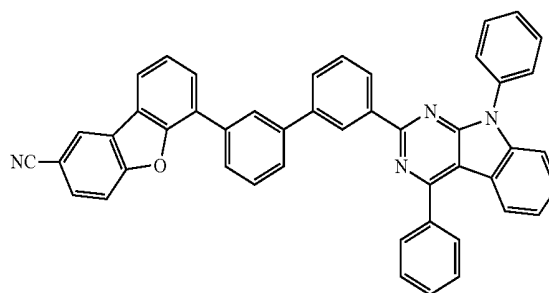


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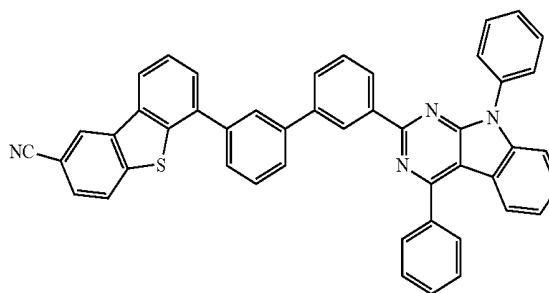
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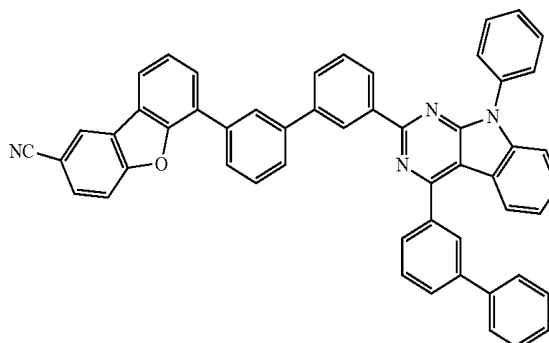
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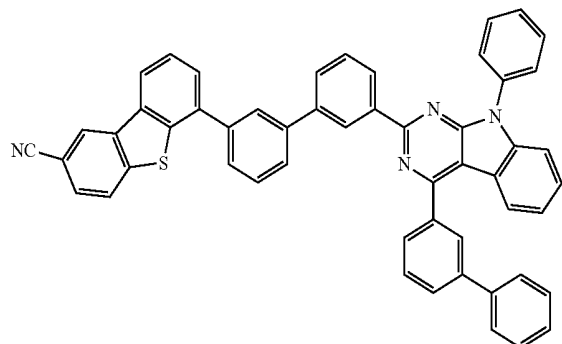


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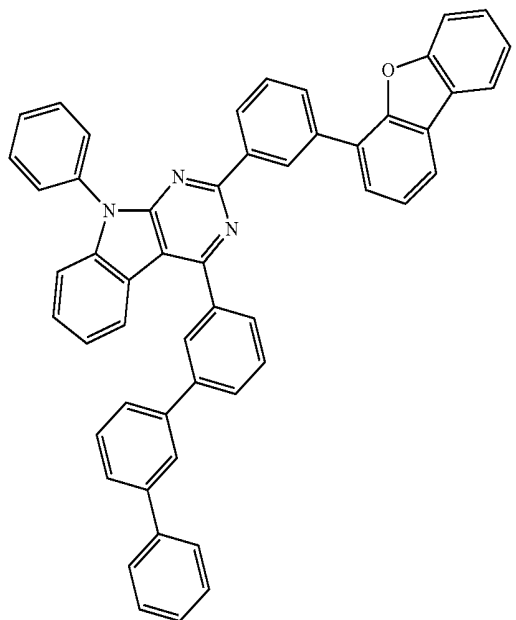


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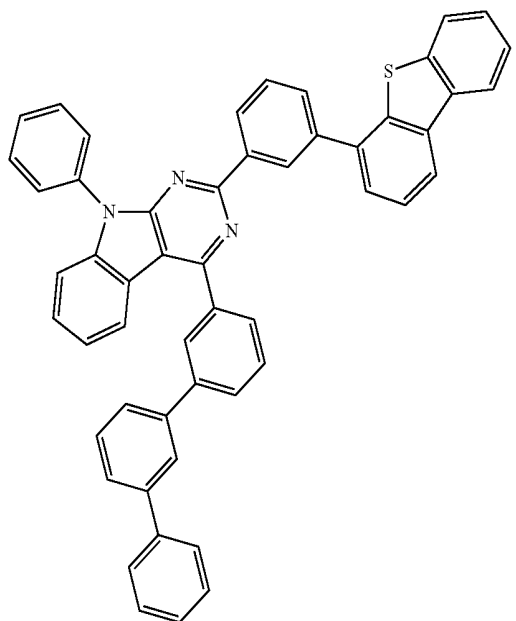
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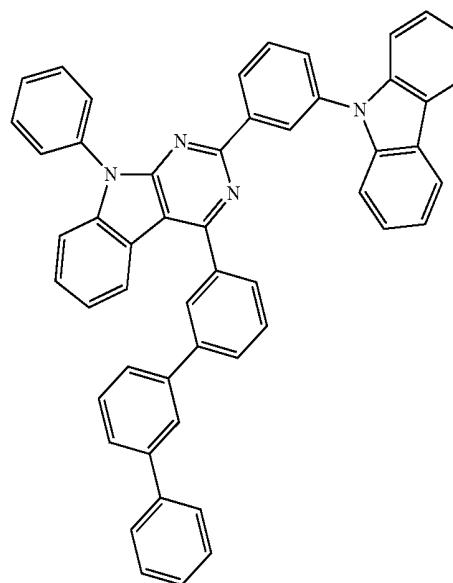


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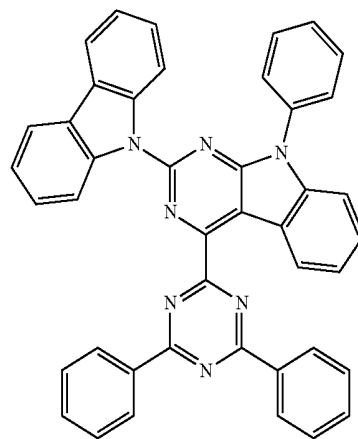


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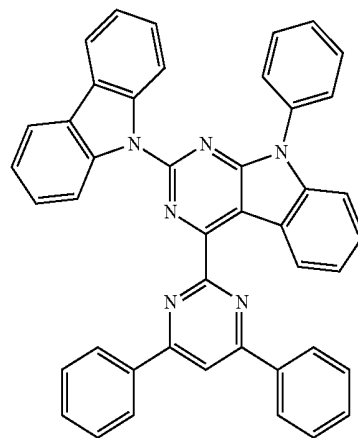
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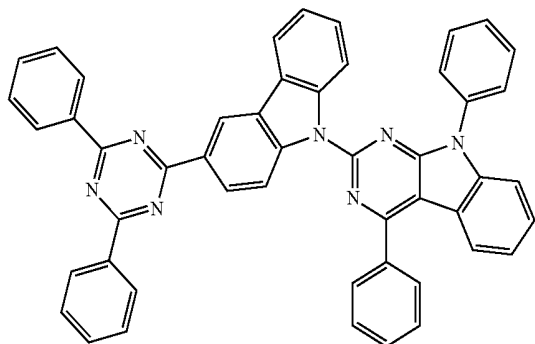


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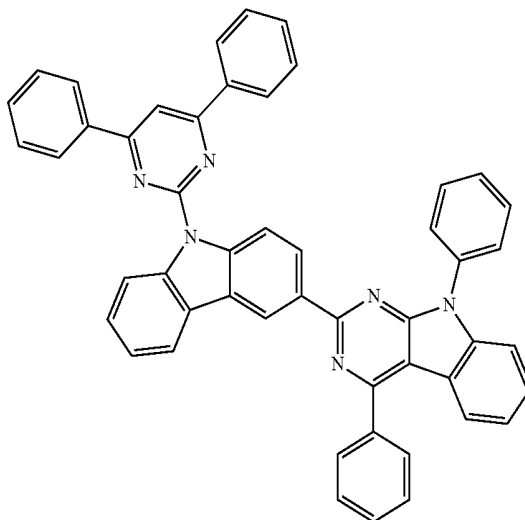
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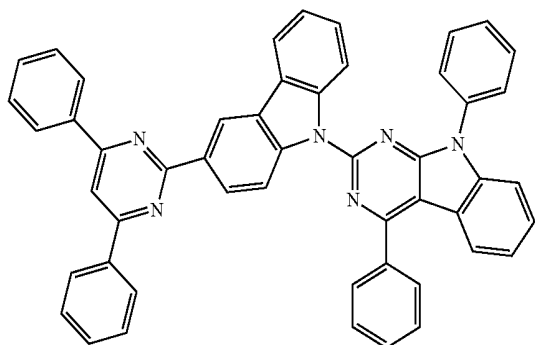


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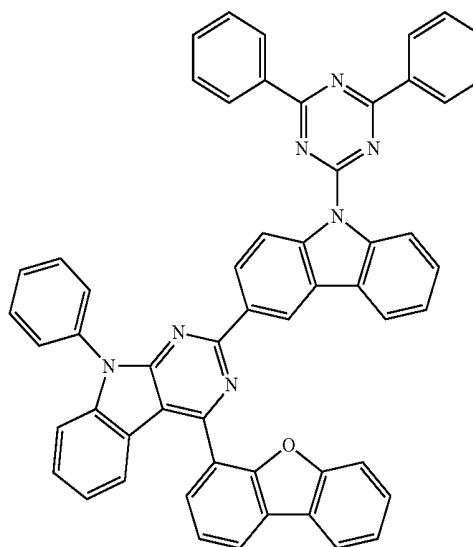
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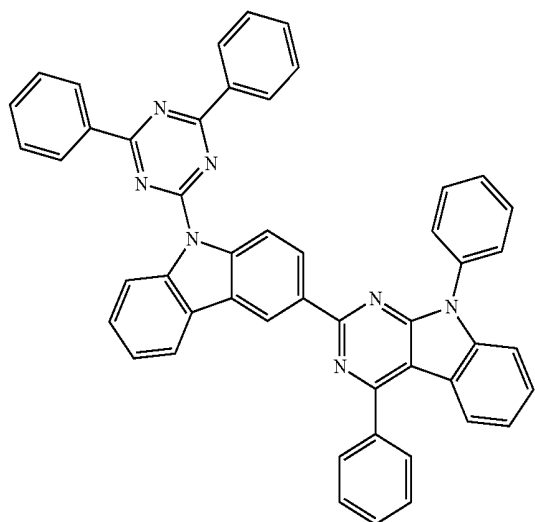
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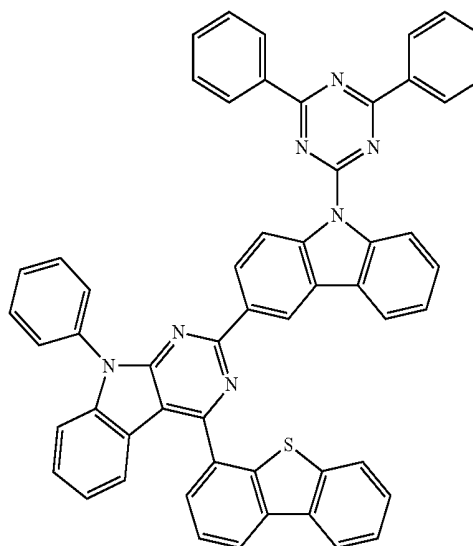
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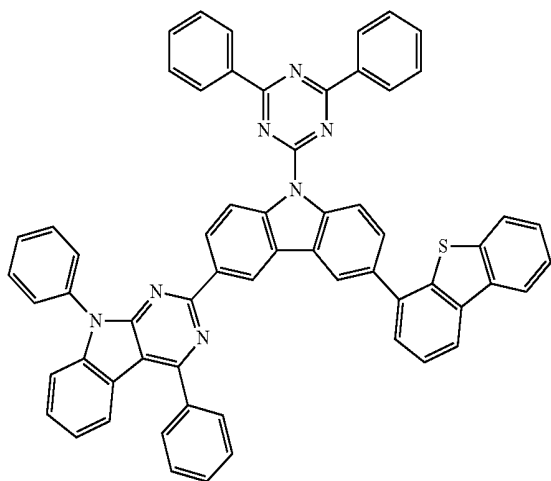


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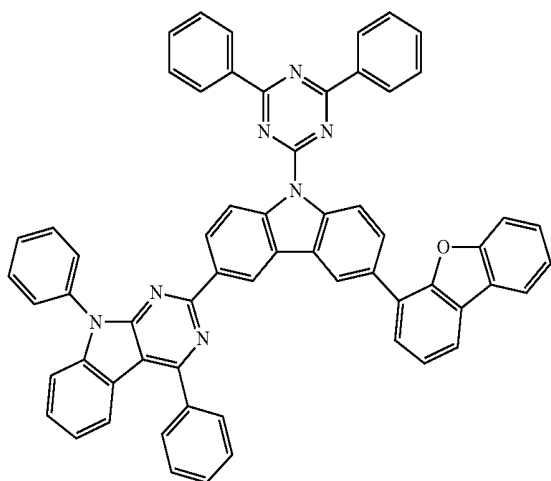


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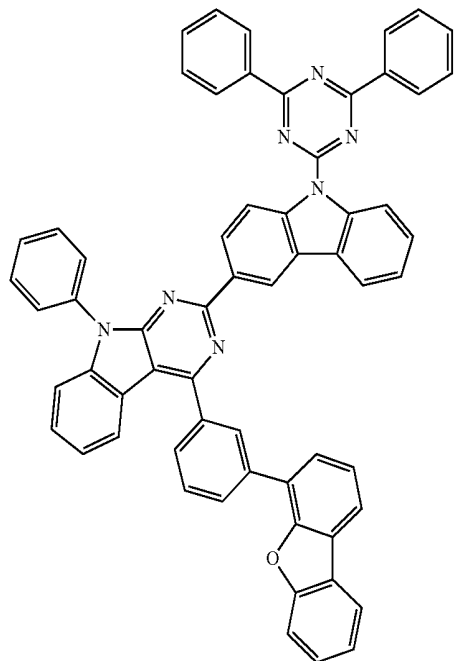
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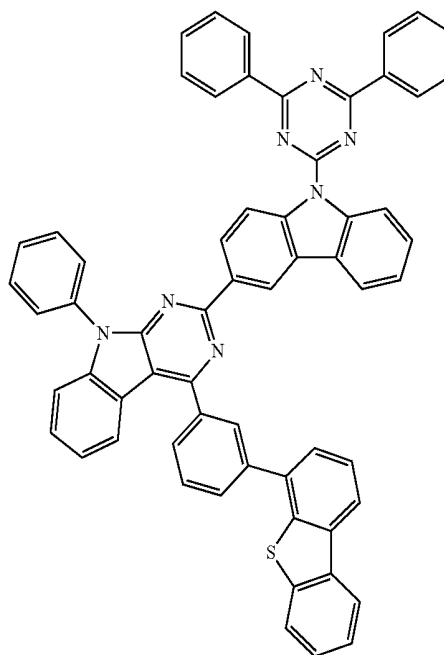


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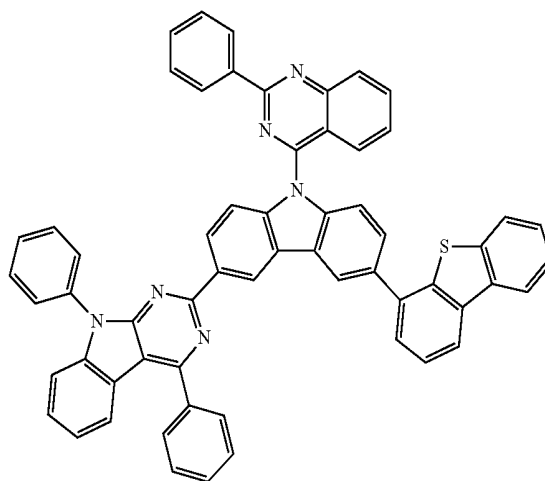


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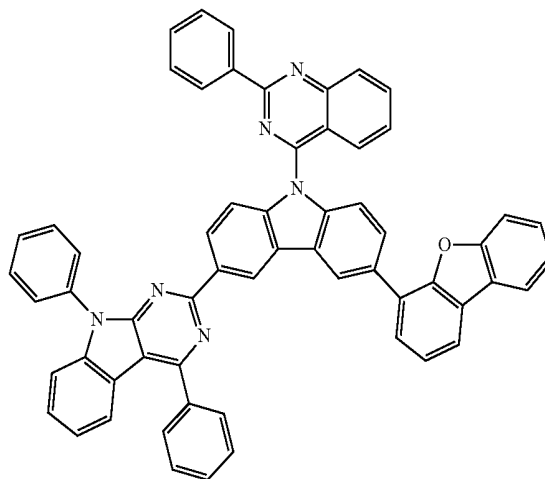
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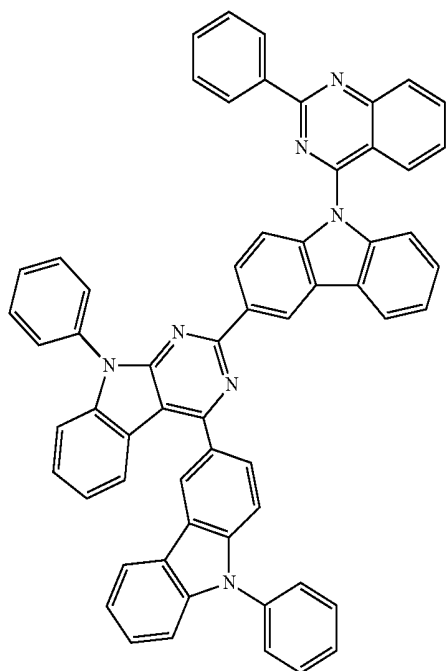
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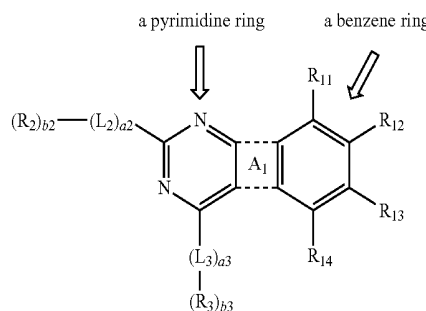
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and a dopant). The condensed cyclic compound of Formula 1 may have good thermal and electrical stabilities, and accordingly, an organic light-emitting device using the condensed cyclic compound of Formula 1 may have high efficiency and long lifetime characteristics.

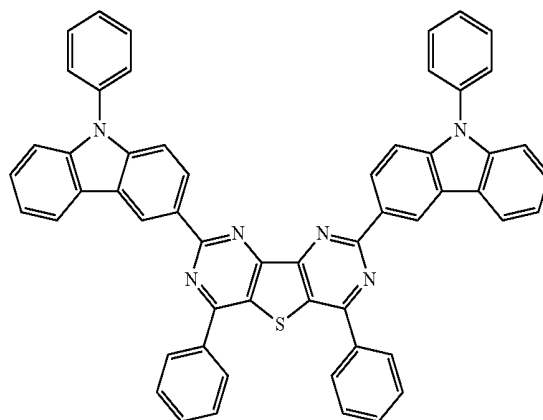
&lt;Formula 1'&gt;



**[0167]** The condensed cyclic compound of Formula 1 above has a core in which a pyrimidine ring and a benzene ring are condensed to opposite sides of the ring A<sub>1</sub>, respectively (refer to Formula 1' above), and accordingly may have a HOMO energy level, a LUMO energy level, a T1 energy level, and an S1 energy level that are appropriate for use as a material for an organic layer (for example, a material for the EML) disposed between a pair of electrodes of an organic light-emitting device, and have good thermal and electrical stabilities. For example, when the condensed cyclic compound of Formula 1 above is used as a host in the EML of an organic light-emitting device, the organic light-emitting device may have high efficiency and long lifetime, based on the host-dopant energy transfer mechanism.

**[0168]** Although not limited to any specific theory, Compound B below may have too strong electron transport ability to achieve an equilibrium between hole transport and electron transport. Accordingly, an organic light-emitting device including Compound B may have poor efficiency characteristics. Compound C below includes a condensed cyclic core in a pyrazine ring, instead of a pyrimidine ring, and thus may have poor thermal and electrical stabilities.

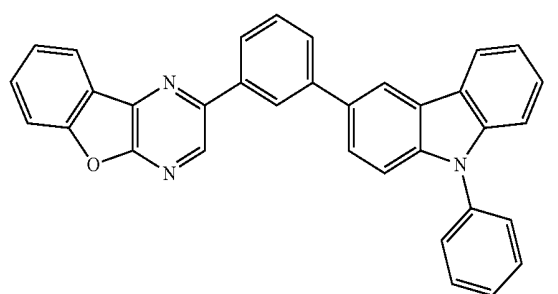
&lt;Compound B&gt;



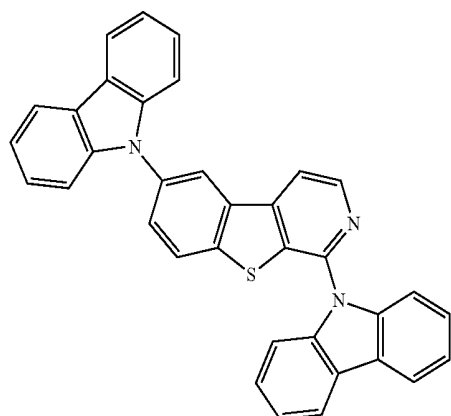
**[0166]** In Formula 1 above, at least one of R<sub>2</sub> and R<sub>3</sub> may be selected from a substituted or unsubstituted monoaromatic condensed heteropolycyclic group. Thus, the condensed cyclic compound of Formula 1 above may have a highest occupied molecular orbital (HOMO) energy level, a lowest unoccupied molecular orbital (LUMO) energy level, a T1 energy level, and an S1 energy level that are appropriate for a material for an organic light emitting device, for example, a host material for the EML (for example, a host material for the EML including both a host

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&lt;Compound D&gt;



**[0169]** The HOMO, LUMO, and triplet (T1) energy levels of Compounds 5, 16, 9, 37, 40, 21, 12, 13, 18, 11, 45, 48, 8, a-9, a-10, a-12, a-13, a-31, a-32, a-41, a-45, a-47, a-49, e-23, and f-9, and Compounds B, C and D were measured using Gaussian simulation. The results are shown in Table 1 below.

TABLE 1

Compound No.	HOMO (eV)	LUMO (eV)	T1 energy level (eV)
5	-5.420	-1.946	2.593
16	-5.316	-1.776	2.629
9	-5.519	-1.902	2.697
37	-5.413	-2.035	2.526
40	-5.605	-1.850	2.847
21	-5.320	-1.675	2.815
12	-5.329	-1.869	2.740
13	-5.301	-1.870	2.859
18	-5.209	-1.741	2.772
11	-5.258	-1.801	2.770
45	-5.258	-1.873	2.841
48	-5.307	-1.843	2.564
8	-5.62	-1.78	2.918
a-9	-5.237	-1.764	2.871
a-10	-5.13	-1.82	2.86
a-12	-5.14	-1.81	2.86
a-13	-5.13	-1.83	2.85
a-31	-5.218	-1.768	2.846
a-32	-5.171	-1.778	2.844
a-41	-5.283	-1.845	2.852

TABLE 1-continued

Compound No.	HOMO (eV)	LUMO (eV)	T1 energy level (eV)
a-45	-5.716	-1.807	2.849
a-47	-5.237	-1.826	2.769
a-49	-5.223	-1.874	2.587
e-23	-5.26	-1.828	2.683
f-9	-5.237	-1.784	2.71
B	-5.302	-2.145	2.705
C	-5.392	-1.660	2.866
D	-5.501	-1.563	2.684

**[0170]** Referring to Table 1, the absolute value of the LUMO energy level of Compound B was greater than the absolute values of the LUMO energy levels of Compounds 5, 16, 9, 37, 40, 21, 12, 13, 18, 11, 45, 48, 8, a-9, a-10, a-12, a-13, a-31, a-32, a-41, a-45, a-47, a-49, e-23, and f-9, indicating too strong electron transport ability of Compound B. The absolute values of the LUMO energy levels of Compounds C and D were smaller than those of Compounds 5, 16, 9, 37, 40, 21, 12, 13, 18, 11, 45, 48, 8, a-9, a-10, a-12, a-13, a-31, a-32, a-41, a-45, a-47, a-49, e-23, and f-9, indicating too weak electron transport ability of Compounds C and D. Accordingly, Compounds B, C and D were found to be less likely to achieve equilibrium between hole transport and electron transport, compared to Compounds 5, 16, 9, 37, 40, 21, 12, 13, 18, 11, 45, 48, 8, a-9, a-10, a-12, a-13, a-31, a-32, a-41, a-45, a-47, a-49, e-23, and f-9.

**[0171]** A synthesis method of the condensed cyclic compound of Formula 1 above may be easily understood to one of ordinary skill in the art based on the synthesis examples described below.

**[0172]** As described above, the condensed cyclic compound of Formula 1 above may be appropriate for use as a host or a electron transport auxiliary layer of the EML of the organic layer.

**[0173]** Due to the inclusion of the organic layer including the condensed cyclic compound of Formula 1 described above, the organic light-emitting device may have a low driving voltage, a high efficiency, and a long lifetime.

**[0174]** The condensed cyclic compound of Formula 1 above may be used between a pair of electrodes of an organic light-emitting device. For example, the condensed cyclic compound of Formula 1 above may be included in at least one of the EML, a hole transport region between the first electrode and the EML (for example, the hole transport region may include at least one of a hole injection layer (HIL), a hole transport layer (HTL), and an electron blocking layer (EBL)), and an electron transport region between the EML and the second electrode (for example, the electron transport region may include at least one of a hole blocking layer (HBL), an electron transport layer (ETL), and an electron injection layer (EIL)). For example, the condensed cyclic compound of Formula 1 above may be included in the EML, wherein the EML may further include a dopant, and the condensed cyclic compound of Formula 1 in the EML may serve as a host. For example, the EML may be a green EML, and the dopant may be a phosphorescent dopant.

[0175] As used herein, “(for example, the organic layer) including at least one condensed cyclic compound means that “(the organic layer) including one of the condensed cyclic compounds of Formula 1 above, or at least two different condensed cyclic compounds of Formula 1 above”.

[0176] For example, the organic layer of the organic light-emitting device may include only Compound 1 as the condensed cyclic compound. For example, Compound 1 may be included in the EML of the organic light-emitting device. In some embodiments, the organic layer of the organic light-emitting device may include Compounds 1 and 2 as the condensed cyclic compound. For example, Compounds 1 and 2 may be included in the same layer (for example, in the EML) or in different layers.

[0177] For example, the above condensed cyclic compound may be included as a host or an electron transport auxiliary layer in the emission layer.

[0178] For example, the first electrode may be an anode, the second electrode may be a cathode, and the organic layer may include i) a hole transport region disposed between the first electrode and the emission layer and comprising at least one of a hole injection layer, a hole transport layer, and an electron blocking layer; and ii) an electron transport region disposed between the emission layer and the second electrode and including at least one of a hole blocking layer, an electron transport layer, and an electron injection layer.

[0179] The term “organic layer” as used herein refers to a single layer and/or a plurality of layers disposed between the first and second electrodes of the organic light-emitting device. The “organic layer” may include, for example, an organic compound or an organometallic complex including a metal.

[0180] According to another embodiment of the present disclosure, an organic light-emitting device includes a first electrode, a second electrode, and an organic layer disposed between the first electrode and the second electrode and including an EML and the EML includes the condensed cyclic compounds of Formula 1 above.

[0181] FIGS. 1 to 3 are schematic views of an organic light-emitting device 10 according to an embodiment of the present disclosure. Hereinafter, a structure of an organic light-emitting device according to an embodiment of the present disclosure and a method of manufacturing the same will now be described with reference to FIG. 1. Referring to FIG. 1, the organic light-emitting device 10 has a structure in which a substrate, a first electrode 11, an organic layer 15, and a second electrode 19 are sequentially stacked in this order.

[0182] A substrate (not shown) may be disposed under the first electrode 11 or on the second electrode 19 in FIG. 1. The substrate may be any substrate that is used in conventional organic light emitting devices. In some embodiments the substrate may be a glass substrate or a transparent plastic substrate with strong mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water resistance.

[0183] The first electrode 11 may be formed by depositing or sputtering a first electrode-forming material on the substrate. The first electrode 11 may be an anode. A material

having a high work function may be selected as a material for the first electrode to facilitate hole injection. The first electrode 11 may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. For example, the material for the first electrode 13 may be indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO<sub>2</sub>), or zinc oxide (ZnO). In some embodiments, the material for the first electrode 13 may be metals, for example, magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), magnesium-silver (Mg—Ag), or the like.

[0184] The first electrode 11 may have a single-layer structure or a multi-layer structure including at least two layers.

[0185] The organic layer 15 may be disposed on the first electrode 11.

[0186] The organic layer 15 may include at least one a hole transport region; an EML, and an electron transport region.

[0187] The hole transport region may be disposed between the first electrode 11 and the EML.

[0188] The hole transport region may include at least one of a hole injection layer (HIL), a hole transport layer (HTL), an electron blocking layer (EBL), and a buffer layer.

[0189] For example, an organic light-emitting device according to an embodiment of the present disclosure will now be described with reference to FIG. 2.

[0190] The organic layer 15 includes a hole transport layer 31, an emission layer 32, and a hole transport auxiliary layer 33 interposed between the hole transport layer 31 and the emission layer 32.

[0191] The hole transport region may include at least two hole transport layers, and a hole transport layer contacting the emission layer is defined to be a hole transport auxiliary layer.

[0192] The hole transport region may include exclusively the HIL or the HTL. In some embodiments, the electron transport region may have a structure including a HIL/HTL or a HIL/HTL/EBL, wherein the layers forming the structure of the electron transport region may be sequentially stacked on the first electrode 11 in the stated order.

[0193] For example, a hole injection layer 37 and an electron injection layer 36 are additionally included and thus a first electrode 11/hole injection layer 37/hole transport layer 31/hole transport auxiliary layer 33/emission layer 32/electron transport auxiliary layer 35/electron transport layer 34/electron injection layer 36/a second electrode 19 are sequentially stacked, as shown in FIG. 3.

[0194] The hole injection layer 37 may improve interface properties between ITO as an anode and an organic material used for the hole transport layer 31, and is applied on a non-planarized ITO and thus planarizes the surface of the ITO. For example, the hole injection layer 37 may include a material having a median value, particularly desirable conductivity between a work function of ITO and HOMO of the hole transport layer 31, in order to adjust a difference a work function of ITO as an anode and HOMO of the hole transport layer 31. In connection with the present disclosure,

the hole injection layer **37** may include N4,N4'-diphenyl-N4,N4'-bis(9-phenyl-9H-carbazol-3-yl)biphenyl-4,4'-diamine), but is not limited thereto. In addition, the hole injection layer **37** may further include a conventional material, for example, copper phthalocyanine (CuPc), aromatic amines such as N,N'-dinaphthyl-N,N'-phenyl-(1,1'-biphenyl)-4,4'-diamine, NPD), 4,4',4''-tris[methylphenyl(phenyl)amino] triphenyl amine (m-MTDATA), 4,4',4''-tris[1-naphthyl(phenyl)amino] triphenyl amine (1-TNATA), 4,4',4''-tris[2-naphthyl(phenyl)amino] triphenyl amine (2-TNATA), 1,3,5-tris[N-(4-diphenylaminophenyl)phenylamino] benzene (p-DPA-TDAB), and the like, compounds such as 4,4'-bis[N-[4-{N,N-bis(3-methylphenyl)amino}phenyl]-N-phenylamino]biphenyl (DNTPD), hexaazatriphenylene-hexacarbonitrile (HAT-CN), and the like, a polythiophene derivative such as poly(3,4-ethylenedioxythiophene)-poly(styrenesulfonate) (PEDOT) as a conductive polymer. The hole injection layer **37** may be, for example coated on ITO as an anode in a thickness of 10 to 300 Å.

**[0195]** The electron injection layer **36** is stacked on the electron transport layer to facilitate electron injection into a cathode and improves power efficiency. The electron injection layer **36** may include any generally-used material in this art without limitation, for example, LiF, Liq, NaCl, CsF, Li<sub>2</sub>O, BaO, and the like.

**[0196]** When the hole transport region includes the HIL, the HIL may be formed on the first electrode **11** by any of a variety of methods, for example, vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, or the like.

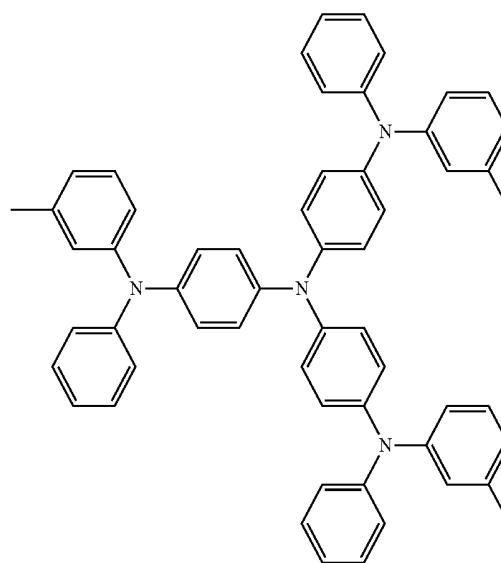
**[0197]** When the HIL is formed using vacuum deposition, vacuum deposition conditions may vary depending on the material that is used to form the HIL, and the desired structure and thermal properties of the HIL to be formed. For example, vacuum deposition may be performed at a temperature of about 100° C. to about 500° C., a pressure of about 10<sup>-8</sup> torr to about 10<sup>-3</sup> torr, and a deposition rate of about 0.01 to about 100 Å/sec. However, the deposition conditions are not limited thereto.

**[0198]** When the HIL is formed using spin coating, the coating conditions may vary depending on the material that is used to form the HIL, and the desired structure and thermal properties of the HIL to be formed. For example, the coating rate may be in the range of about 2000 rpm to about 5000 rpm, and a temperature at which heat treatment is performed to remove a solvent after coating may be in a range of about 80° C. to about 200° C. However, the coating conditions are not limited thereto.

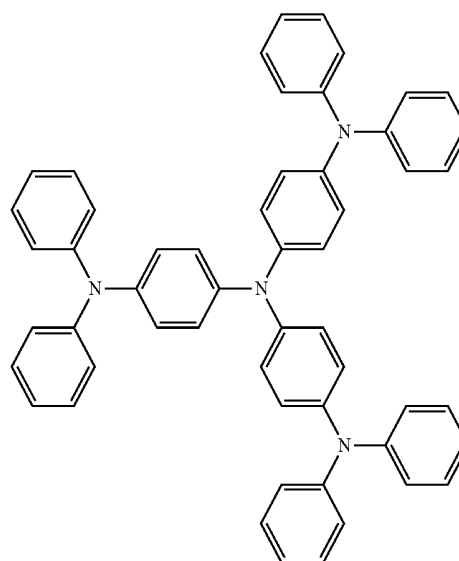
**[0199]** Conditions for forming the HTL and the EBL may be defined based on the above-described formation conditions for the HIL.

**[0200]** In some embodiments, the hole transport region may include at least one of m-MTDATA, TDATA, 2-TNATA, NPB, β-NPB, TPD, Spiro-TPD, Spiro-NPB, methylated NPB, TAPC, HMTPD, 4,4',4''-tris(N-carbazolyl)

triphenylamine (TCTA), polyaniline/dodecylbenzene sulfonic acid (Pani/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate)(PEDOT/PSS), polyaniline/camphor sulfonic acid (Pani/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201 below, and a compound represented by Formula 202 below.

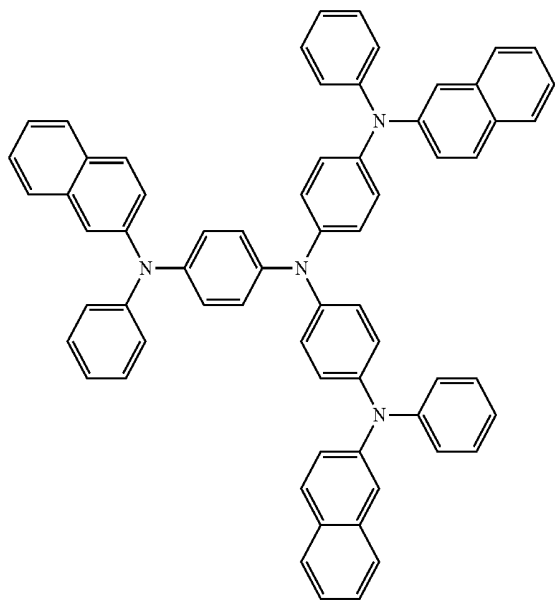


m-MTDATA



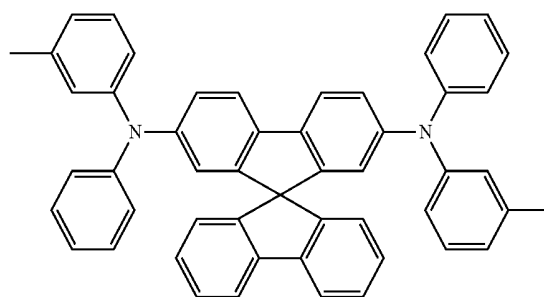
TDATA

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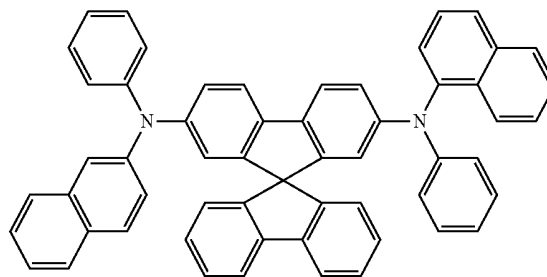


2-TNATA

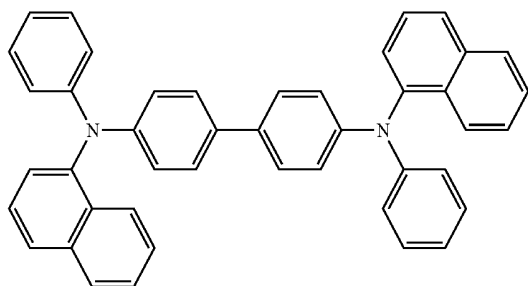
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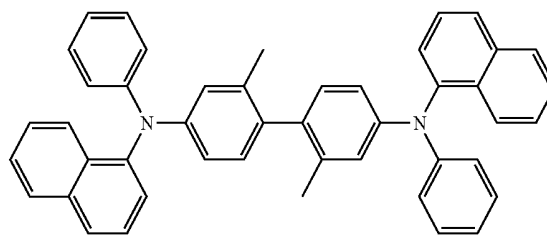
Spiro-TPD



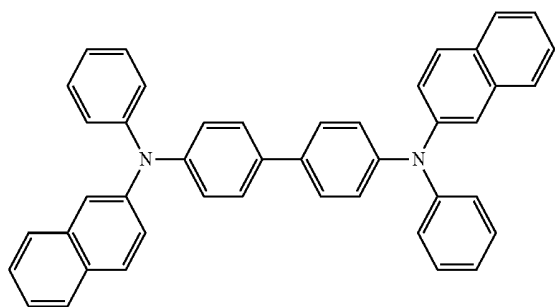
Spiro-NPB



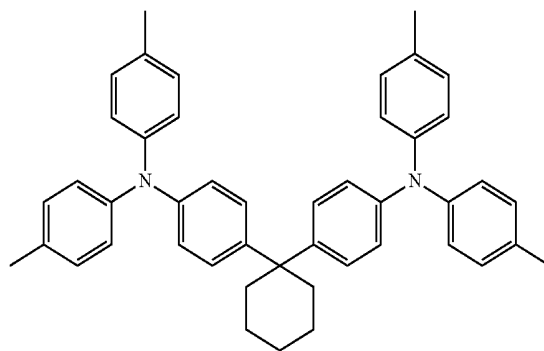
NPB



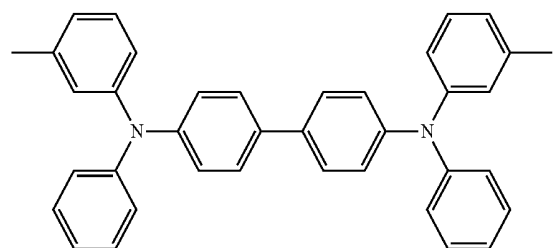
methylate NPB



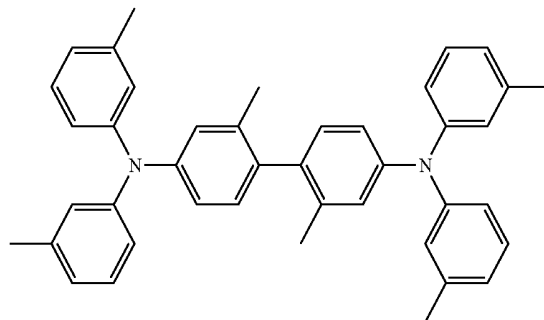
$\beta$ -NPB



TAPC



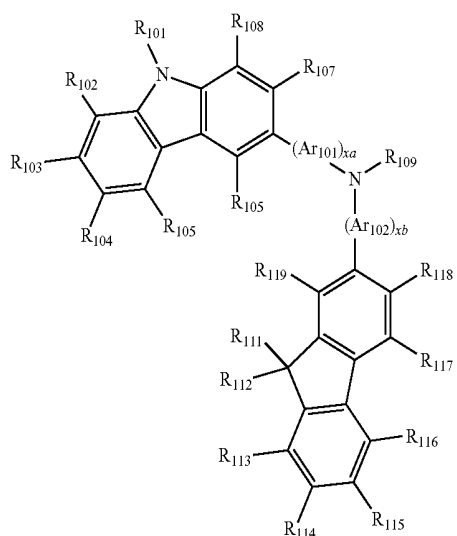
TPD



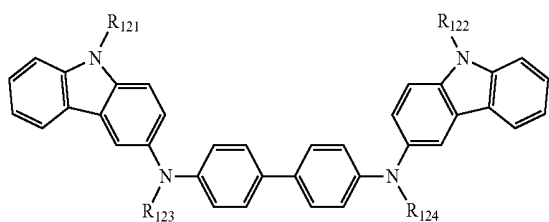
HMTPD

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&lt;Formula 201&gt;



&lt;Formula 202&gt;



[0201] In Formula 201 above, Ar<sub>101</sub> and Ar<sub>102</sub> may be each independently selected from

[0202] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an acenaphthylene group, a fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group, and

[0203] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an acenaphthylene group, a fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl

group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0204] In Formula 201, xa and xb may be each independently an integer from 0 to 5, for example, may be 0, 1, or 2. For example, xa may be 1, and xb may be 0, but are not limited thereto.

[0205] In Formulae 201 and 202, R<sub>101</sub> to R<sub>108</sub>, R<sub>111</sub> to R<sub>119</sub>, and R<sub>121</sub> to R<sub>124</sub> may be each independently selected from

[0206] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C<sub>1</sub>-C<sub>10</sub> alkyl group (for example, a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, or the like), and a C<sub>1</sub>-C<sub>10</sub> alkoxy group (for example, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentoxy group, or the like);

[0207] a C<sub>1</sub>-C<sub>10</sub> alkyl group and a C<sub>1</sub>-C<sub>10</sub> alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

[0208] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group; and

[0209] a phenyl group, a naphthyl group, an anthracenyl group, a fluorenyl group, and a pyrenyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C<sub>1</sub>-C<sub>10</sub> alkyl group, and a C<sub>1</sub>-C<sub>10</sub> alkoxy group. However, embodiments of the present disclosure are not limited thereto.

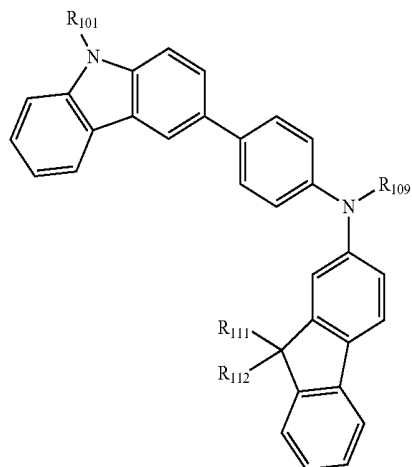
[0210] In Formula 201 above, R<sub>109</sub> may be selected from

[0211] a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group, and

[0212] a phenyl group, a naphthyl group, an anthracenyl group, and a pyridinyl group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C<sub>1</sub>-C<sub>20</sub> alkyl group, and a C<sub>1</sub>-C<sub>20</sub> alkoxy group.

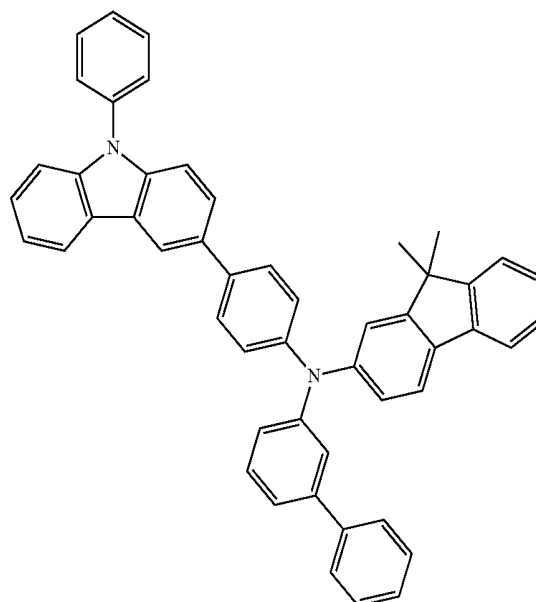
[0213] In some embodiments, the compound of Formula 201 may be represented by Formula 201A, but is not limited thereto:

&lt;Formula 201A)



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HT2

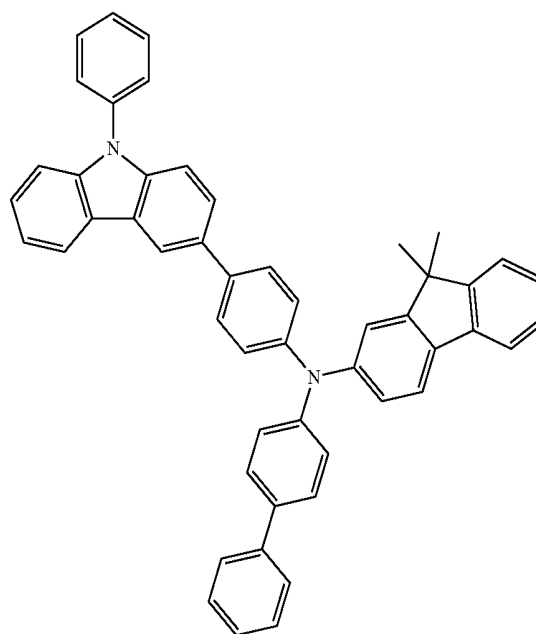
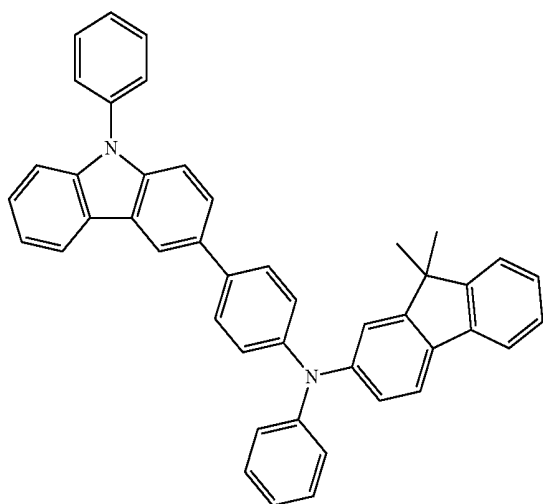


[0214] In Formula 201A, R<sub>101</sub>, R<sub>111</sub>, R<sub>112</sub>, and R<sub>109</sub> may be the same as those defined above.

[0215] For example, the compound of Formula 201 and the compound of Formula 202 may include Compounds HT1 to HT20 below, but are not limited thereto:

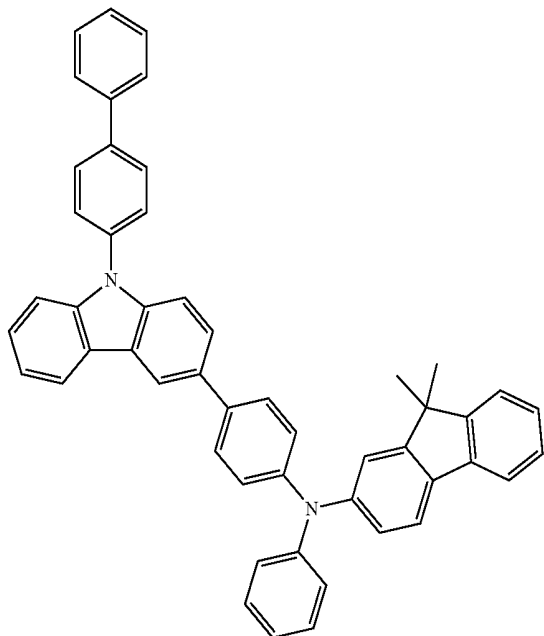
HT3

HT1



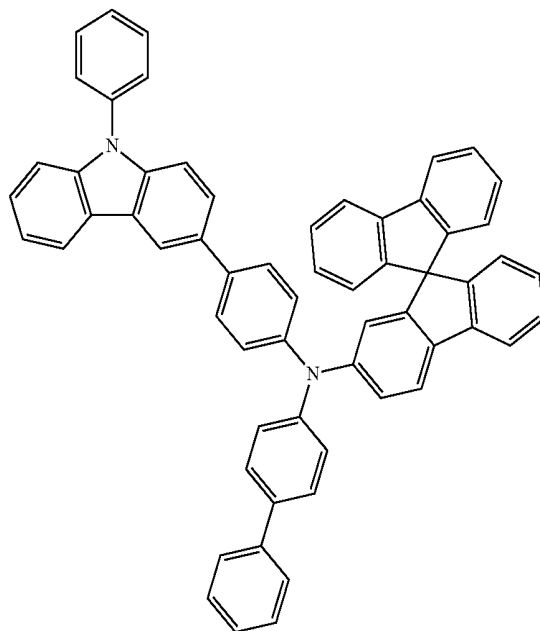
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HT4

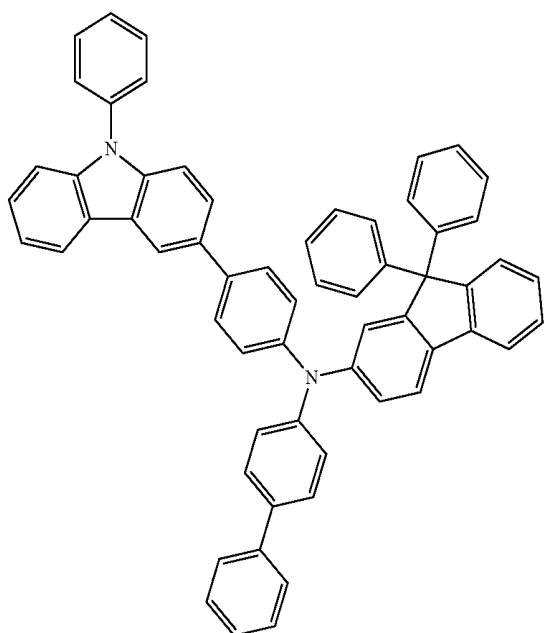


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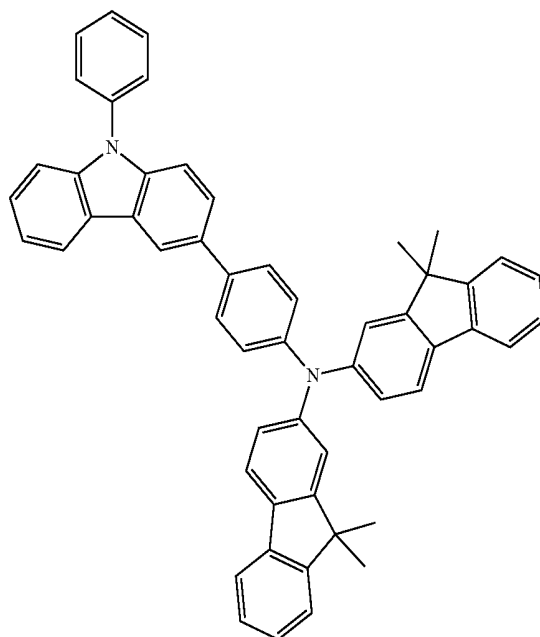
HT6



HT5

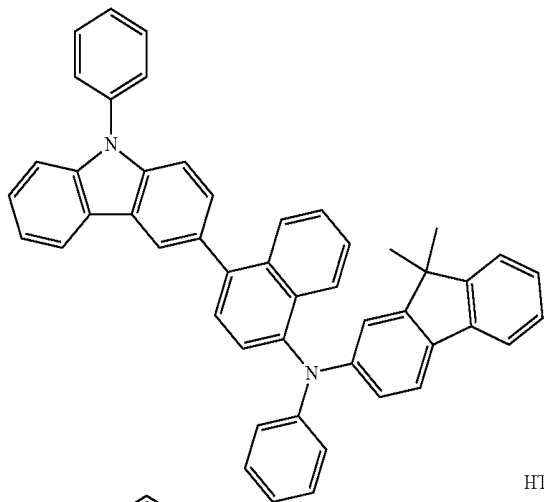


HT7

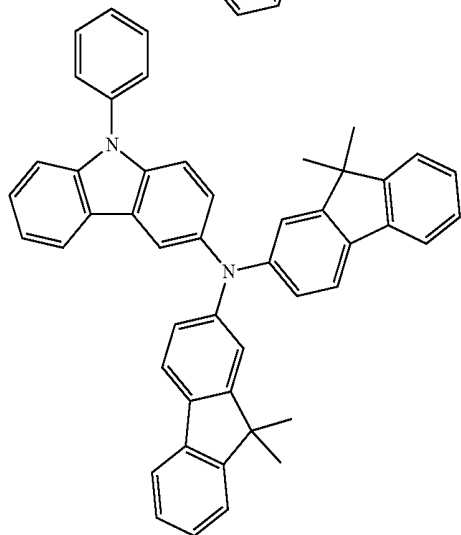


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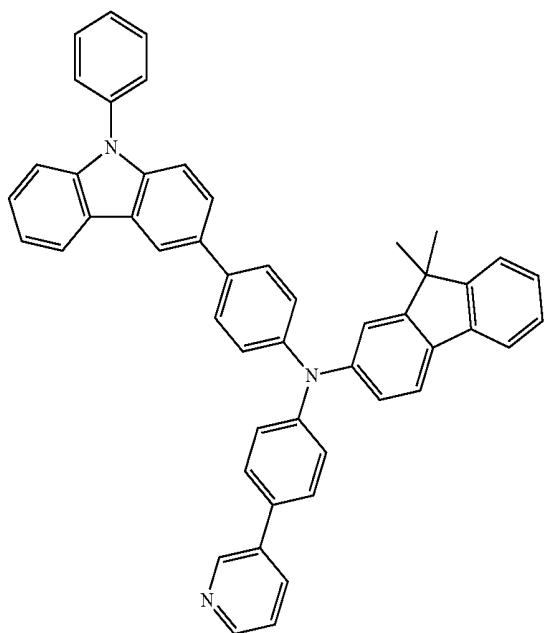
HT8



HT9

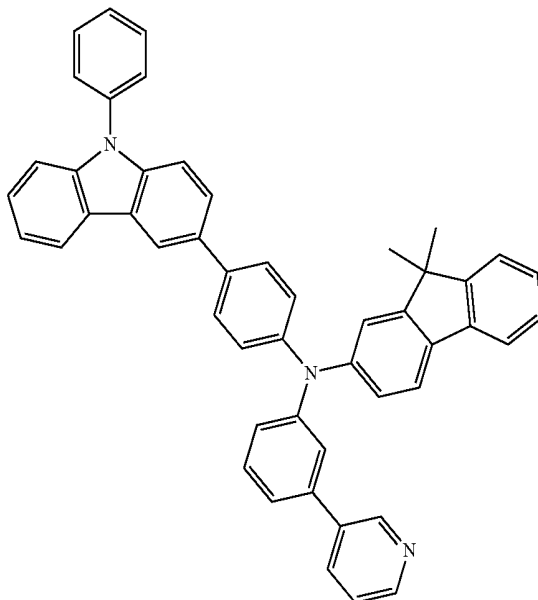


HT10

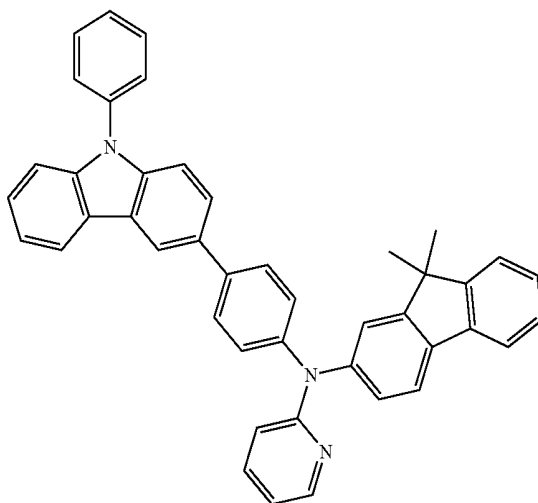


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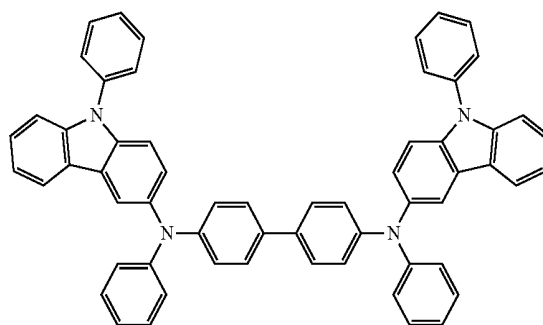
HT11



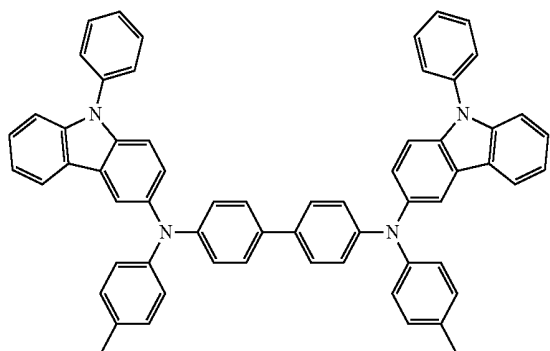
HT12



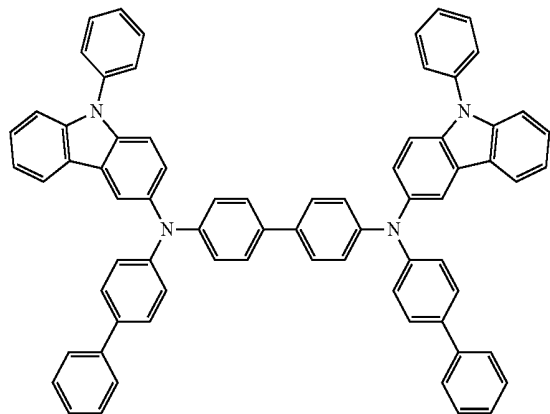
HT13



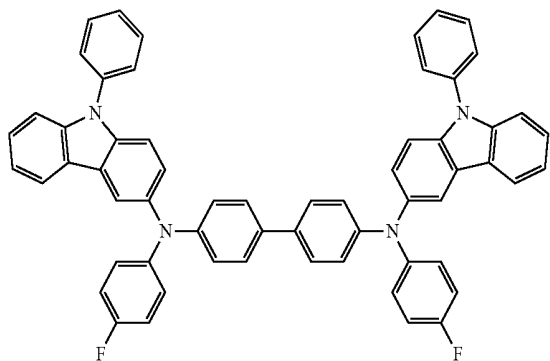
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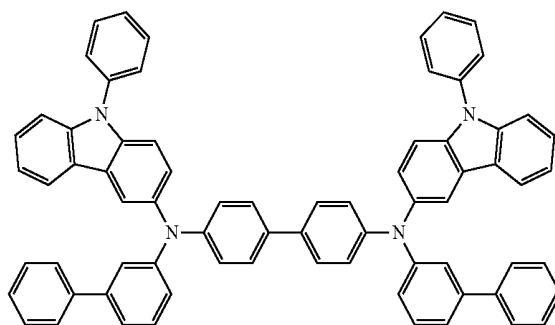
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HT15

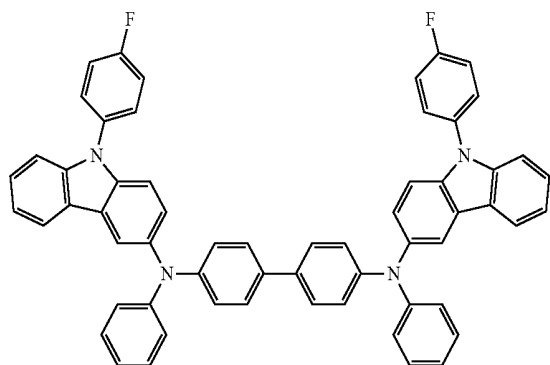
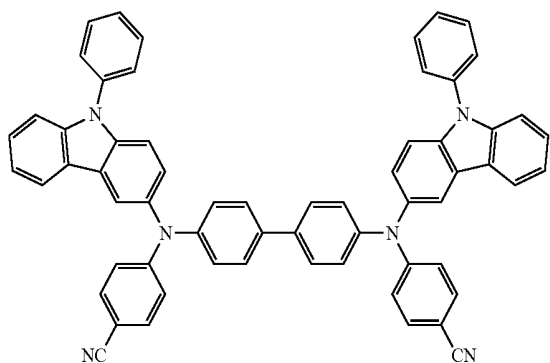


HT19

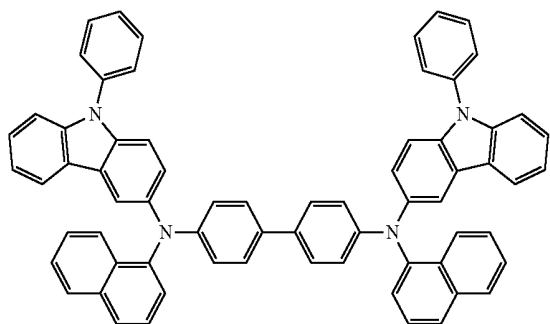


HT20

HT16



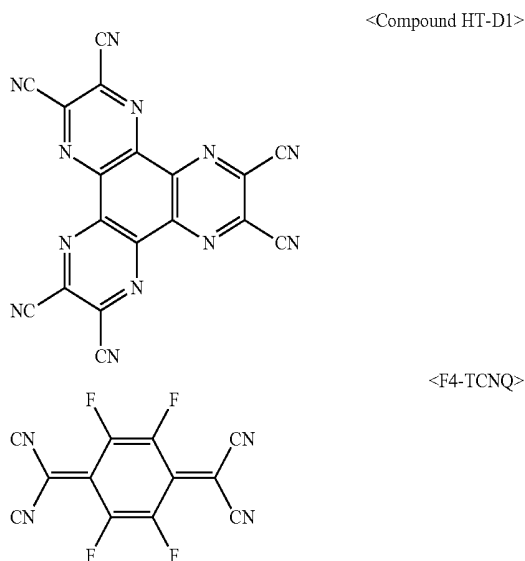
HT17



**[0216]** A thickness of the hole transport region may be from about 100 Å to about 10000 Å, and in some embodiments, from about 100 Å to about 1000 Å. When the hole transport region includes a HIL and a HTL, a thickness of the HIL may be from about 100 Å to about 10,000 Å, and in some embodiments, from about 100 Å to about 1,000 Å, and a thickness of the HTL may be from about 50 Å to about 2,000 Å, and in some embodiments, from about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the HIL, and the HTL are within these ranges, satisfactory hole transport characteristics may be obtained without a substantial increase in driving voltage.

**[0217]** The hole transport region may further include a charge-generating material to improve conductivity, in addition to the materials as described above. The charge-generating material may be homogeneously or inhomogeneously dispersed in the hole transport region.

[0218] The charge-generating material may be, for example, a p-dopant. The p-dopant may be one of a quinine derivative, a metal oxide, and a cyano group-containing compound, but is not limited thereto. Non-limiting examples of the p-dopant are quinone derivatives such as tetracyanoquinonodimethane (TCNQ), 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonodimethane (F4-TCNQ), and the like; metal oxides such as tungsten oxide, molybdenum oxide, and the like; and cyano-containing compounds such as Compound HT-D1.



[0219] The hole transport region may further include a buffer layer.

[0220] The buffer layer may compensate for an optical resonance distance of light according to a wavelength of the light emitted from the EML, and thus may increase efficiency.

[0221] The EML may be formed on the hole transport region by using vacuum deposition, spin coating, casting, LB deposition, or the like. When the EML is formed using vacuum deposition or spin coating, the conditions for deposition and coating may be similar to those for the formation of the HIL, though the conditions for the deposition and coating may vary depending on the material that is used to form the EML.

[0222] The EML may include a host and a dopant. The host may include at least one of the condensed cyclic compounds of Formula 1 above.

[0223] For example, the above host may include the first host and the second host, and the first host and second host may differ from each other.

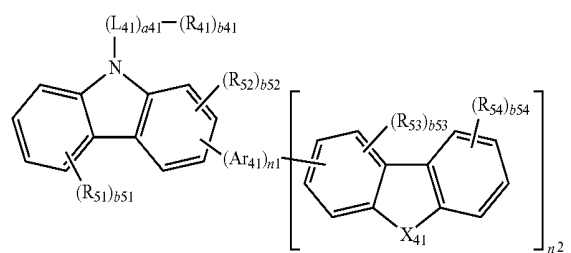
[0224] In some embodiments, the organic layer of the organic light-emitting device may further include at least one of a first compound represented by Formula 41 below and a second compound represented by Formula 61 below, in addition to the condensed cyclic compound of Formula 1 above:

[0225] the second host may include at least one of a first compound represented by Formula 41 and a second compound represented by Formula 61.

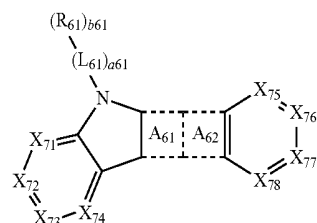
[0226] the following ring  $A_{61}$  of Formula 61 is represented by the following Formula 61A, and the following ring  $A_{62}$  of Formula 62 is represented by the following Formula 61B.

[0227] In Formula 61 above, the ring  $A_{61}$  is fused to an adjacent 5-membered ring and the ring  $A_{62}$  with sharing carbons therewith, and the ring  $A_{62}$  is fused to the adjacent ring  $A_{61}$  and a 6-membered ring with sharing carbons therewith.

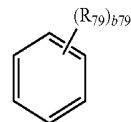
<Formula 41>



<Formula 61>



<Formula 61A>



<Formula 61B>



[0228] In Formulae 41 and 61 above,

[0229]  $X_{41}$  may be N-[( $L_{42}$ ) $a_{42}$ -( $R_{42}$ ) $b_{42}$ ], S, O, S(=O), S(=O)<sub>2</sub>, a C(=O), a C( $R_{43}$ )( $R_{44}$ ), Si( $R_{43}$ )( $R_{44}$ ), P( $R_{43}$ ), P(=O)( $R_{43}$ ), or C=N( $R_{43}$ ),

[0230] Ring  $A_{61}$  in Formula 61 may be represented by Formula 61A above;

[0231] Ring  $A_{62}$  in Formula 61 may be represented by Formula 61B above;

[0232]  $X_{61}$  may be N-[( $L_{62}$ ) $a_{62}$ -( $R_{62}$ ) $b_{62}$ ], S, O, S(=O), S(=O)<sub>2</sub>, a C(=O), a C( $R_{63}$ )( $R_{64}$ ), Si( $R_{63}$ )( $R_{64}$ ), P( $R_{63}$ ), P(=O)( $R_{63}$ ), or C=N( $R_{63}$ );

[0233]  $X_{71}$  may be C( $R_{71}$ ) or N;  $X_{72}$  may be C( $R_{72}$ ) or N;  $X_{73}$  may be C( $R_{73}$ ) or N;  $X_{74}$  may be C( $R_{74}$ ) or N;  $X_{75}$  may be C( $R_{75}$ ) or N;  $X_{76}$  may be C( $R_{76}$ ) or N;  $X_{77}$  may be C( $R_{77}$ ) or N;  $X_{78}$  may be C( $R_{78}$ ) or N;

[0234]  $Ar_{41}$ ,  $L_{41}$ ,  $L_{42}$ ,  $L_{61}$ , and  $L_{62}$  may be each independently selected from a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkylene group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkenylene group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroarylene group, a substituted or unsubstituted divalent nonaromatic condensed polycyclic group,

and a substituted or unsubstituted divalent nonaromatic condensed heteropolycyclic group;

[0235] n1 and n2 may be each independently an integer selected from 0 to 3;

[0236] R<sub>41</sub> to R<sub>44</sub>, R<sub>51</sub> to R<sub>54</sub>, R<sub>61</sub> to R<sub>64</sub>, and R<sub>71</sub> to R<sub>79</sub> may be each independently selected from a hydrogen, a deuterium, a fluoro group (—F), a chloro group (—Cl), a bromo group (—Br), an iodo group (—I), a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylthio group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent nonaromatic condensed polycyclic group, a substituted or unsubstituted monovalent nonaromatic condensed heteropolycyclic group, —N(Q<sub>1</sub>)(Q<sub>2</sub>), —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), and —B(Q<sub>6</sub>)(Q<sub>7</sub>);

[0237] a41, a42, a61, and a62 may be each independently an integer selected from 0 to 3; and

[0238] b41, b42, b51 to b54, b61, b62, and b79 may be each independently an integer selected from 1 to 3.

[0239] In some embodiments, in Formulae 41 and 61, R<sub>41</sub> to R<sub>44</sub>, R<sub>51</sub> to R<sub>54</sub>, R<sub>61</sub> to R<sub>64</sub>, and R<sub>71</sub> to R<sub>79</sub> may be each independently selected from

[0240] a hydrogen atom, a deuterium atom, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>20</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>20</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, and a substituted or unsubstituted monovalent nonaromatic condensed polycyclic group.

[0241] In some embodiments, X<sub>41</sub> in Formula 41 may be N-[(L<sub>42</sub>)<sub>a42</sub>-(R<sub>42</sub>)<sub>b42</sub>], S, or O, but is not limited thereto.

[0242] In some embodiments, X<sub>61</sub> in Formula 61 may be N-[(L<sub>62</sub>)<sub>a62</sub>-(R<sub>62</sub>)<sub>b62</sub>], S, or O, but is not limited thereto.

[0243] In some embodiments, in Formula 61, X<sub>71</sub> may be C(R<sub>71</sub>), X<sub>72</sub> may be C(R<sub>72</sub>), X<sub>73</sub> may be C(R<sub>73</sub>), X<sub>74</sub> may be C(R<sub>74</sub>), X<sub>75</sub> may be C(R<sub>75</sub>), X<sub>76</sub> may be C(R<sub>76</sub>), X<sub>77</sub> may be C(R<sub>77</sub>), and X<sub>78</sub> may be C(R<sub>78</sub>). However, embodiments of the present disclosure are not limited thereto.

[0244] In Formula 61 above, at least two of R<sub>71</sub> to R<sub>74</sub> may be optionally linked to each other to form a saturated or unsaturated ring, for example, benzene, naphthalene, or the like.

[0245] In Formula 61 above, at least two of R<sub>75</sub> to R<sub>78</sub> may be optionally linked to each other to form a saturated or unsaturated ring, for example, benzene, naphthalene, or the like.

[0246] In Formulae above, Ar<sub>41</sub>, L<sub>41</sub>, L<sub>42</sub>, L<sub>61</sub>, and L<sub>62</sub> may be each independently selected from

[0247] a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkylene group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkenylene group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylene group, a substituted or unsubstituted

C<sub>2</sub>-C<sub>60</sub> heteroarylene group, a substituted or unsubstituted divalent nonaromatic condensed polycyclic group, and a substituted or unsubstituted divalent nonaromatic condensed heterocyclic group.

[0248] In some embodiments, in Formulae 41 and 61, Ar<sub>41</sub>, L<sub>41</sub>, L<sub>42</sub>, L<sub>61</sub>, and L<sub>62</sub> may be each independently selected from

[0249] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylenylene group, a pyrrolylene group, an imidazolylene group, a pyrazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzooxazolylene group, a benzimidazolylene group, a furanylene group, a benzofuranylene group, a thiophenylene group, a benzothiophenylene group, a thiazolylene group, an isothiazolylene group, a benzothiazolylene group, an isoxazolylene group, an oxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, an imidazopyrimidinylene group, and an imidazopyridinylene group; and

[0250] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylenylene group, a pyrrolylene group, an imidazolylene group, a pyrazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzooxazolylene group, a benzimidazolylene group, a furanylene group, a benzofuranylene group, a thiophenylene group, a benzothiophenylene group, a thiazolylene group, an isothiazolylene group, a benzothiazolylene group, an isoxazolylene group, an oxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene

group, a dibenzocarbazolylylene group, an imidazopyrimidinylene group, and an imidazopyridinylene group, each substituted with at least one of a deuterium atom, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a C<sub>6</sub>-C<sub>20</sub> aryl group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent nonaromatic condensed polycyclic group, a monovalent nonaromatic condensed heterocyclic group, and —Si(Q<sub>33</sub>)(Q<sub>34</sub>)(Q<sub>35</sub>), wherein Q<sub>1</sub> to Q<sub>5</sub>, and Q<sub>33</sub> to Q<sub>35</sub> may be each independently a hydrogen, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a phthalazinyl group, a quinoxalinyl group, a cinnolinyl group, or a quinazolinyl group.

**[0251]** In some other embodiments, in Formula 41 and 61, Ar<sub>41</sub>, L<sub>41</sub>, L<sub>42</sub>, L<sub>61</sub>, and L<sub>62</sub> may be each independently selected from a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkylene group, a substituted or unsubstituted C<sub>3</sub>-C<sub>60</sub> cycloalkenylene group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylene group, and a substituted or unsubstituted divalent nonaromatic condensed polycyclic group.

**[0252]** In some embodiments, in Formulae 41 and 61, R<sub>41</sub> to R<sub>44</sub>, R<sub>51</sub> to R<sub>54</sub>, R<sub>61</sub> to R<sub>64</sub>, and R<sub>71</sub> to R<sub>79</sub> may be each independently selected from

**[0253]** a hydrogen atom, a deuterium atom, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, and a C<sub>1</sub>-C<sub>20</sub> alkoxy group;

**[0254]** a phenyl group, a pentalenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzo-fluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group; and

**[0255]** a phenyl group, a pentalenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzo-fluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a hydrazine group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a pentalenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzo-fluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, but are not limited thereto.

phenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, but are not limited thereto.

**[0256]** For example, L<sub>61</sub> and L<sub>62</sub> may be each independently selected from a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroarylene group, and a substituted or unsubstituted divalent nonaromatic condensed heteropolycyclic group; and

**[0257]** R<sub>51</sub> to R<sub>54</sub>, R<sub>61</sub> to R<sub>64</sub>, and R<sub>71</sub> to R<sub>79</sub> may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>20</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>20</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>20</sub> aryl group, and a substituted or unsubstituted a substituted or unsubstituted monovalent nonaromatic condensed heteropolycyclic group.

**[0258]** In some embodiments, R<sub>51</sub>, R<sub>53</sub>, and R<sub>54</sub> in Formula 41, and R<sub>71</sub> to R<sub>79</sub> in Formula 61 may be each independently selected from hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>2</sub>-C<sub>20</sub> alkenyl group, a C<sub>2</sub>-C<sub>20</sub> alkynyl group, and a C<sub>1</sub>-C<sub>20</sub> alkoxy group.

**[0259]** In some other embodiments, R<sub>51</sub>, R<sub>53</sub>, and R<sub>54</sub> in Formula 41, and R<sub>71</sub> to R<sub>79</sub> in Formula 61 may be all hydrogens.

**[0260]** In some other embodiments, R<sub>41</sub>, R<sub>42</sub>, and R<sub>52</sub> in Formula 41, and R<sub>61</sub> and R<sub>62</sub> in Formula 61 may be each independently a group represented by one of Formulae 4-1 to 4-31, 4-35, and 4-36 regarding Formula 1 above.

**[0261]** For example, R<sub>41</sub>, R<sub>42</sub>, and R<sub>52</sub> in Formula 41, and R<sub>61</sub> and R<sub>62</sub> in Formula 61 may be each independently a group represented by one of Formulae 4-1 to 4-5, and Formulae 4-26 to 4-31 regarding Formula 1 above.

**[0262]** In some other embodiments, R<sub>41</sub>, R<sub>42</sub>, and R<sub>52</sub> in Formula 41, and R<sub>61</sub> and R<sub>62</sub> in Formula 61 may be each independently a group represented by one of Formulae 5-1 to 5-26, Formulae 5-56 to 5-85, and 5-142 to 5-145 regarding Formula 1 above. However, embodiments of the present disclosure are not limited thereto.

**[0263]** In some other embodiments, the emission layer of the organic light-emitting device may include a first host, a second host, and a dopant, wherein the first host may include the at least one of the condensed cyclic compounds of Formula 1 above, and the first host and the second host are differ from each other,

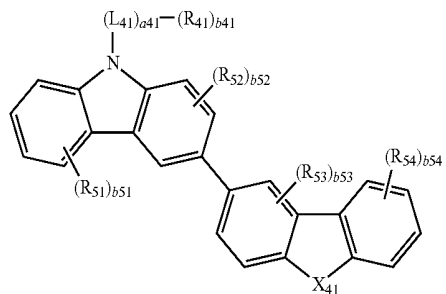
**[0264]** The first host may include the at least one of the condensed cyclic compounds of Formula 1 above, and

**[0265]** the second host may include the at least one of the first compound represented by Formula 41, and the second compound represented by Formula 61.

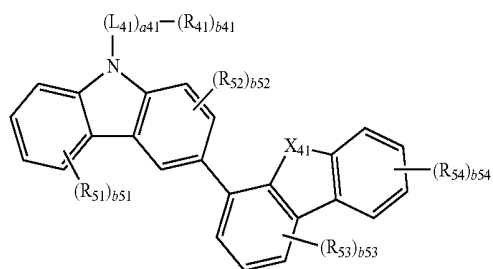
**[0266]** In some other embodiments, the first compound of Formula 41 above may be represented by one of Formulae 41-1 to 41-12 below, and the second compound of Formula 61 above may be represented by one of Formulae 61-1 to 61-6 below. However, embodiments of the present disclosure are not limited thereto.

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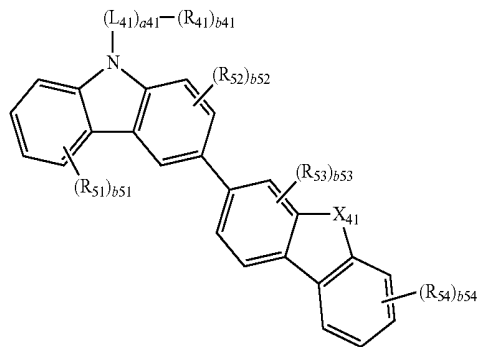
Formula 41-1



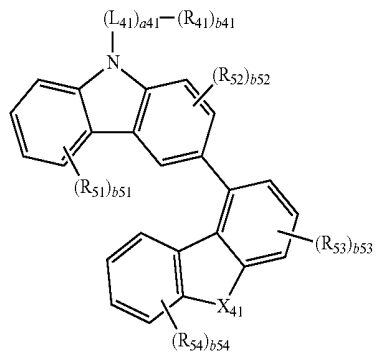
Formula 41-2



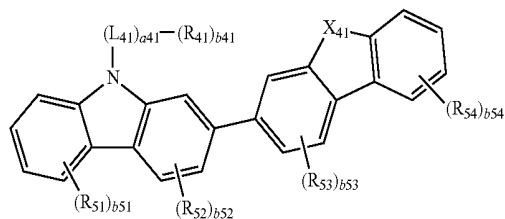
Formula 41-3



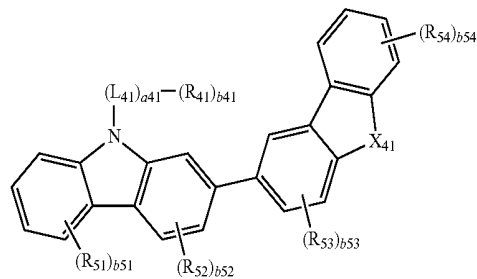
Formula 41-4



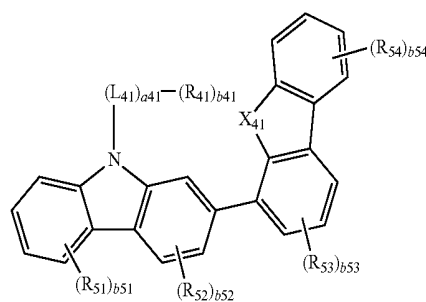
Formula 41-5



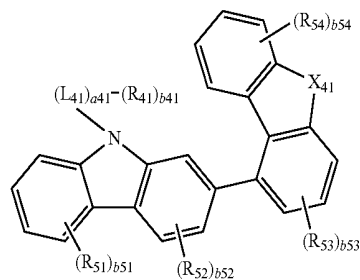
Formula 41-6



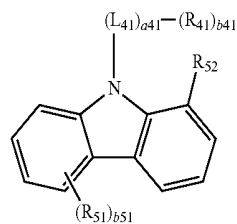
Formula 41-7



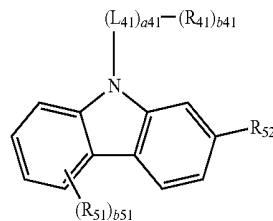
Formula 41-8



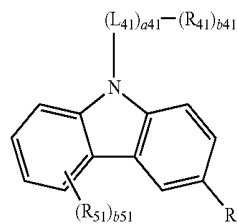
Formula 41-9



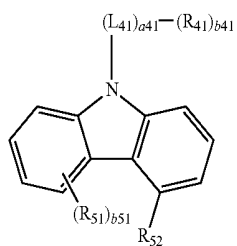
Formula 41-10



Formula 41-11

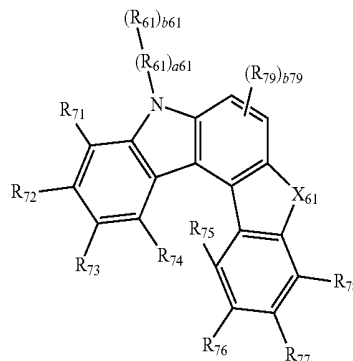


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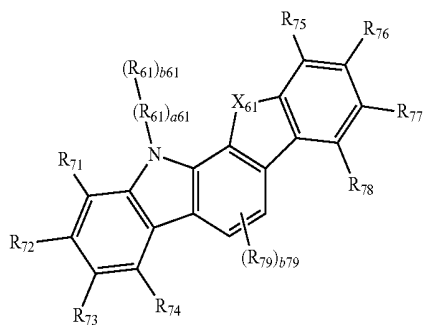
Formula 14-12

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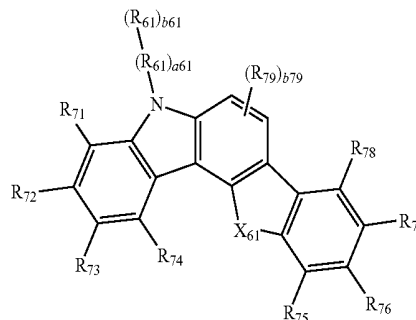


Formula 61-5

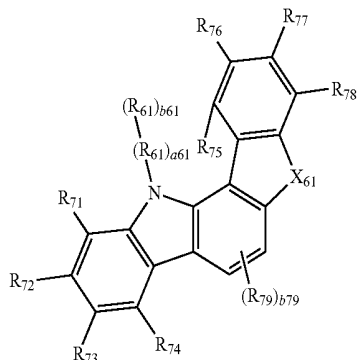
Formula 61-1



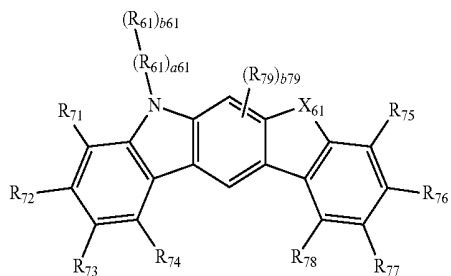
Formula 61-2



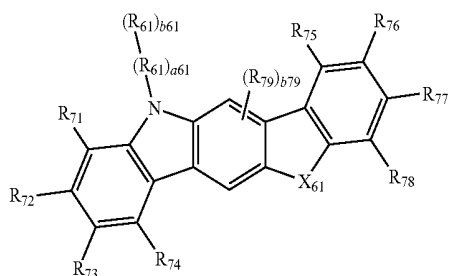
Formula 61-6



Formula 61-3



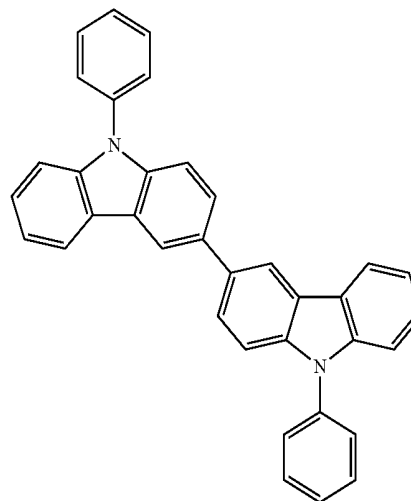
Formula 61-4



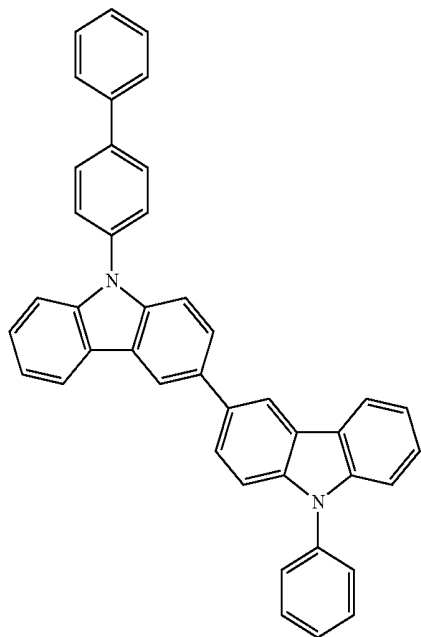
[0267] In Formulae 41-1 to 41-12, and Formulae 61-1 to 61-6,  $X_{41}$ ,  $X_{61}$ ,  $L_{41}$ ,  $a_{41}$ ,  $L_{61}$ ,  $a_{61}$ ,  $R_{41}$ ,  $b_{41}$ ,  $b_{42}$ ,  $R_{51}$  to  $R_{54}$ ,  $R_{61}$ ,  $b_{51}$  to  $b_{54}$ ,  $b_{61}$ ,  $R_{71}$  to  $R_{79}$ , and  $b_{79}$  may be the same as those defined above.

[0268] In some embodiments, the first compound of Formula 41 above may include one of Compounds A1 to A111 below, and the second compound of Formula 61 may include one of Compounds B1 to B20 below. However, embodiments of the present disclosure are not limited thereto.

A1

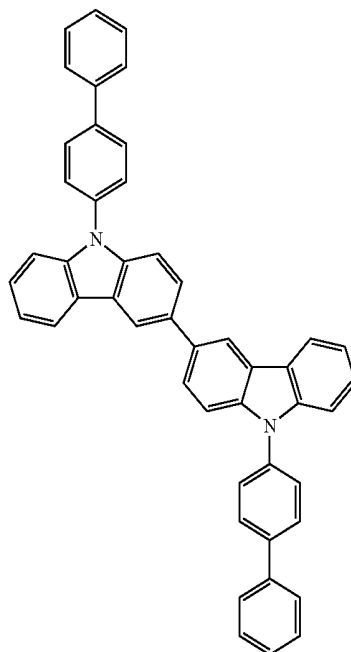


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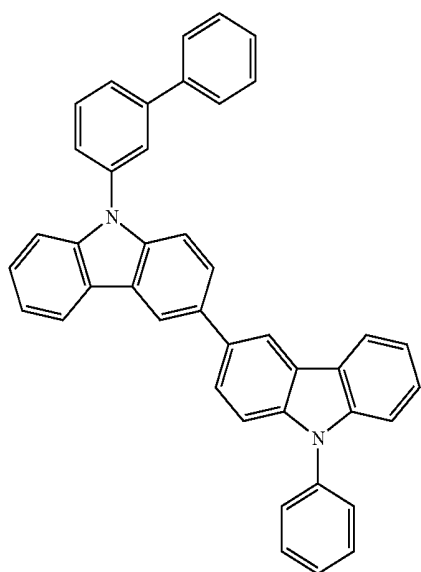


A2

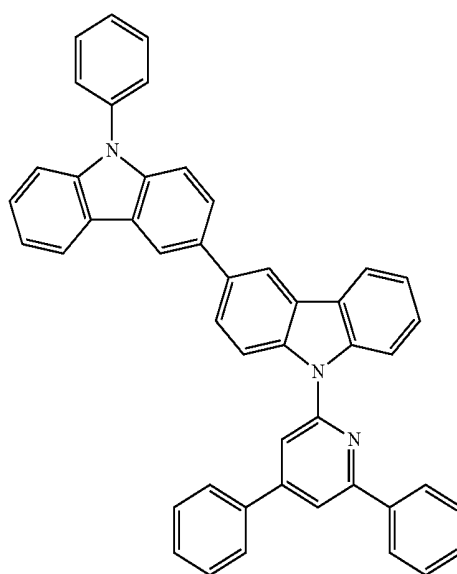
-continued



A4

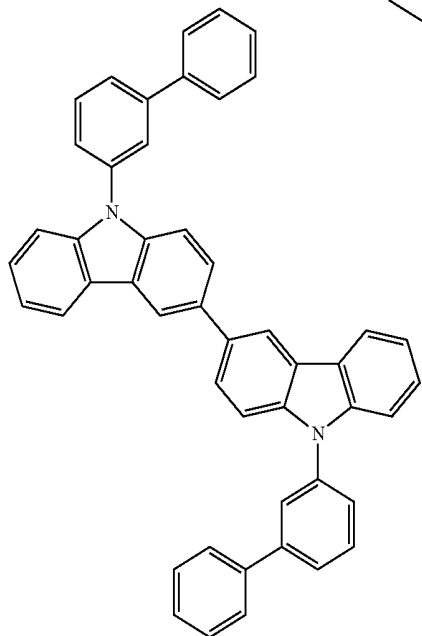
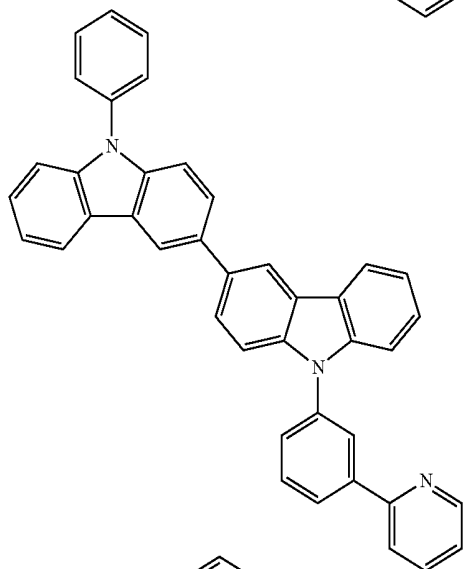
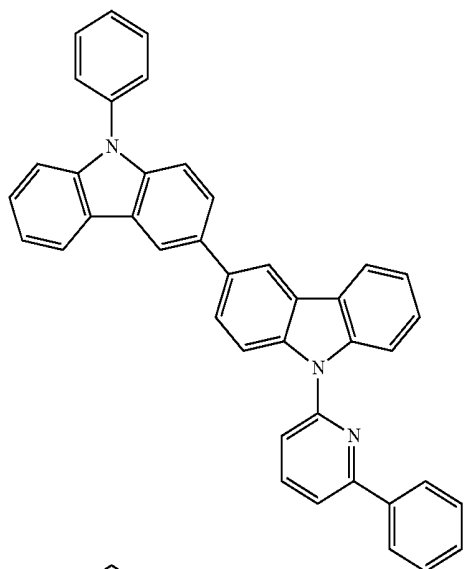


A3

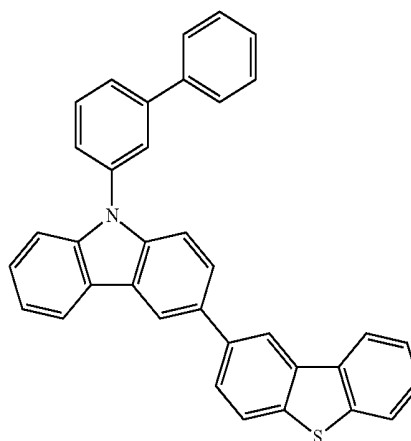
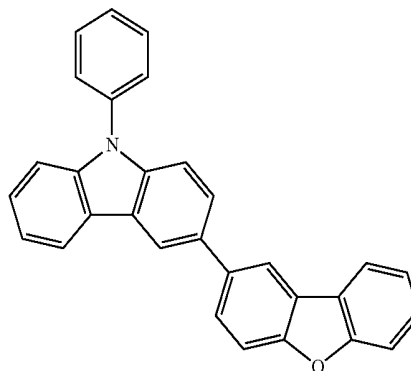
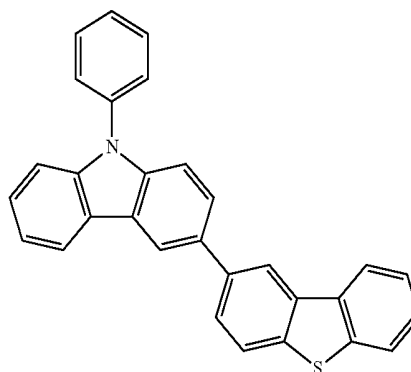
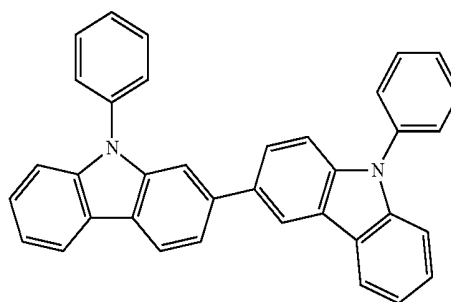


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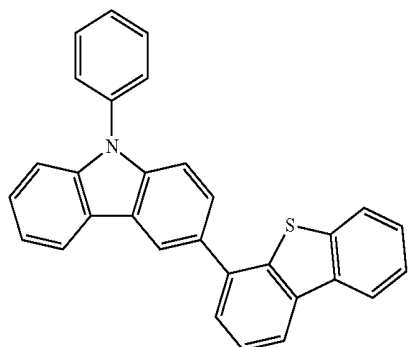
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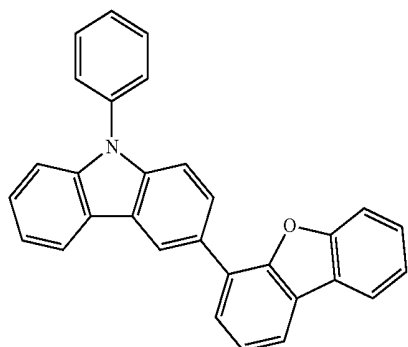
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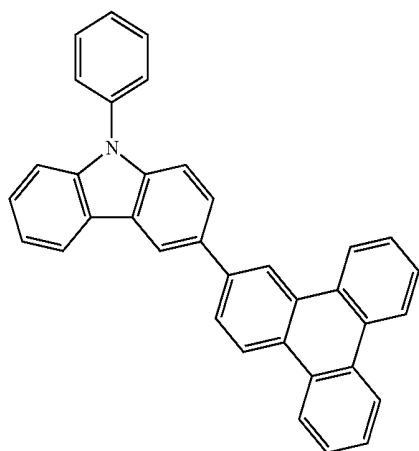
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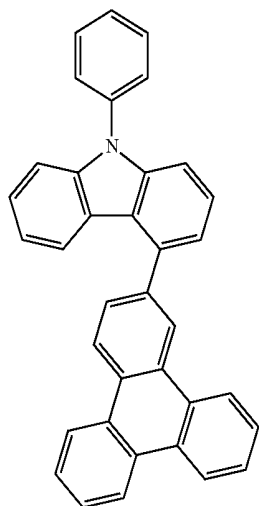
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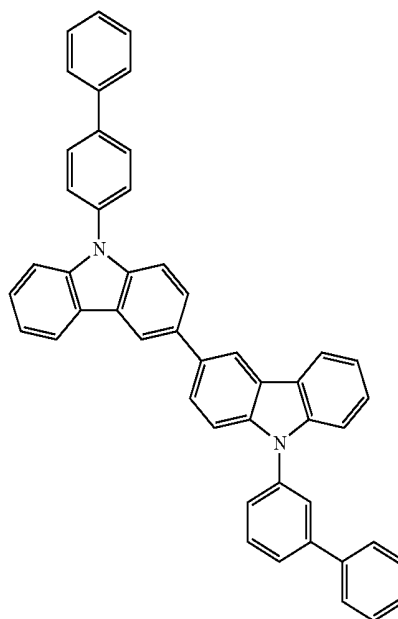


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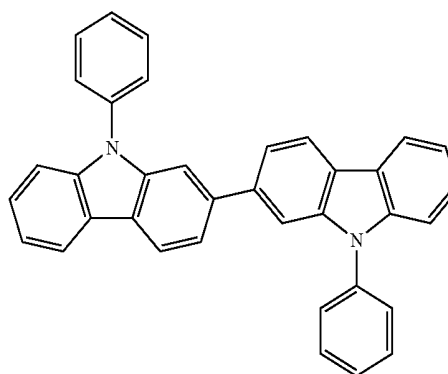


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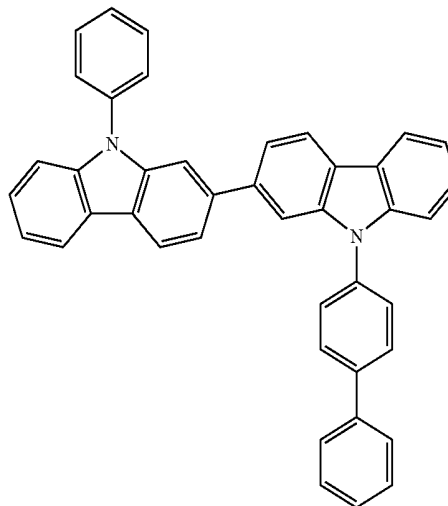
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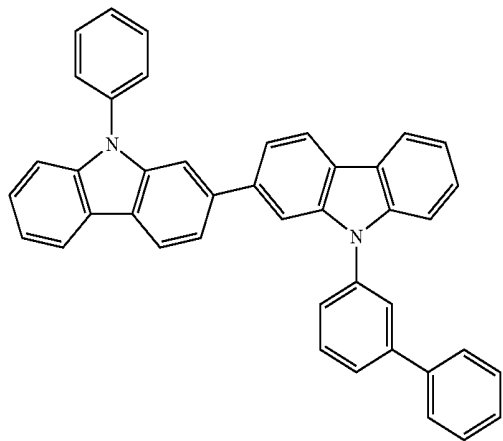
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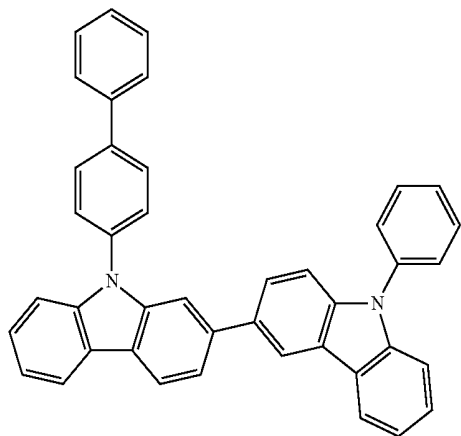
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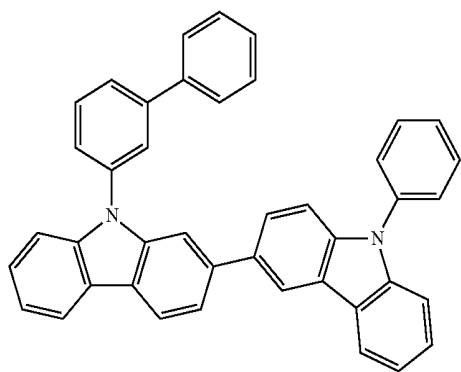
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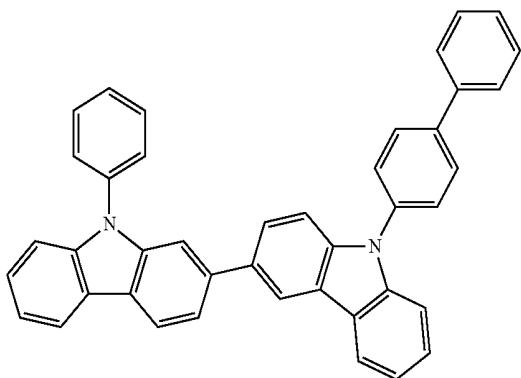
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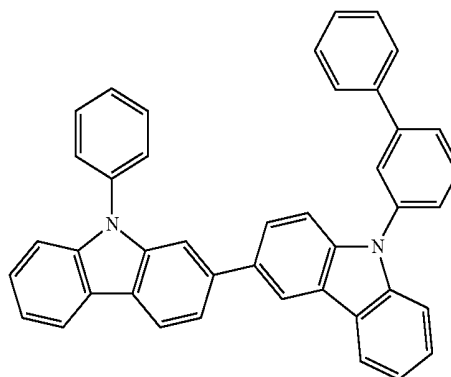


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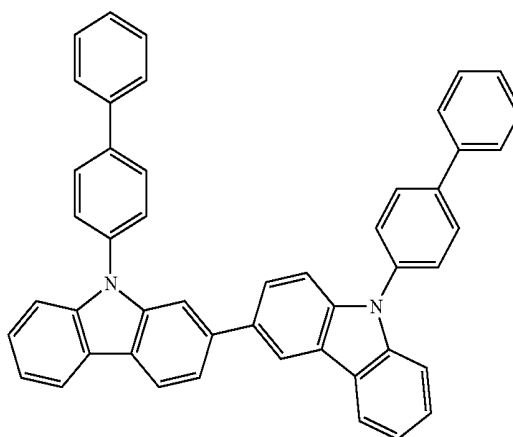


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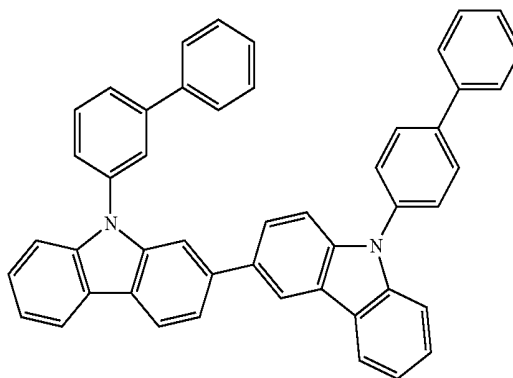
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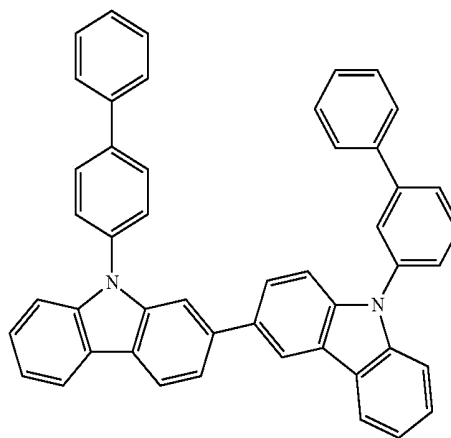
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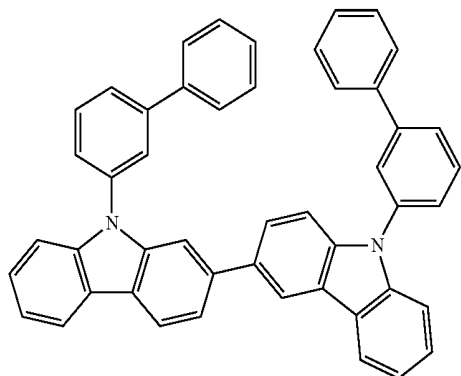
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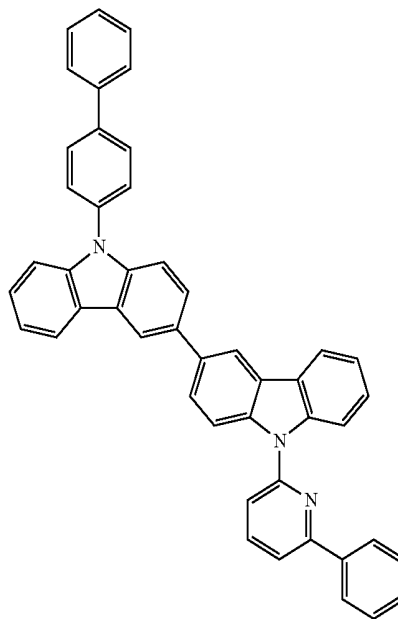


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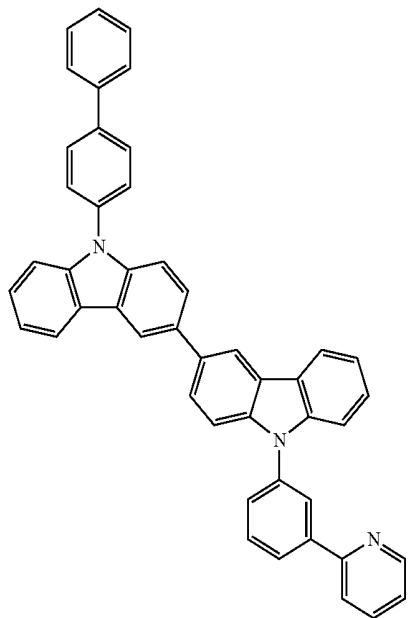


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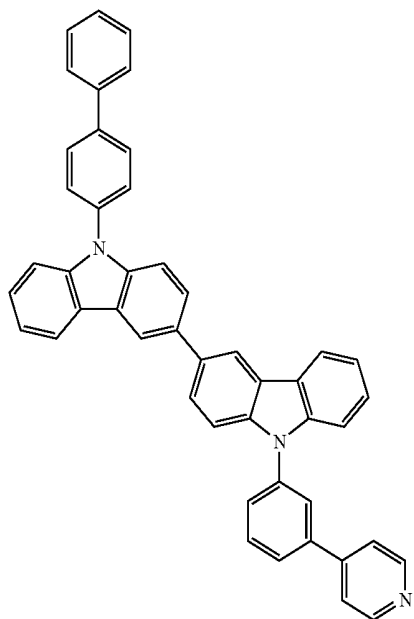
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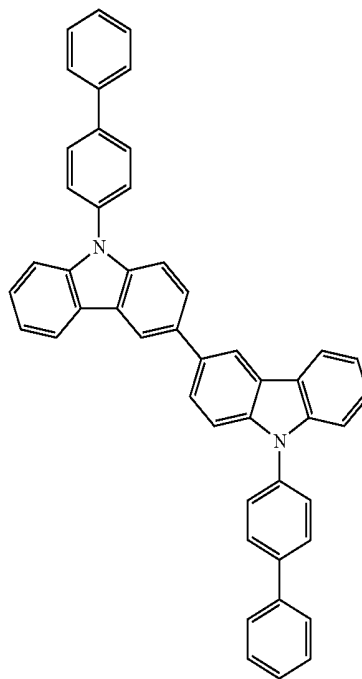
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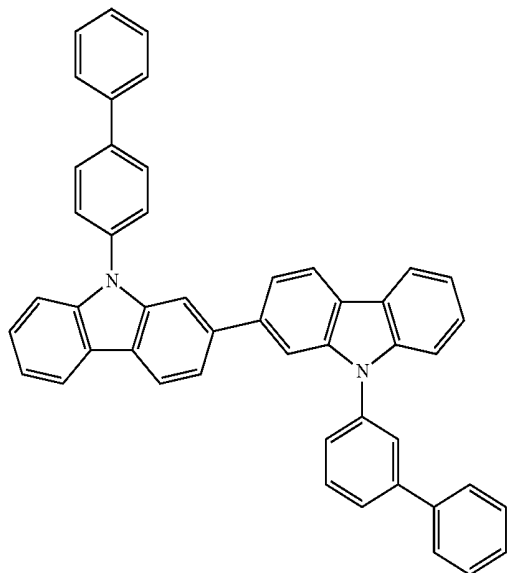
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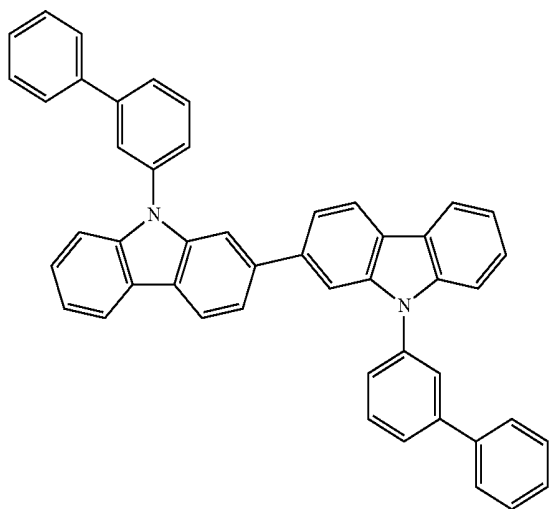
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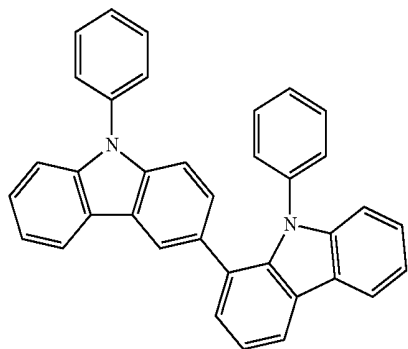
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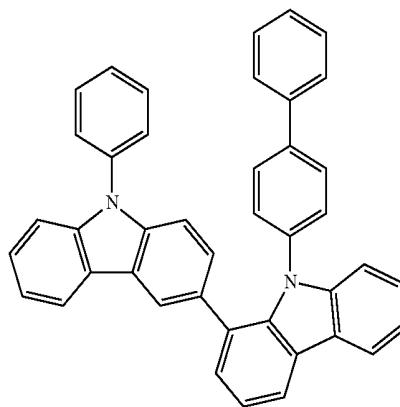


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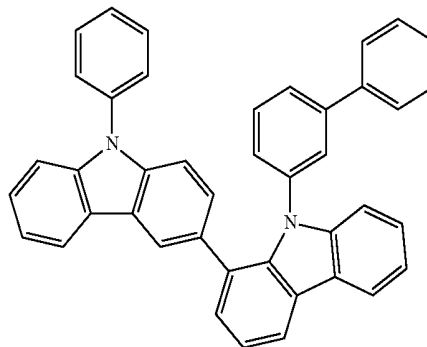


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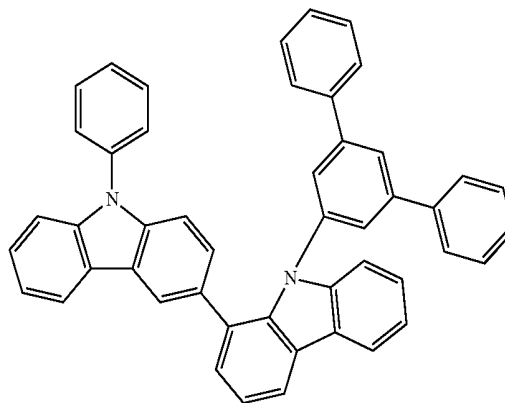
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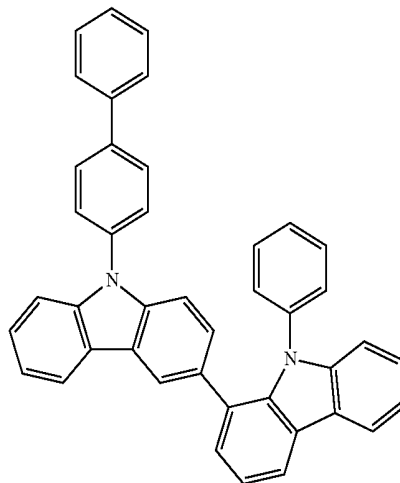
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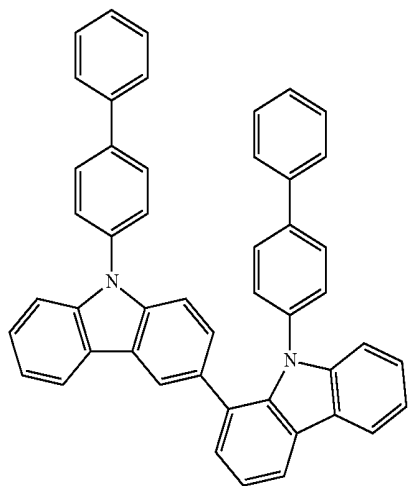
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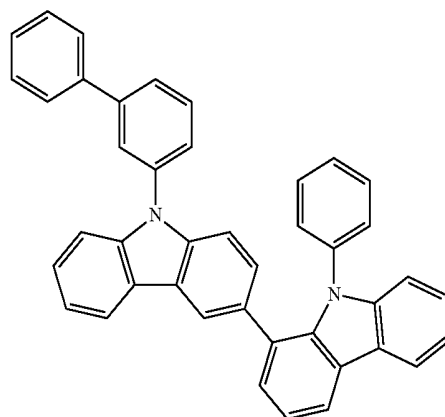


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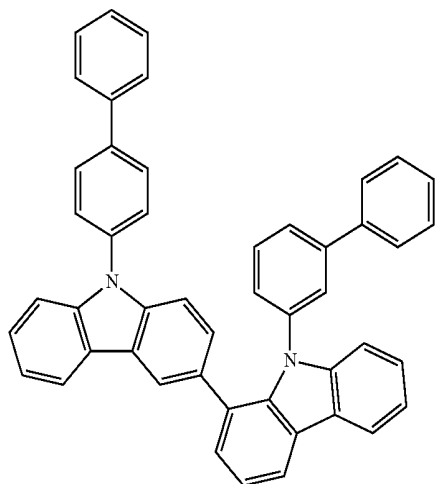


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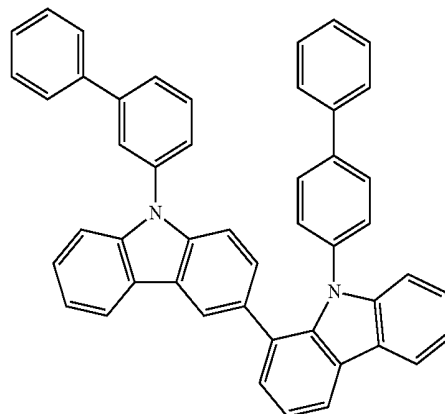
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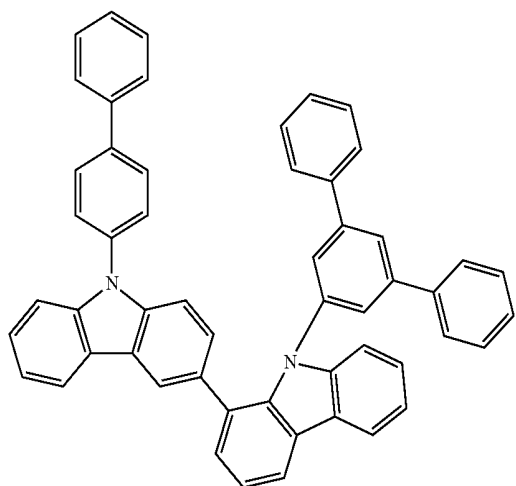
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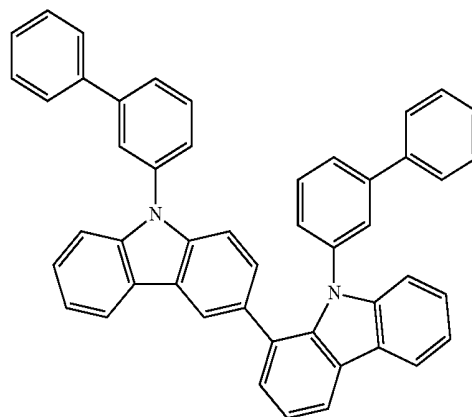
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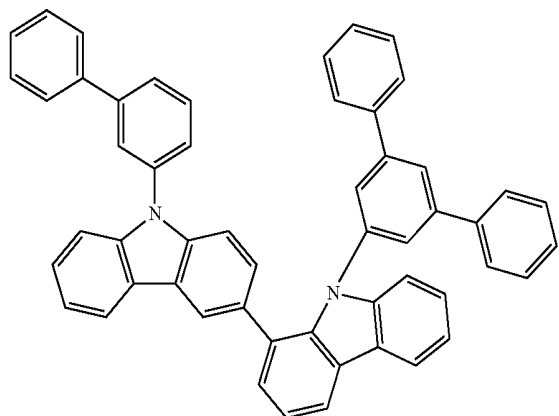
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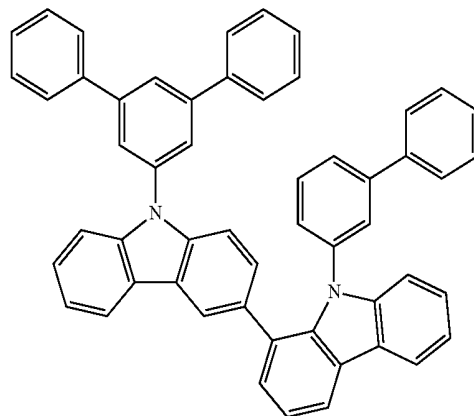
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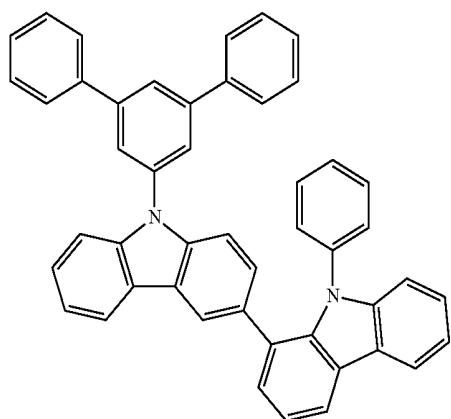


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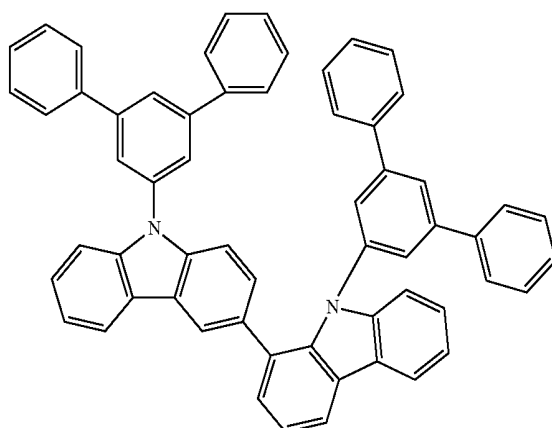
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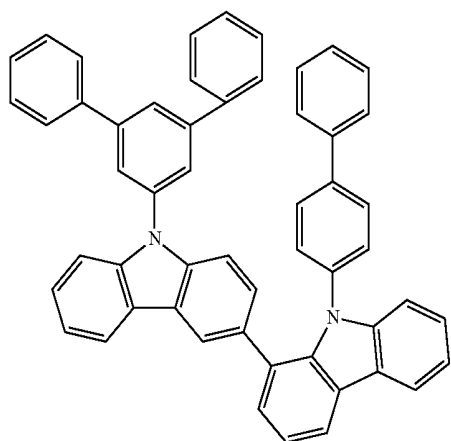
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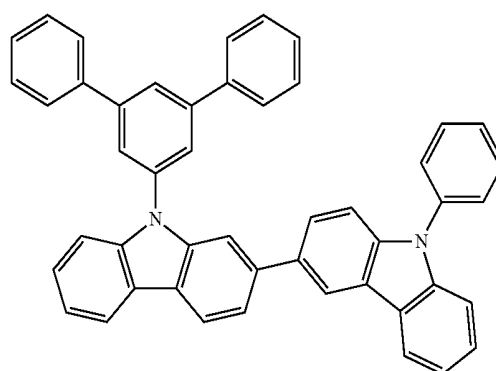
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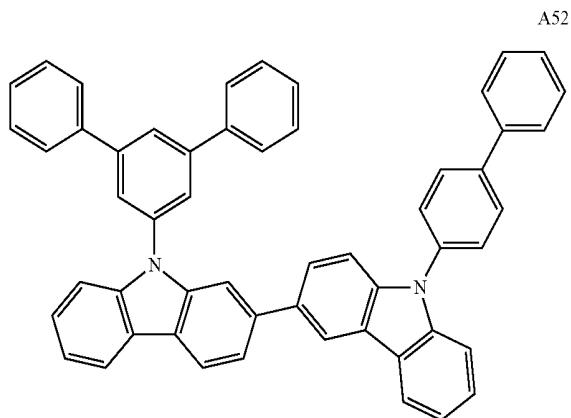
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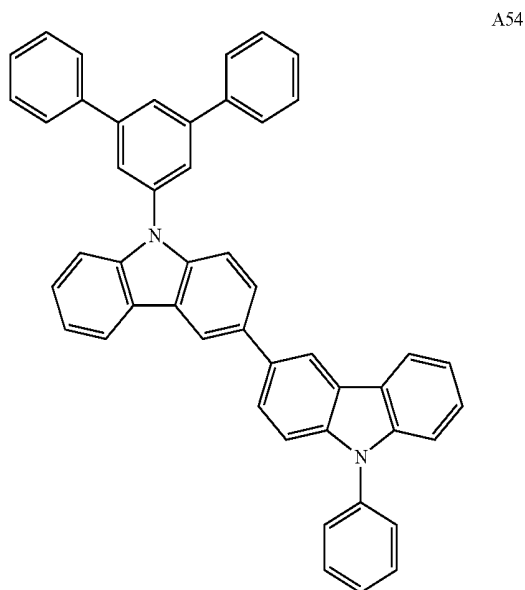
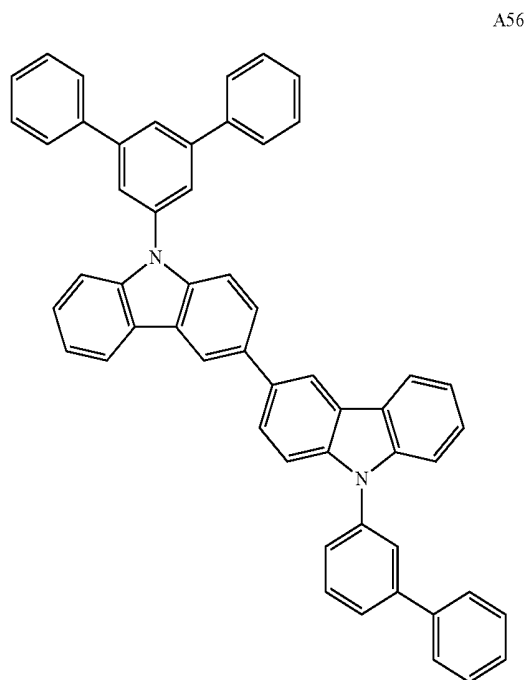
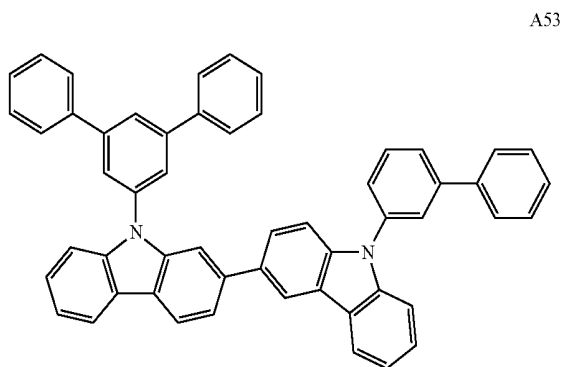
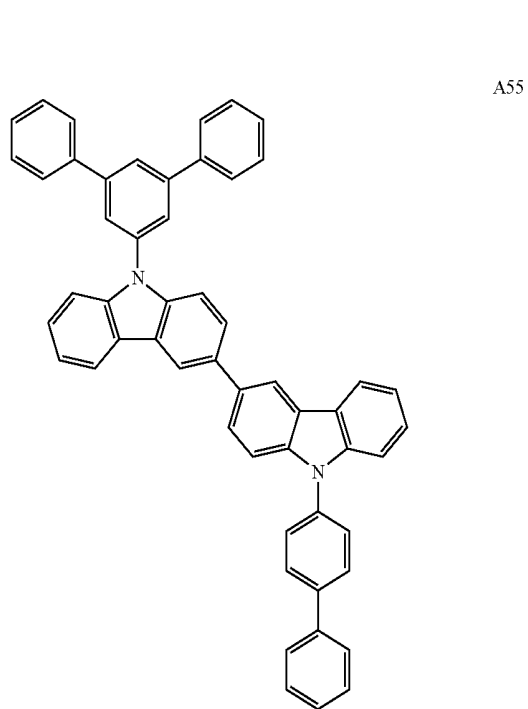
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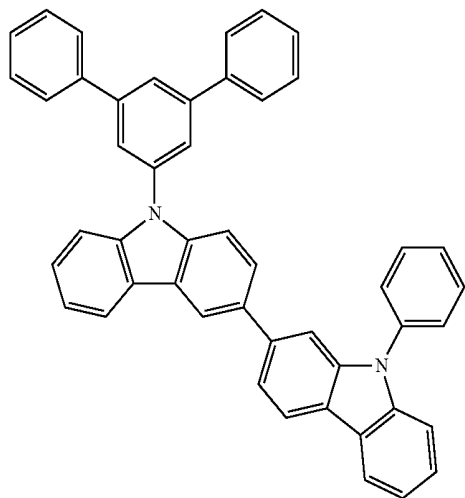


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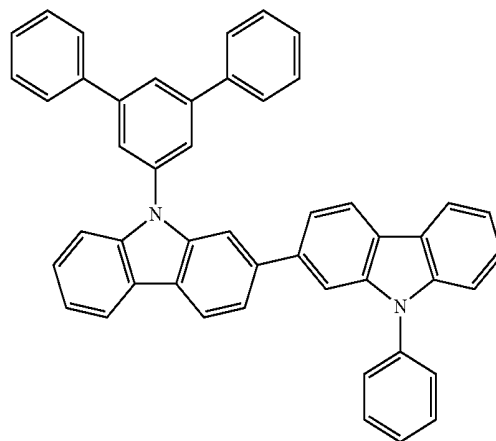
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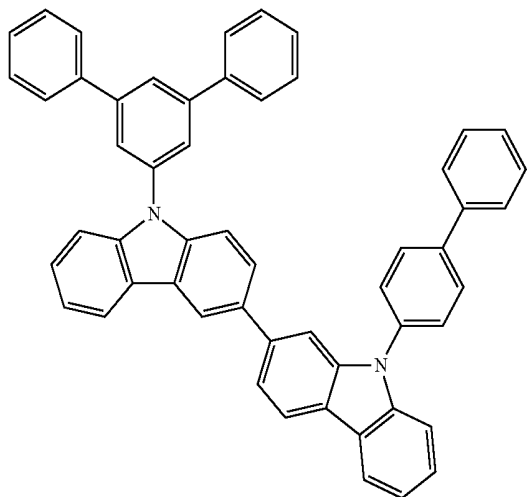


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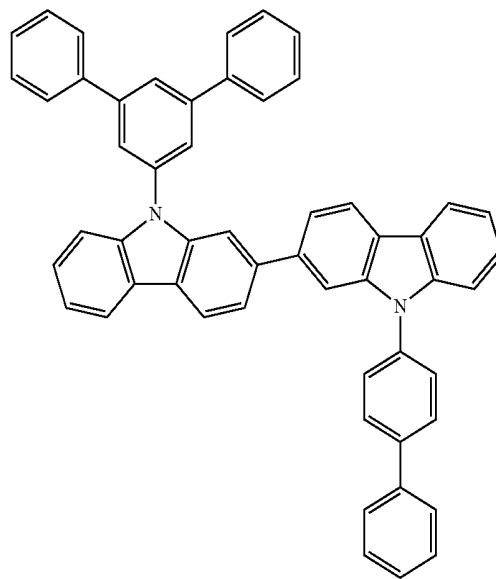
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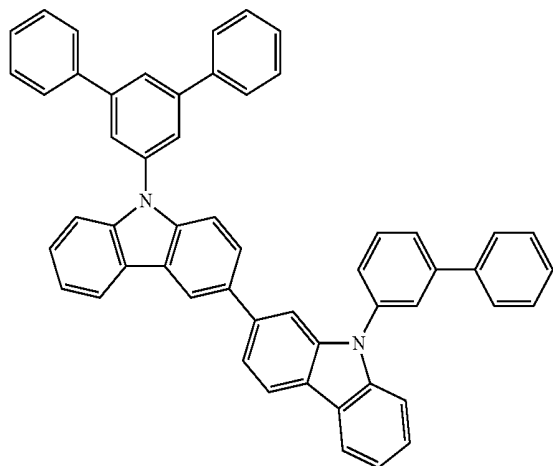
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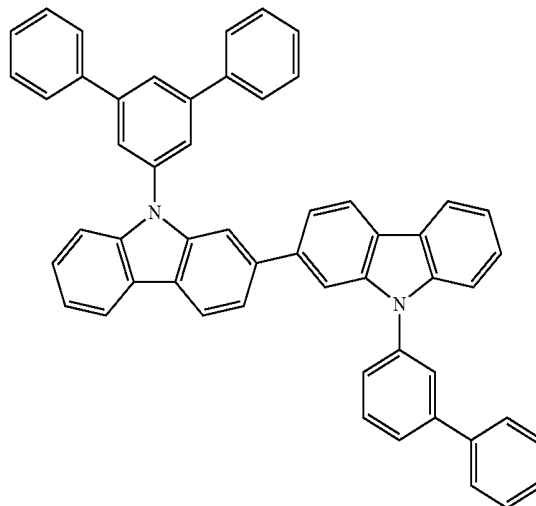
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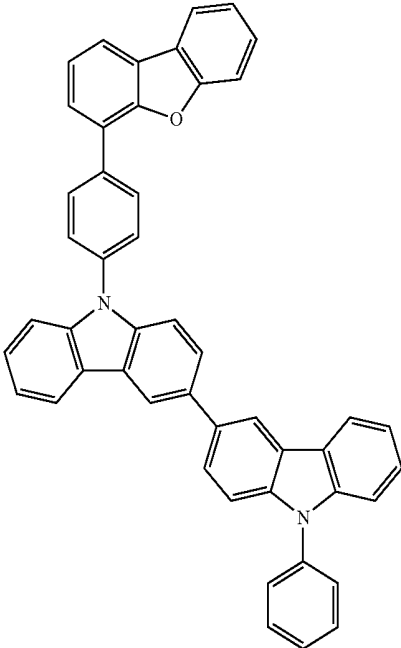
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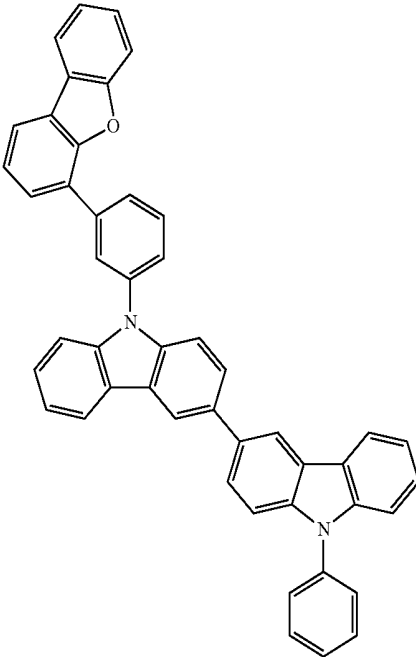


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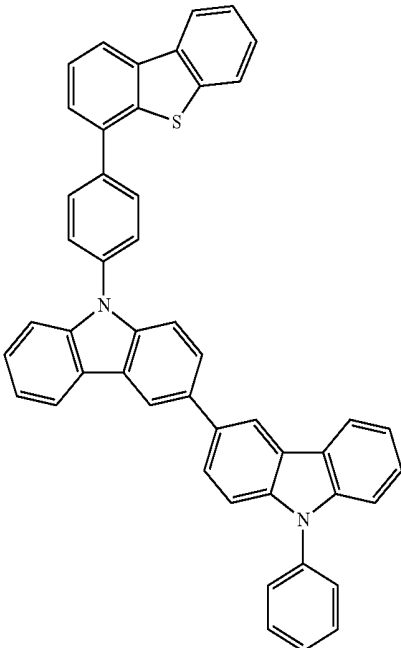


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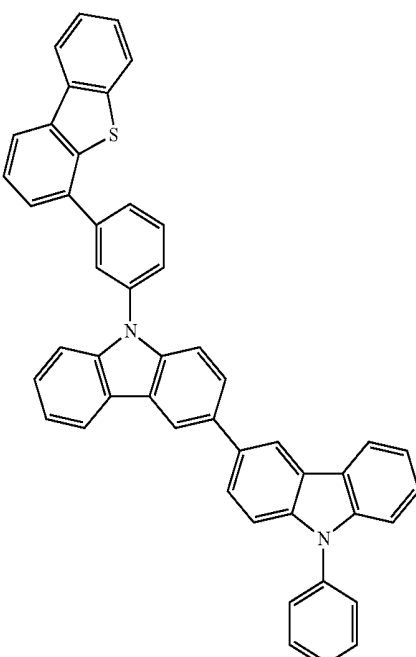
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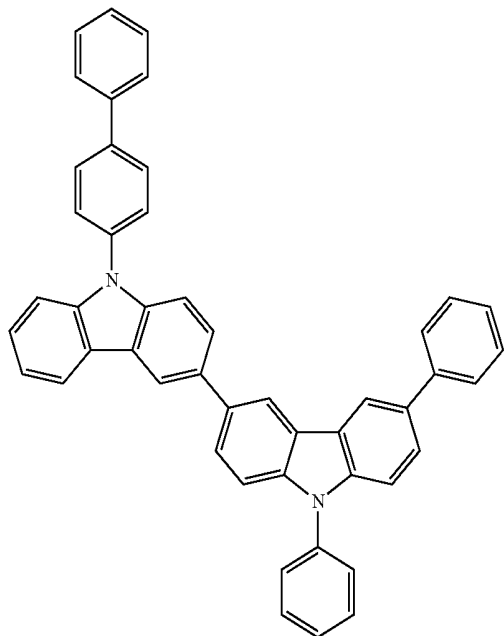
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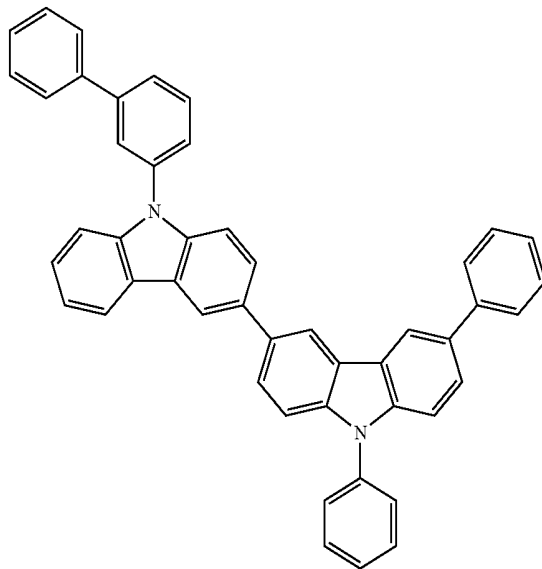
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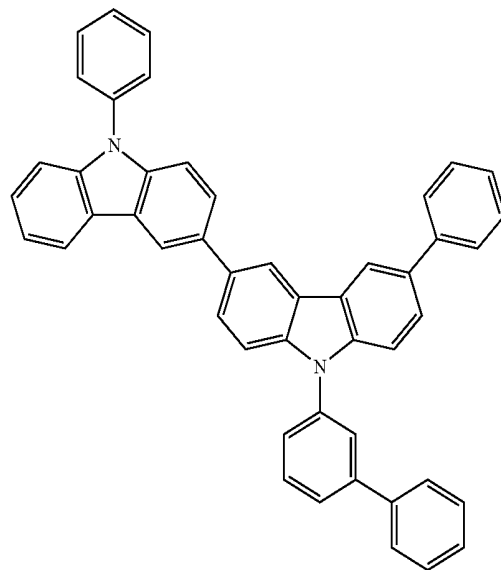
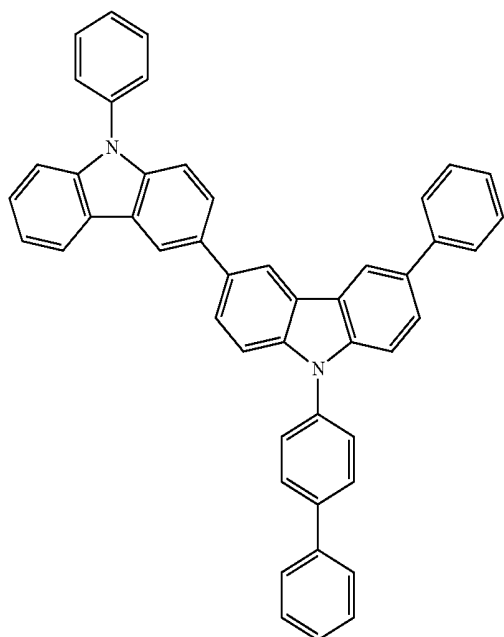
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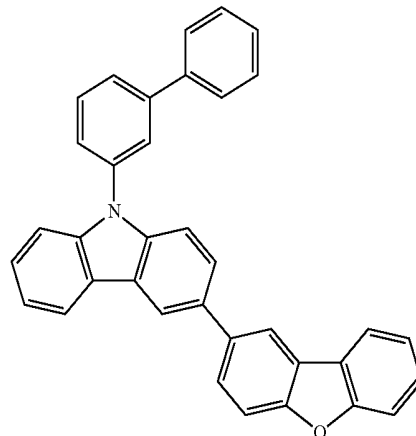


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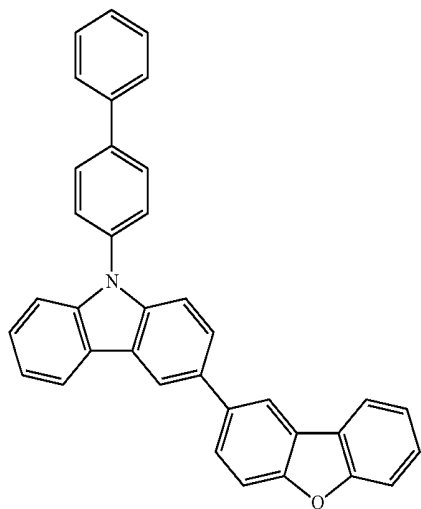
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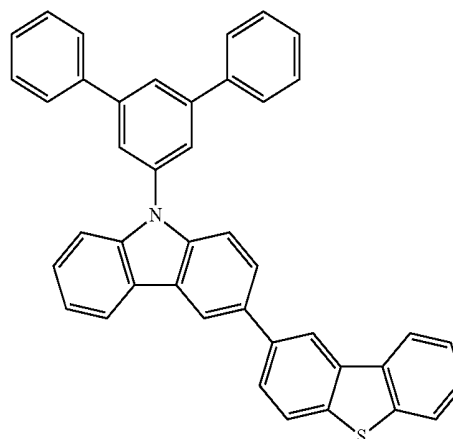


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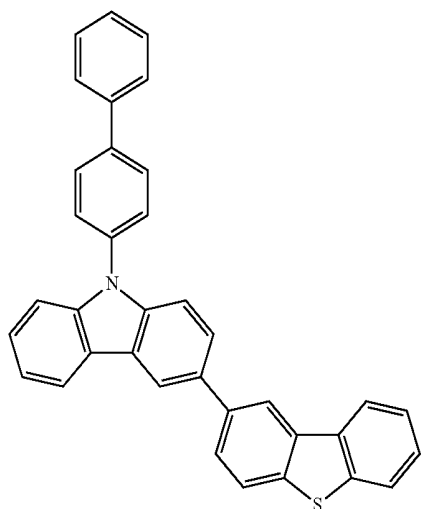
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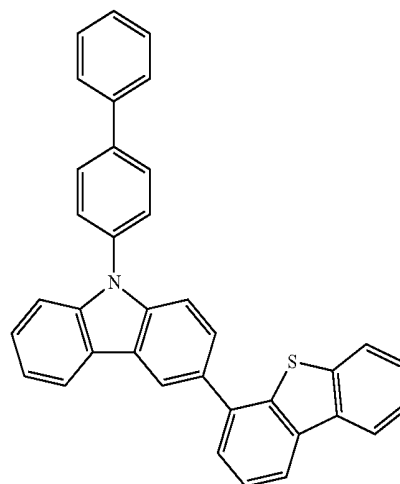


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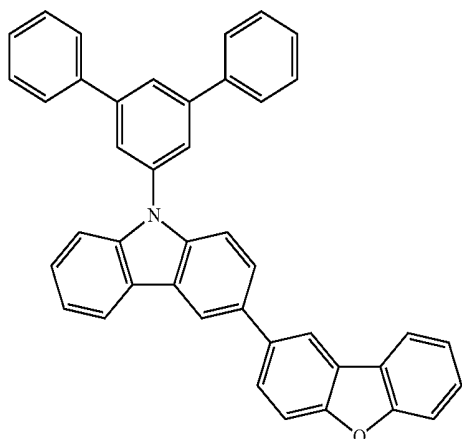
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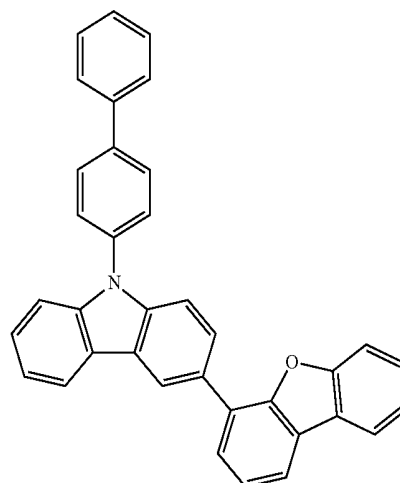
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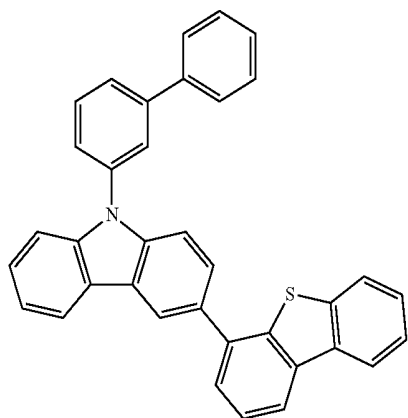
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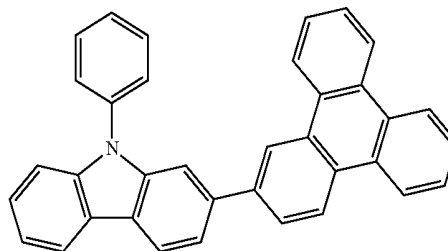


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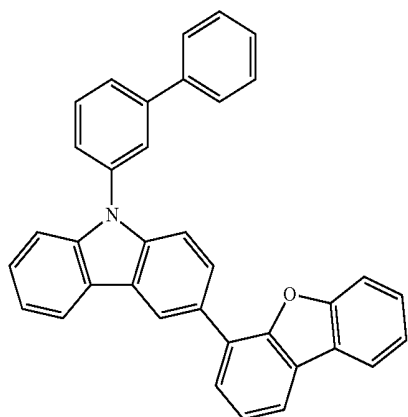


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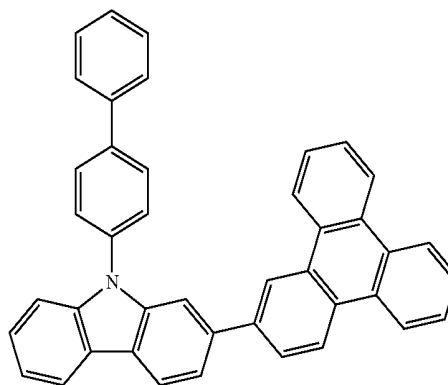
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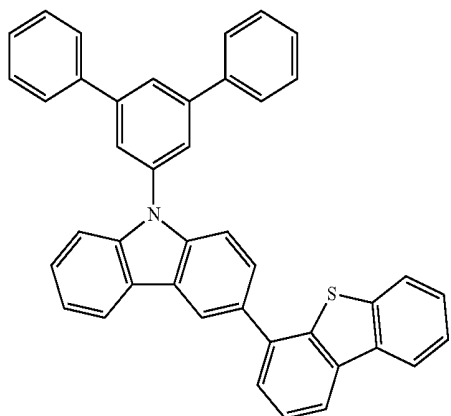
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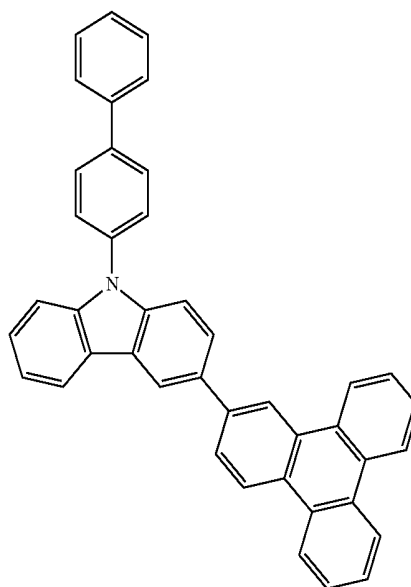
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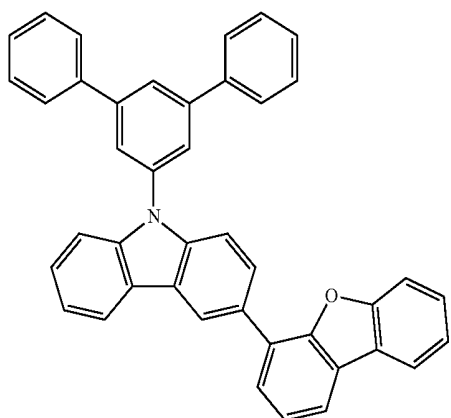
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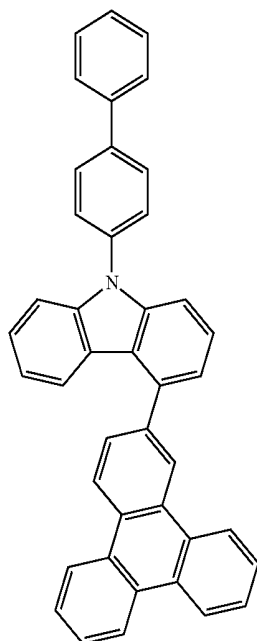


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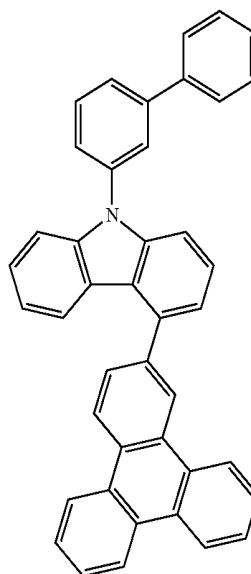
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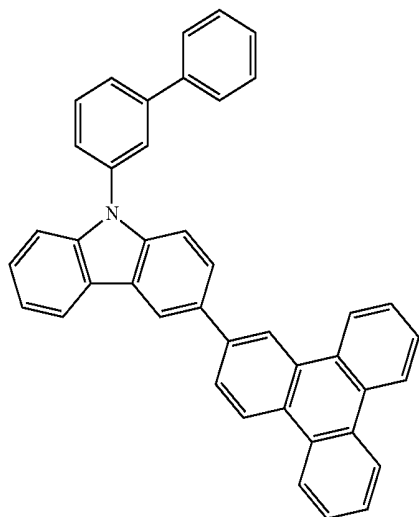


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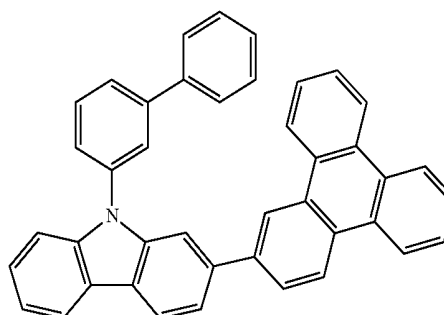
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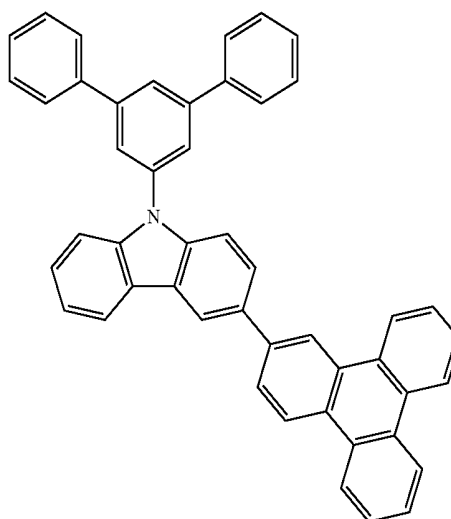
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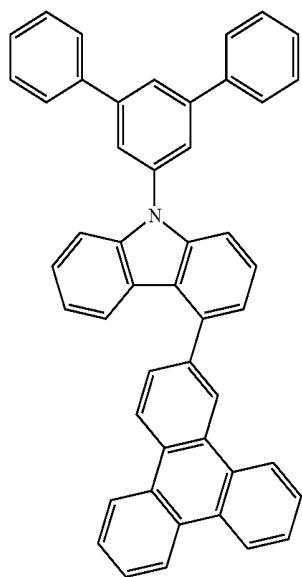


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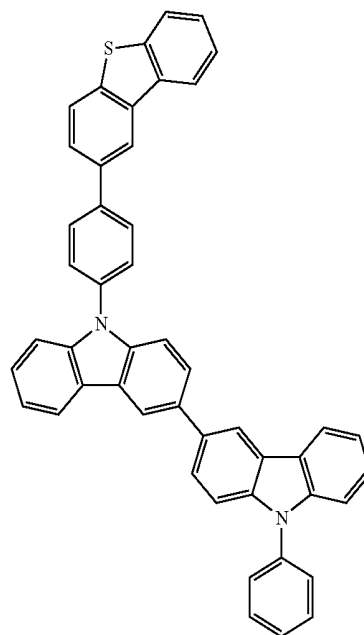
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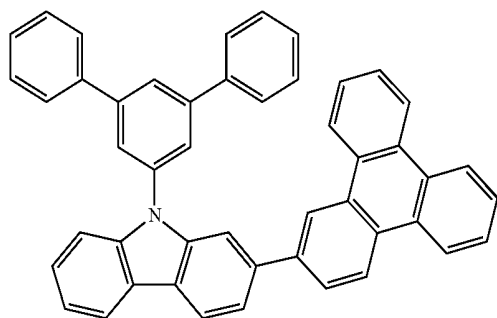


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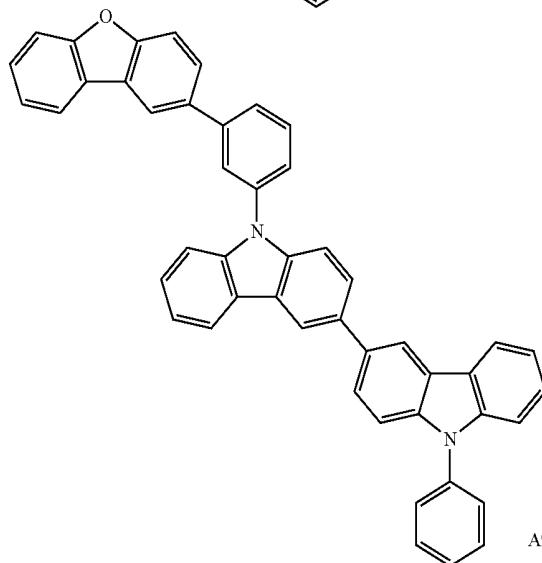
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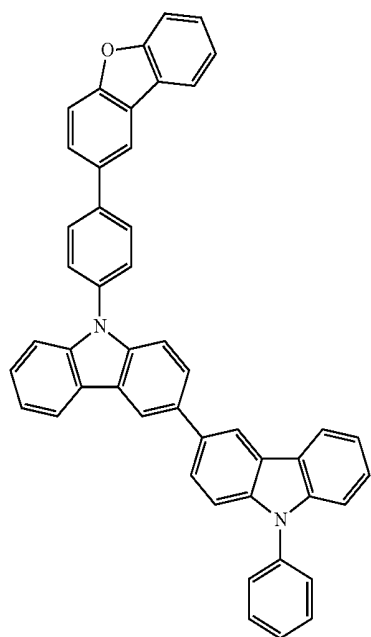
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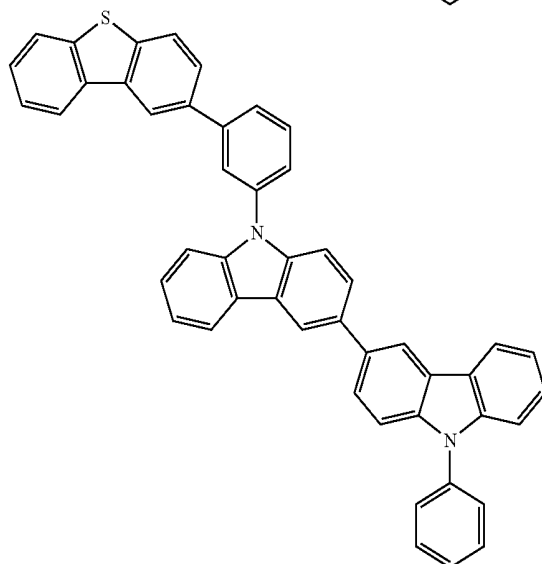
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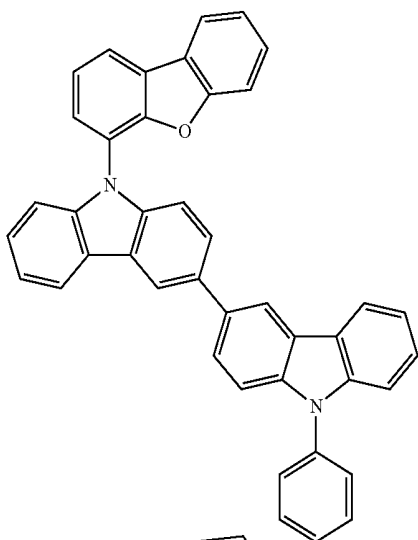


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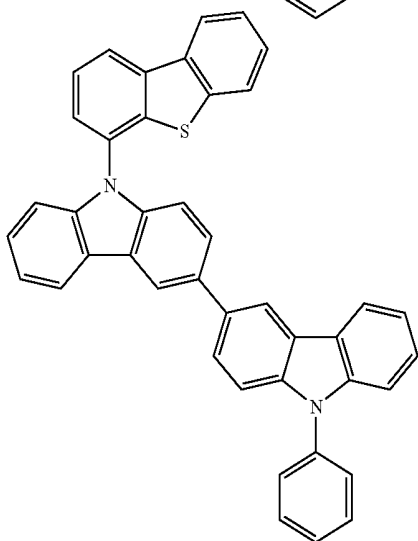


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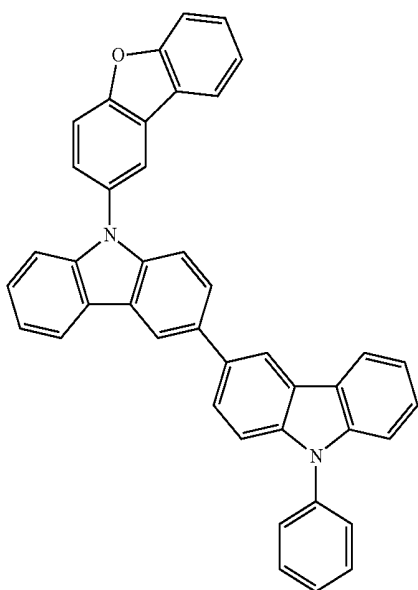
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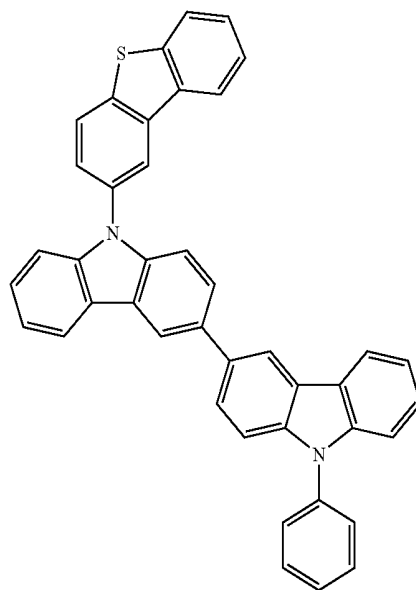


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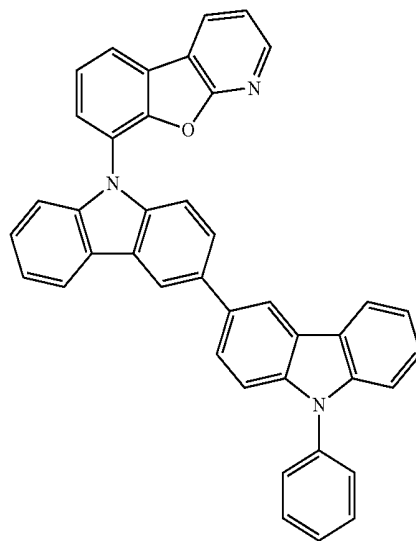


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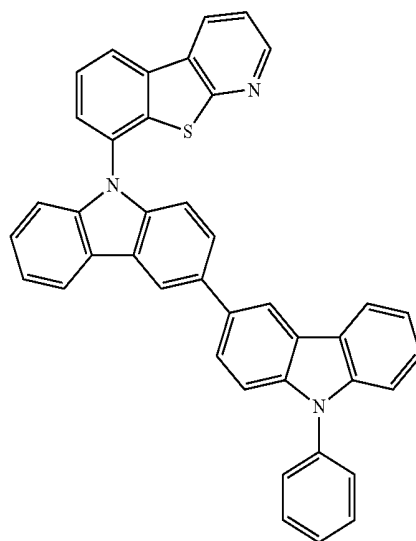
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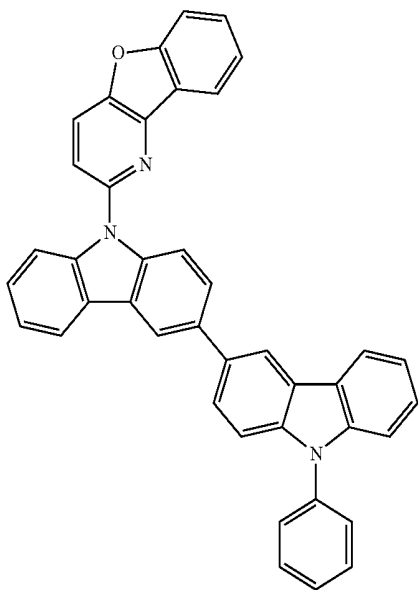


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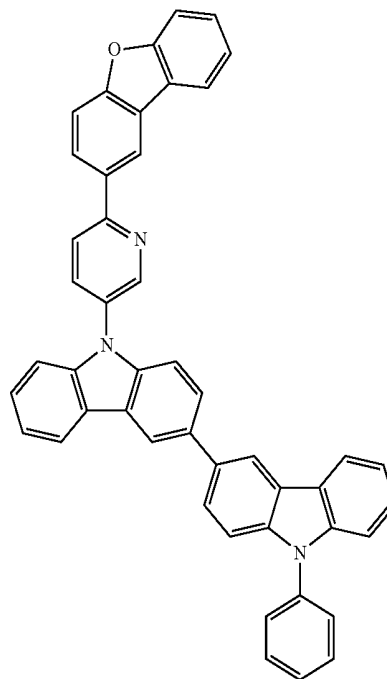
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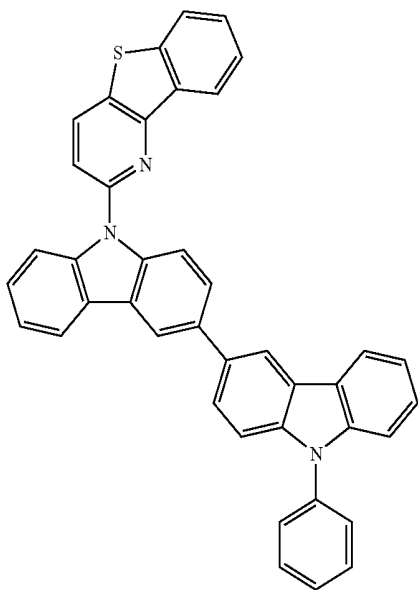
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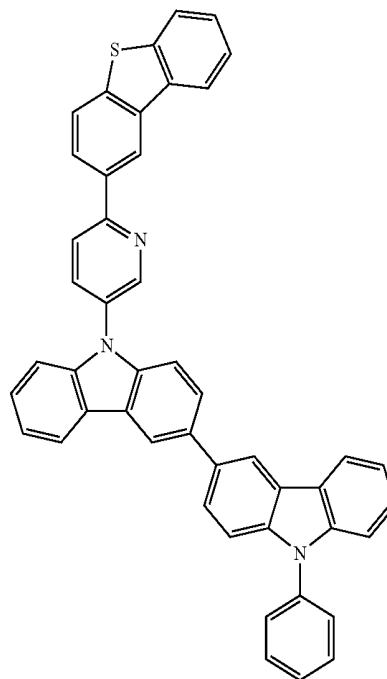


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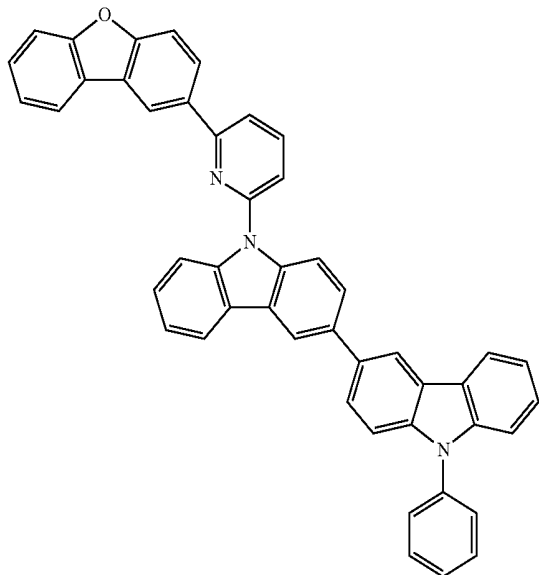


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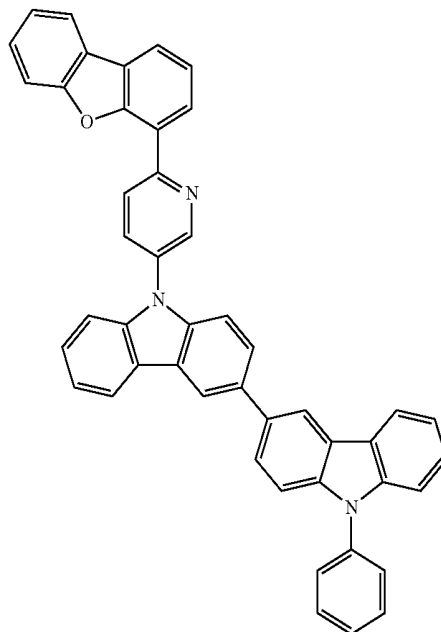
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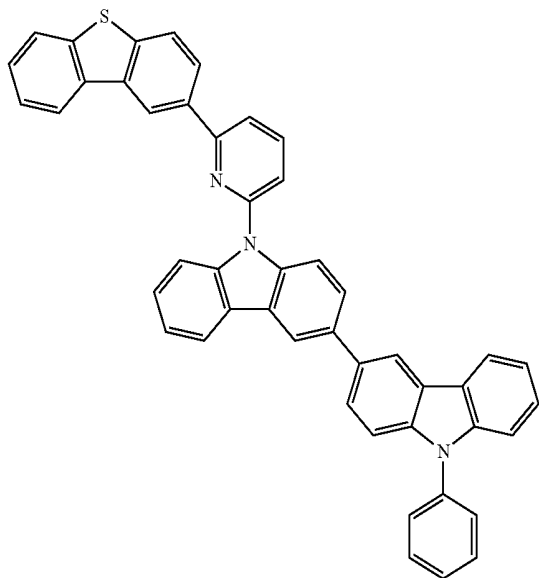


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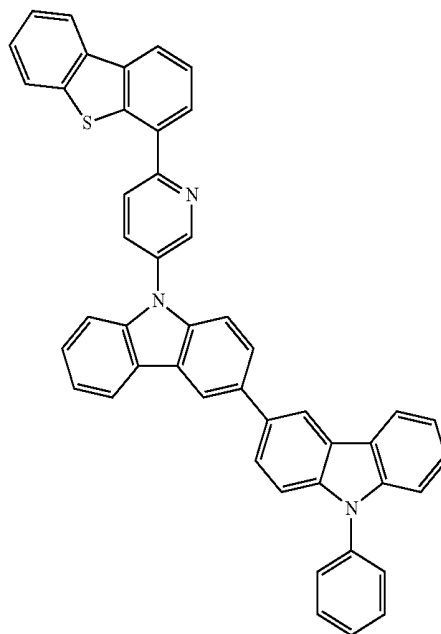
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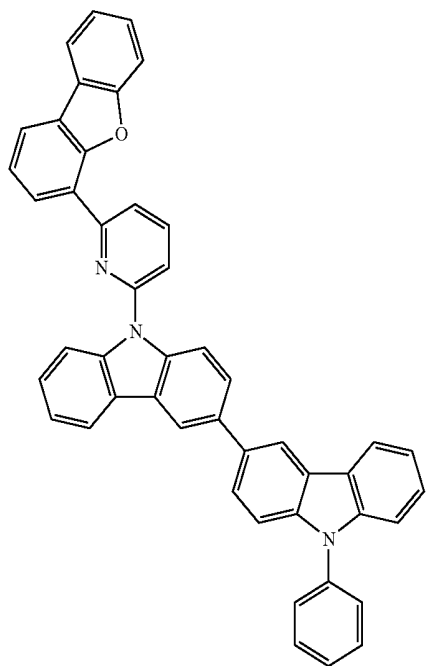
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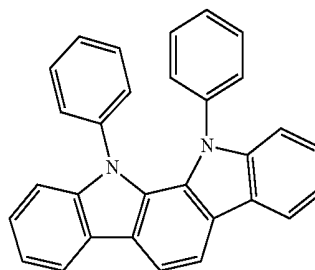


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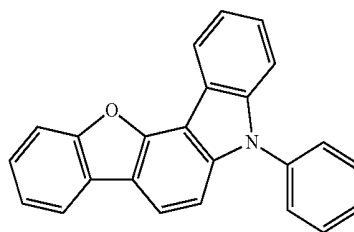


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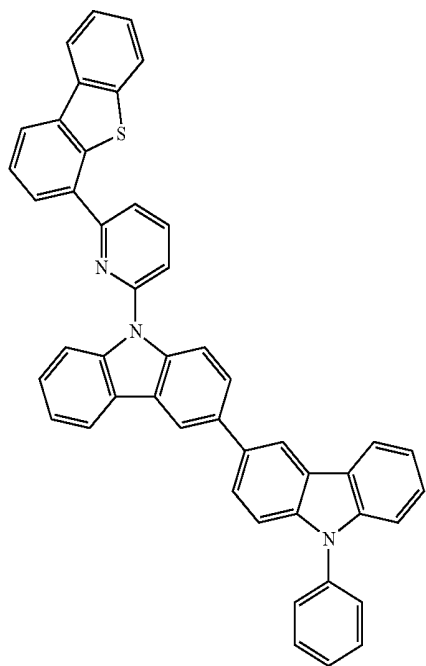


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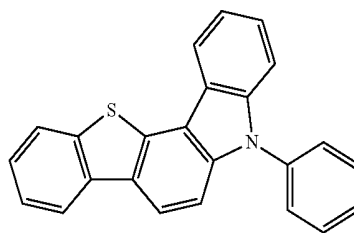


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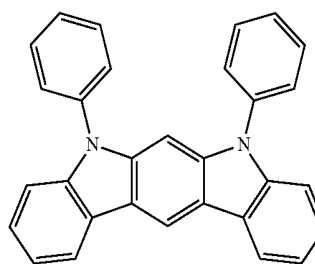
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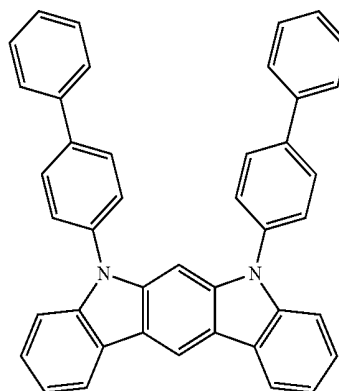
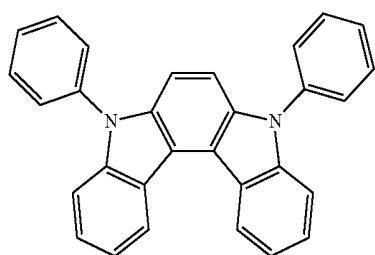


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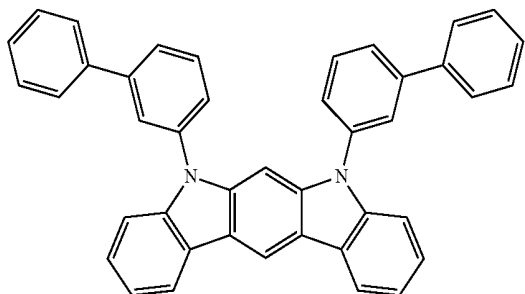
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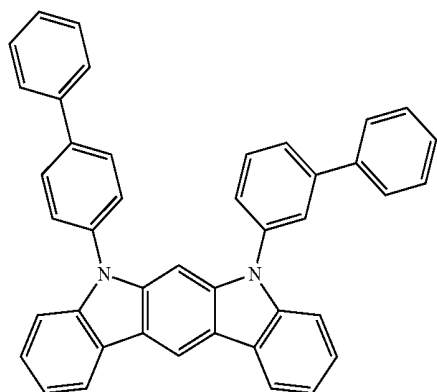


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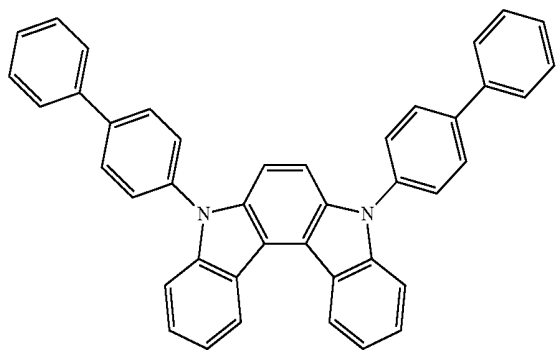
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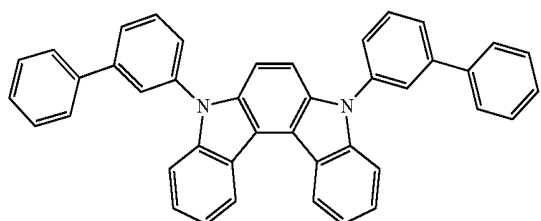
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B9

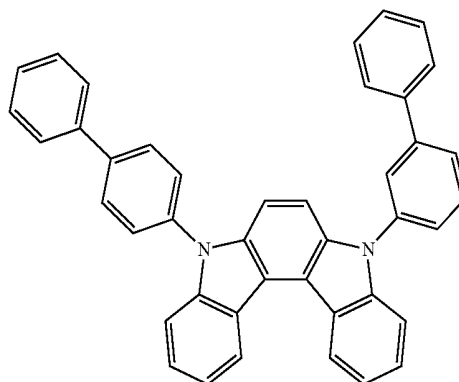


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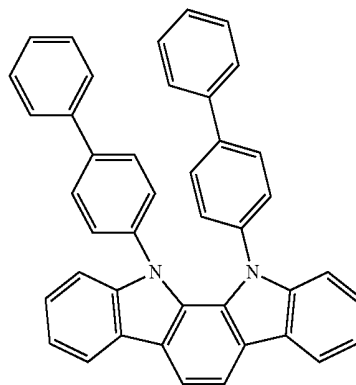


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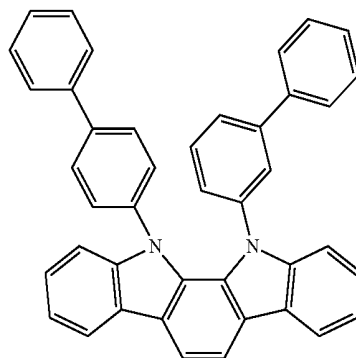
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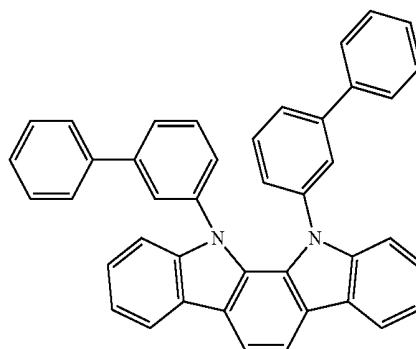
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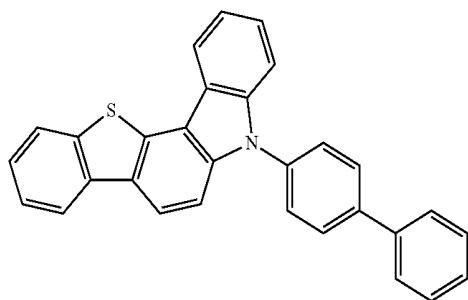
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B14

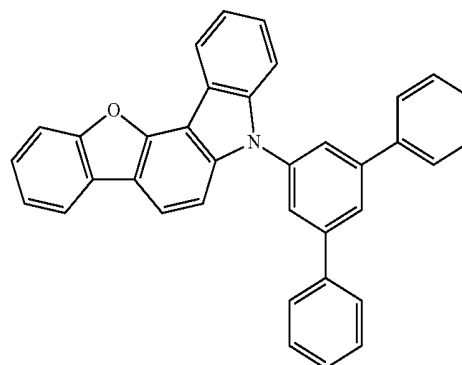


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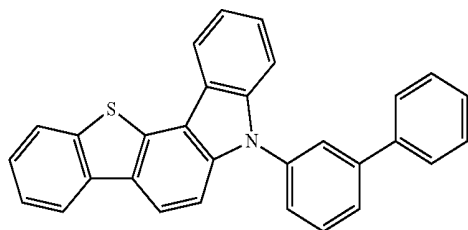


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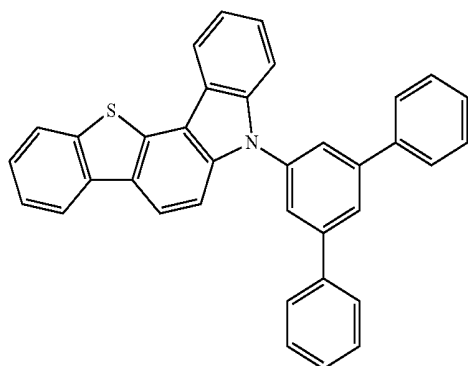


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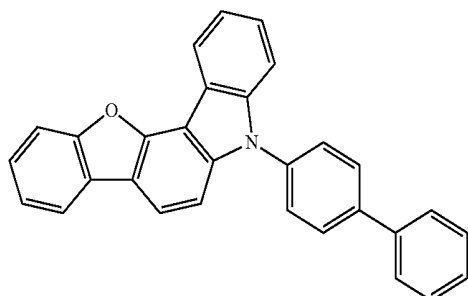
B16

**[0269]** For example, a weight ratio of the first host to the second host may be in a range of about 1:99 to about 99:1, and in some embodiments, about 10:90 to about 90:10. When the weight ratio of the first host to the second host is within these ranges, the electron transport characteristics of the first host and the hole transport characteristics of the second host may reach equilibrium, so that the emission efficiency and lifetime of the organic light-emitting device may be improved.



B17

**[0270]** When the EML includes both a host and a dopant, the amount of the dopant may be from about 0.01 to about 15 parts by weight based on 100 parts by weight of the host. However, the amount of the dopant is not limited to this range.

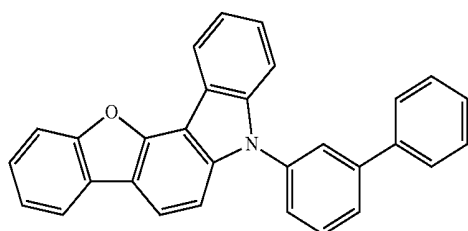


B18

**[0271]** Synthesis methods of the condensed cyclic compound of Formula 1 above, the first compound of Formula 41 above, and the second compound of Formula 61 above may be easily understood to one of ordinary skill in the art based on the synthesis examples described below.

**[0272]** When the organic light-emitting device is a full color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, and a blue emission layer. In some embodiments, the EML may have a stack structure including a red emission layer, a green emission layer, and/or a blue emission layer that are stacked upon one another to emit white light, but is not limited thereto. A host of one of the red emission layer, the green emission layer, and the blue emission layer may include the condensed cyclic compound of Formula 1 above. For example, the host of the green emission layer may include the condensed cyclic compound of Formula 1.

**[0273]** In addition, the electron transport auxiliary layer on the blue emission layer may include the condensed cyclic compound represented by Formula 1.

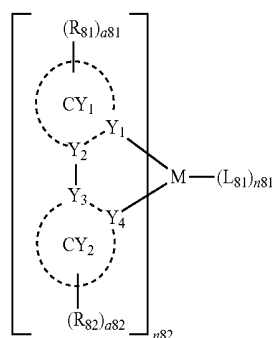


B19

**[0274]** The EML of the light-emitting device may include a dopant, which may be a fluorescent dopant emitting light based on fluorescence mechanism, or a phosphorescent dopant emitting light based on phosphorescence mechanism.

**[0275]** In some embodiments, the EML may include a host including at least one of the condensed cyclic compound of Formula 1, and a phosphorescent dopant. The phosphorescent dopant may include an organometallic complex including a transition metal, for example, iridium (Ir), platinum (Pt), osmium (Os), or rhodium (Rh).

[0276] The phosphorescent dopant may include an organometallic compound represented by Formula 81 below:



[0277] In Formula 81,

[0278] M may be iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), or thulium (Tm);

[0279] Y<sub>1</sub> to Y<sub>4</sub> may be each independently a carbon (C) or a nitrogen (N);

[0280] Y<sub>1</sub> and Y<sub>2</sub> may be linked to each other via a single bond or a double bond, and Y<sub>3</sub> and Y<sub>4</sub> may be linked to each other via a single bond or a double bond;

[0281] CY<sub>1</sub> and CY<sub>2</sub> may be each independently benzene, naphthalene, fluorene, spiro-fluorene, indene, pyrrole, thiophene, furan, imidazole, pyrazole, thiazole, isothiazole, oxazole, isooxazole, pyridine, pyrazine, pyrimidine, pyridazine, quinoline, isoquinoline, benzoquinoline, quinoxaline, quinazoline, carbazole, benzoimidazole, benzofuran (benzofuran), benzothiophene, isobenzothiophene, benzooxazole, isobenzooxazole, triazole, tetrazole, oxadiazole, triazine, dibenzofuran, or dibenzothiophene, wherein CY<sub>1</sub> and CY<sub>2</sub> may be optionally linked to each other via a single bond or an organic linking group;

[0282] R<sub>81</sub> and R<sub>82</sub> may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, —SF<sub>5</sub>, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> alkenyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> alkynyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylthio group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent nonaromatic condensed polycyclic group, a substituted or unsubstituted monovalent nonaromatic condensed heteropolycyclic group, —N(Q<sub>1</sub>)(Q<sub>2</sub>), —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), and —B(Q<sub>6</sub>)(Q<sub>7</sub>);

[0283] a<sub>81</sub> and a<sub>82</sub> may be each independently an integer selected from 1 to 5;

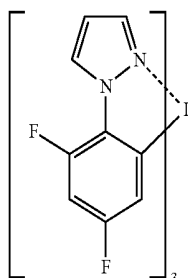
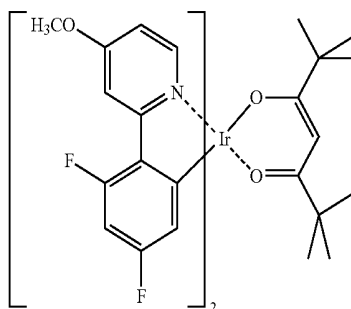
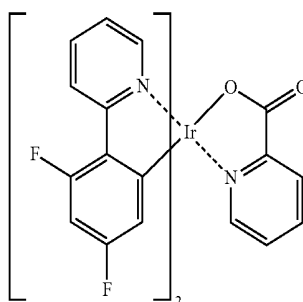
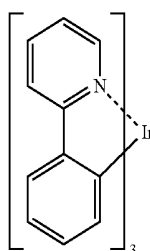
[0284] n<sub>81</sub> may be an integer selected from 0 to 4;

[0285] n<sub>82</sub> may be 1, 2, or 3;

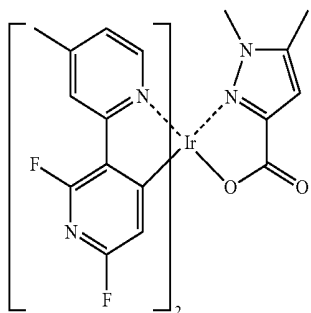
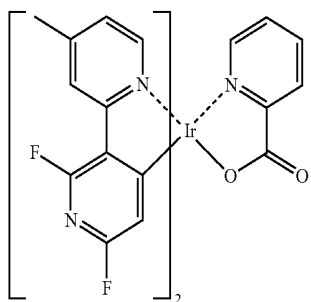
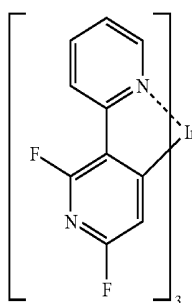
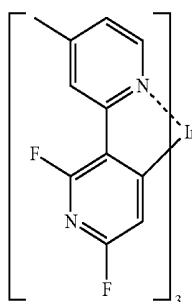
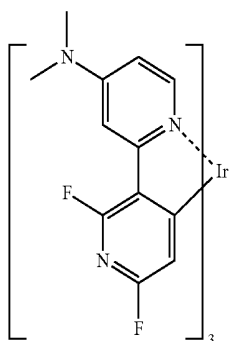
[0286] L<sub>81</sub> may be selected from a monovalent organic ligand, a divalent organic ligand, and a trivalent organic ligand.

[0287] R<sub>81</sub> and R<sub>82</sub> in Formula 81 may be defined to be the same as described above with reference to R<sub>11</sub> above.

[0288] The phosphorescent dopant may include at least one of Compounds PD1 to PD78, but is not limited thereto (the following Compound PD1 is Ir(ppy)<sub>3</sub>):

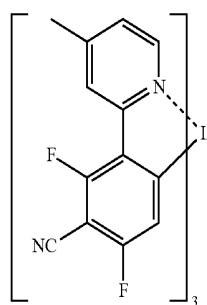


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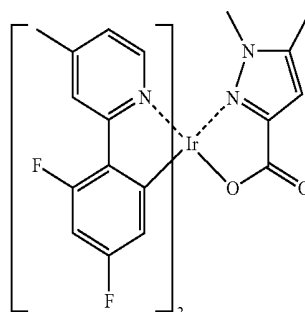
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PD5



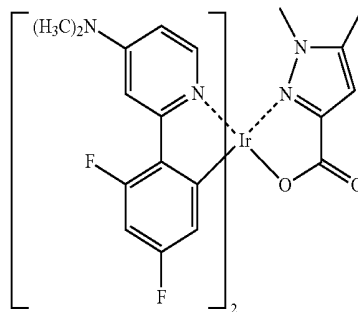
PD10

PD6



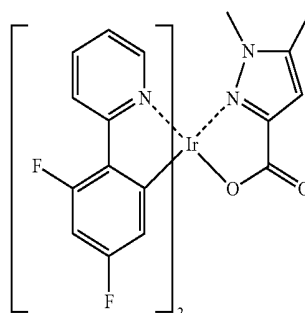
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PD7



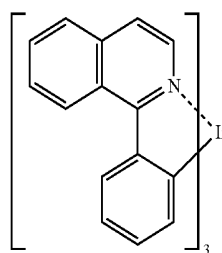
PD12

PD8



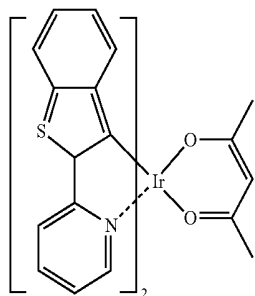
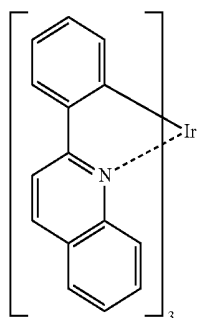
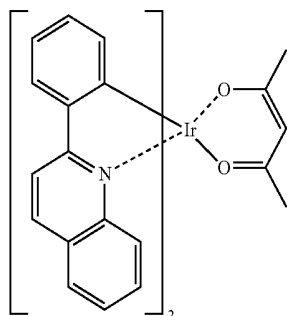
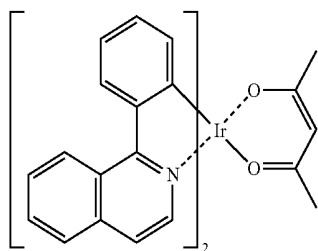
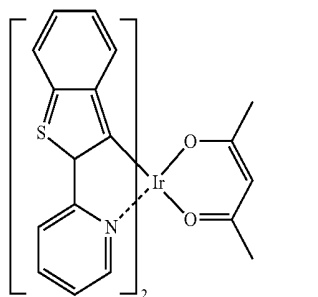
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PD9



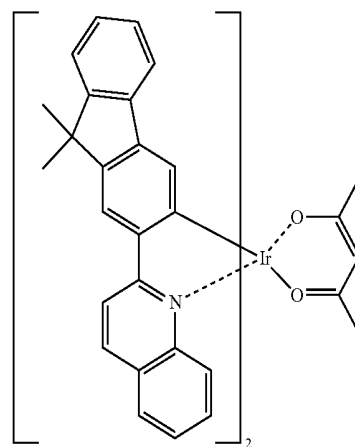
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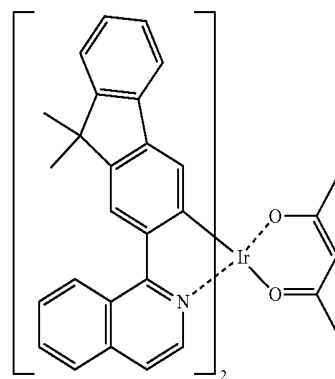
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PD15



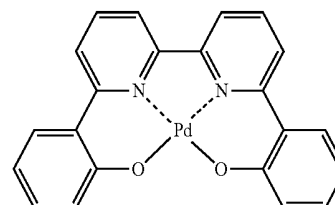
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PD16



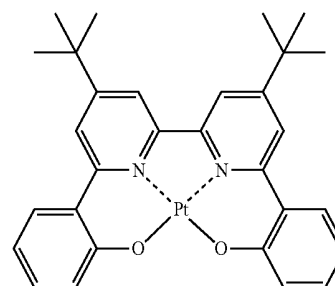
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PD17



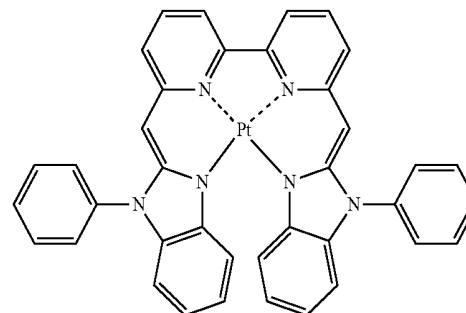
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PD18



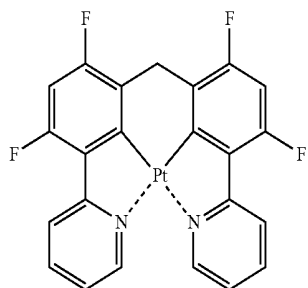
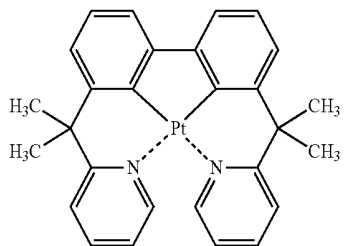
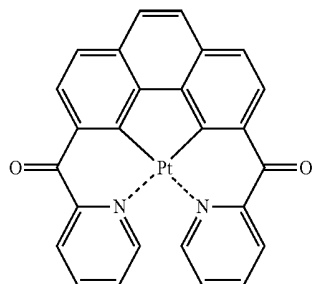
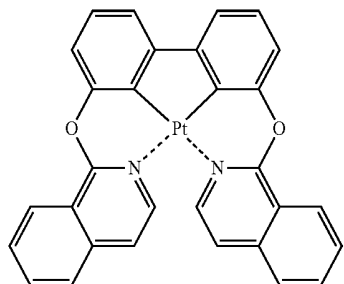
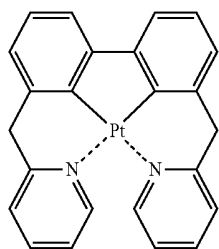
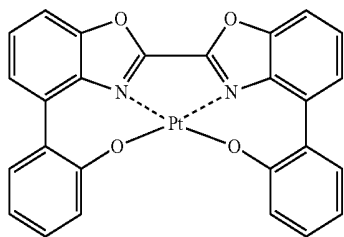
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PD19



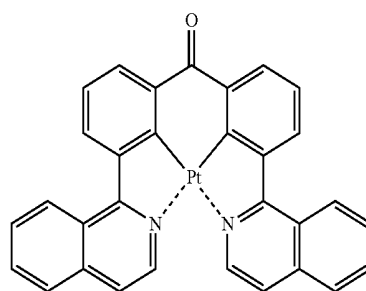
PD24

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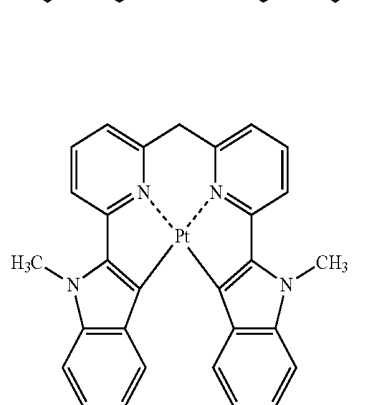
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PD25



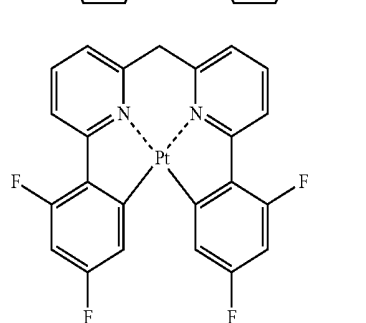
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PD26



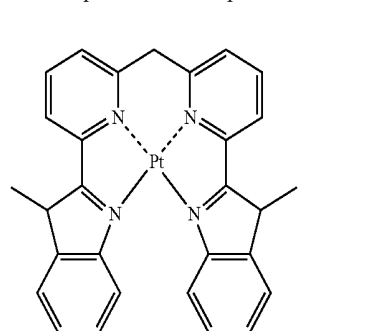
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PD27



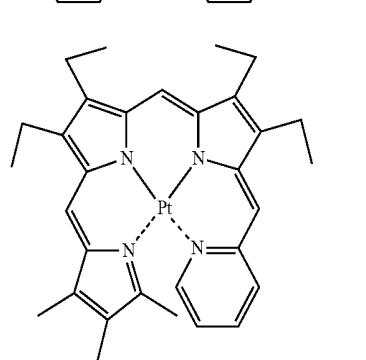
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PD28



PD34

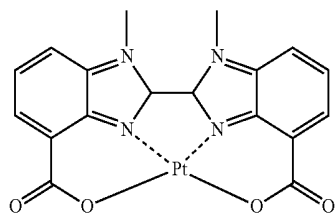
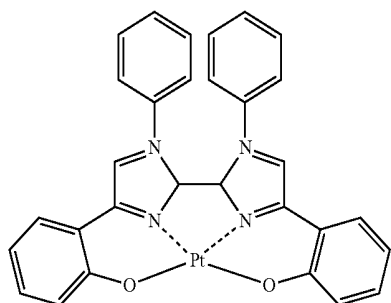
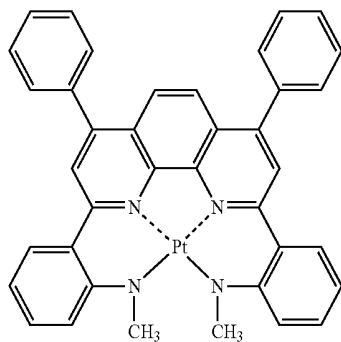
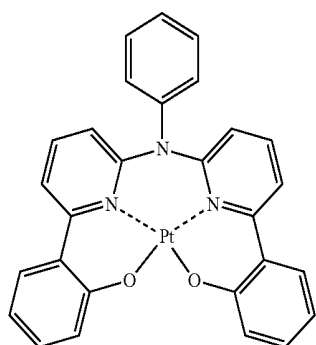
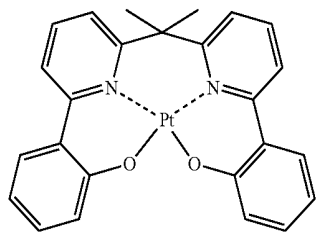
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PD35

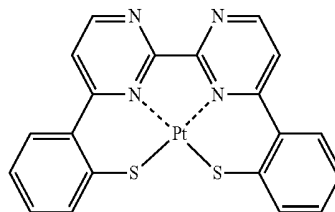
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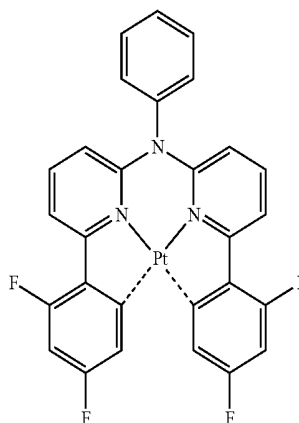
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PD36



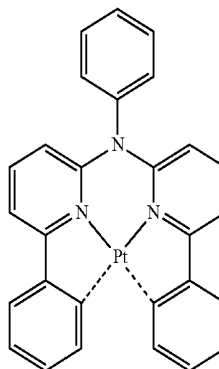
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PD37



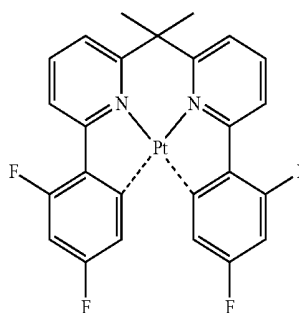
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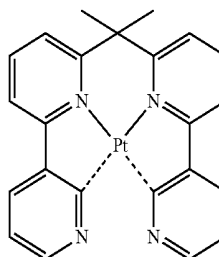
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PD39



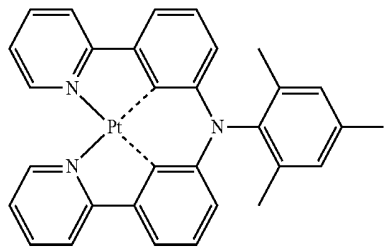
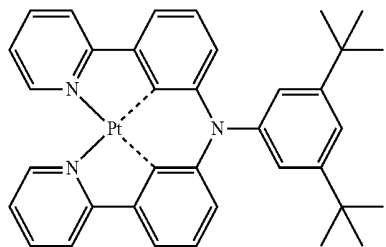
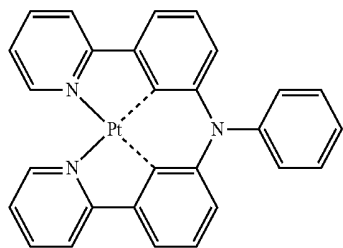
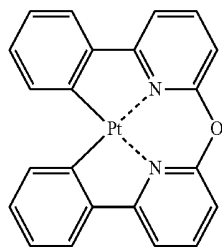
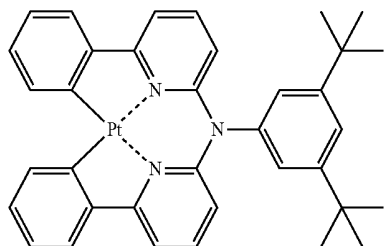
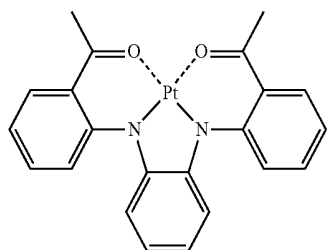
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PD40



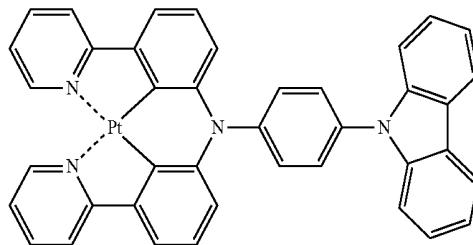
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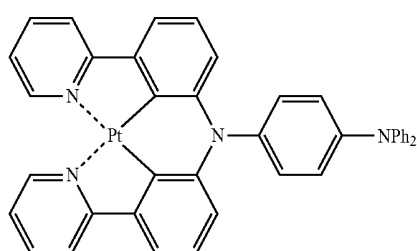
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PD46



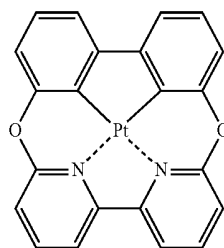
PD52

PD47



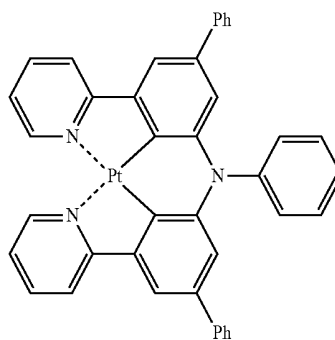
PD53

PD48



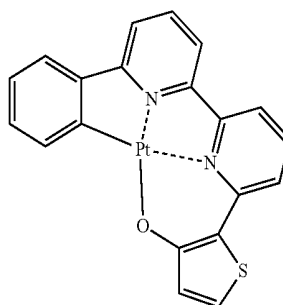
PD54

PD49



PD55

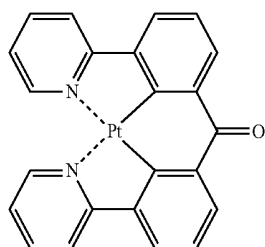
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PD56

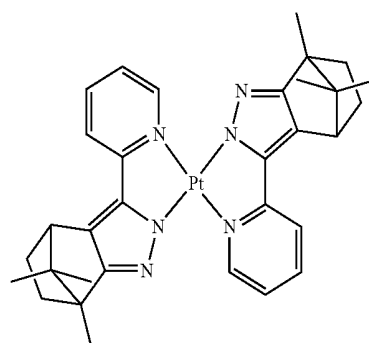
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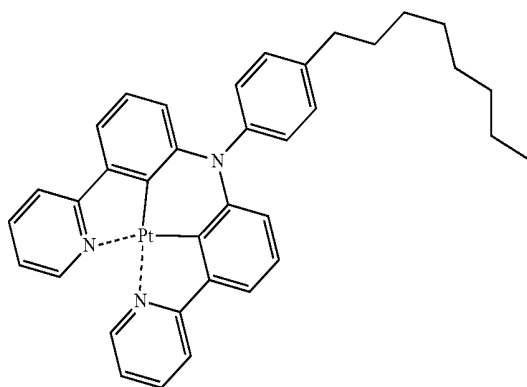
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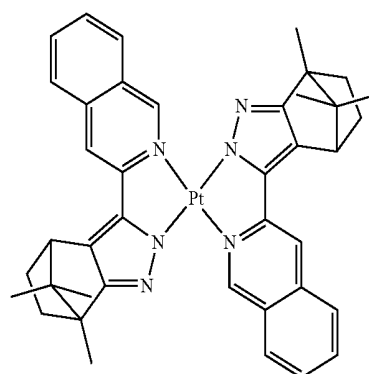


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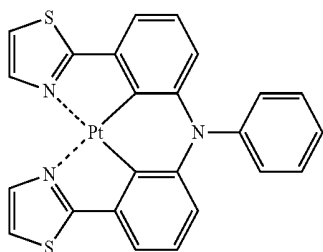
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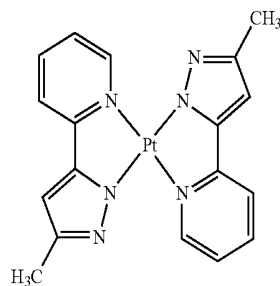
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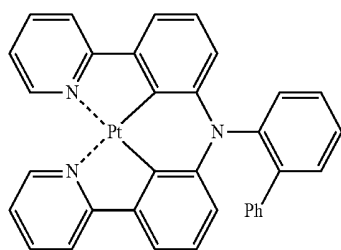
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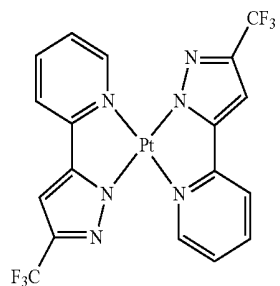
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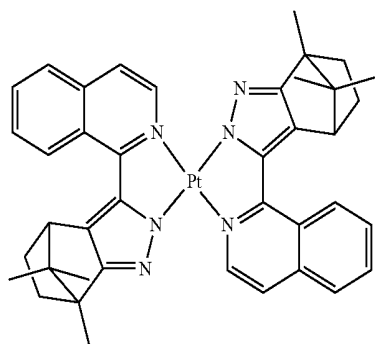
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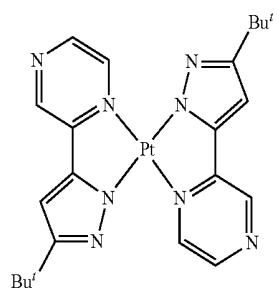
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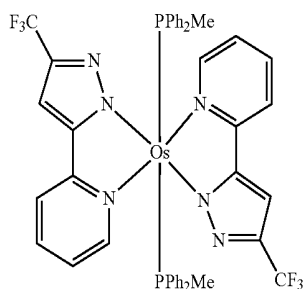
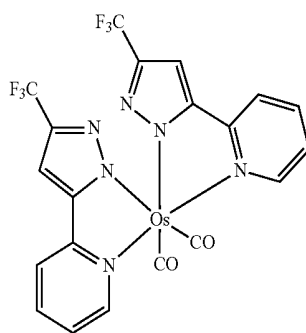
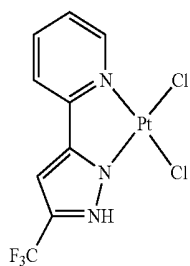
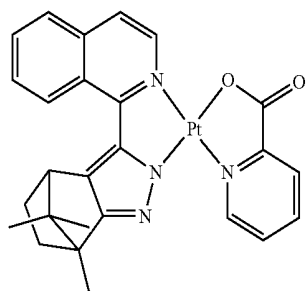
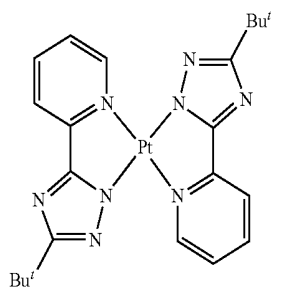
PD61



PD66

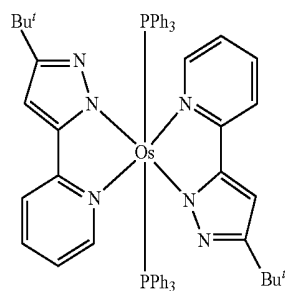


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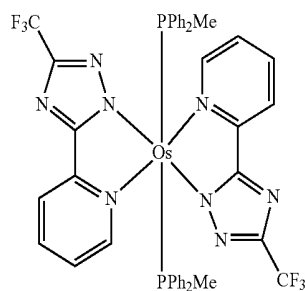
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PD67



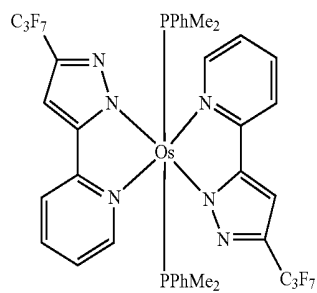
PD72

PD68



PD73

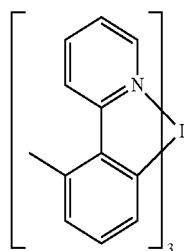
PD69



PD74

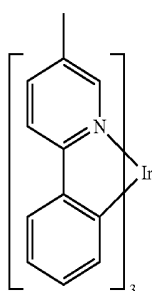
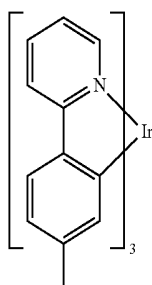
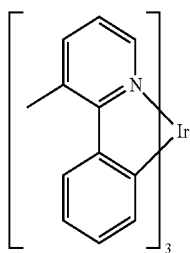
PD70

PD71



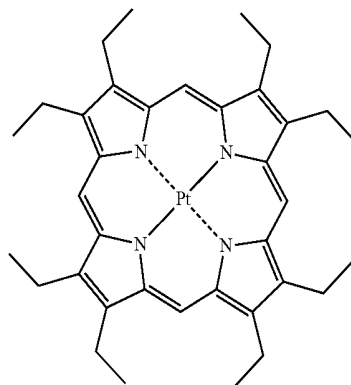
PD75

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**[0289]** In some embodiments, the phosphorescent dopant may include PtOEP or PhGD represented below:

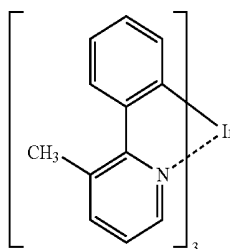
PD76



PD77

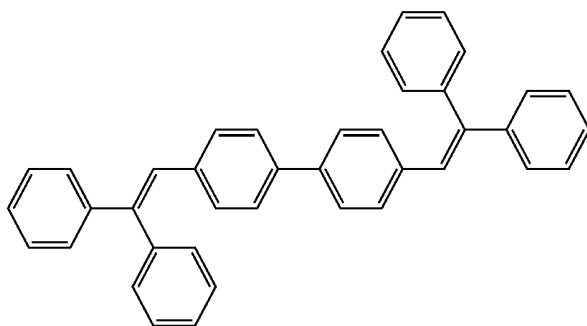
PtOEP

PD78

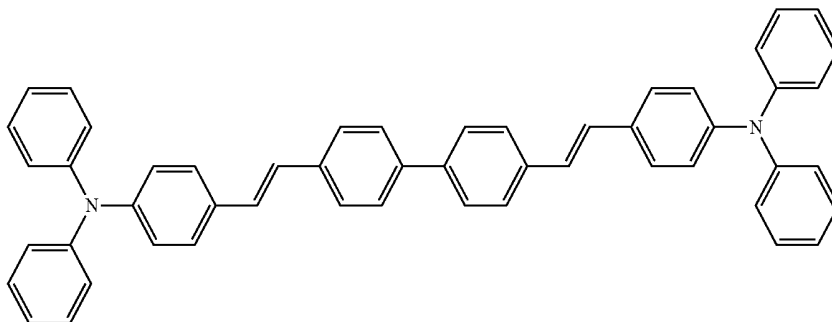


PhGD

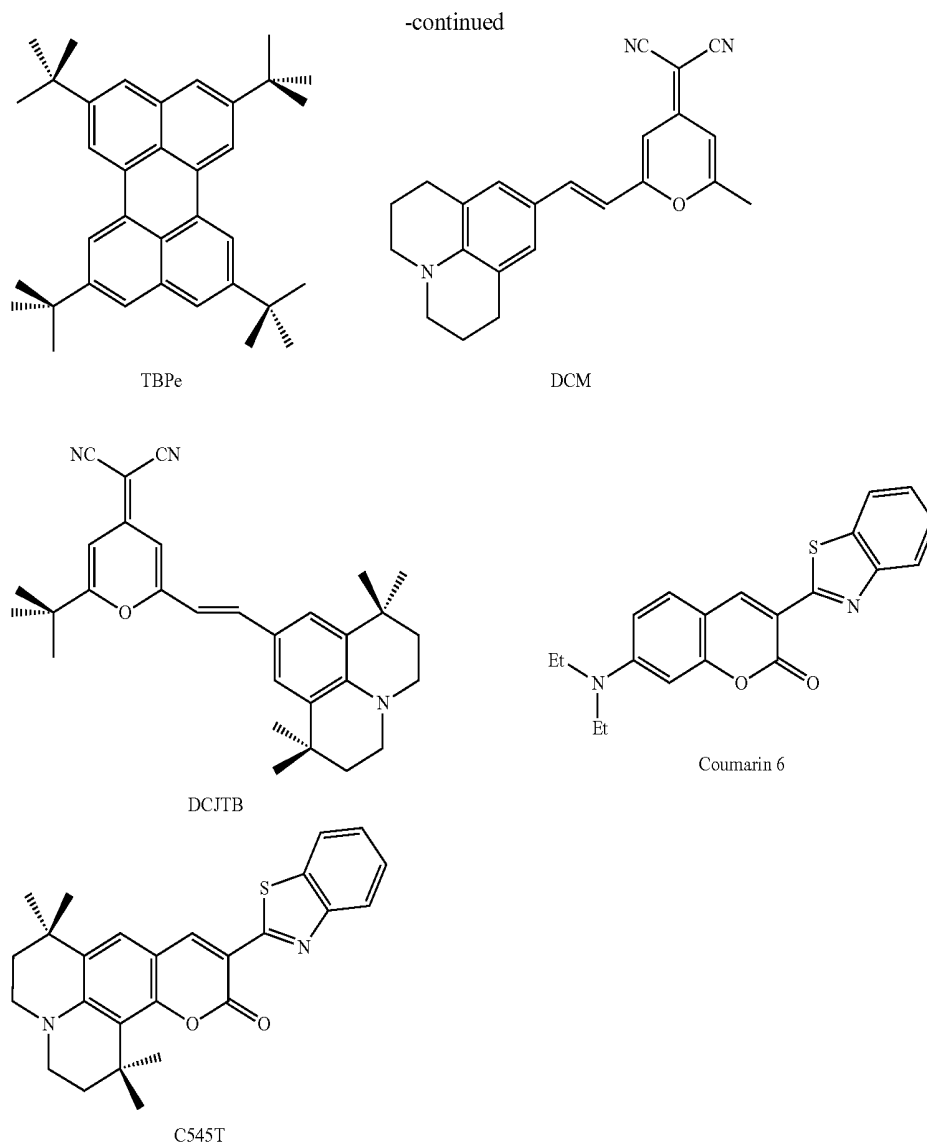
**[0290]** In some other embodiments, the phosphorescent dopant may include at least one of DPVBi, DPAVBi, TBPe, DCM, DCJTb, Coumarin 6, and C545T represented below.



DPVBi



DPAVBi



[0291] When the EML includes both a host and a dopant, the amount of the dopant may be from about 0.01 to about 20 parts by weight based on 100 parts by weight of the host. However, the amount of the dopant is not limited to this range.

[0292] The thickness of the EML may be about 100 Å to about 1000 Å, and in some embodiments, may be from about 200 Å to about 600 Å. When the thickness of the EML is within these ranges, the EML may have improved light emitting ability without a substantial increase in driving voltage.

[0293] Next, the electron transport region may be disposed on the EML.

[0294] The electron transport region may include at least one of a HBL, an ETL, and an EIL.

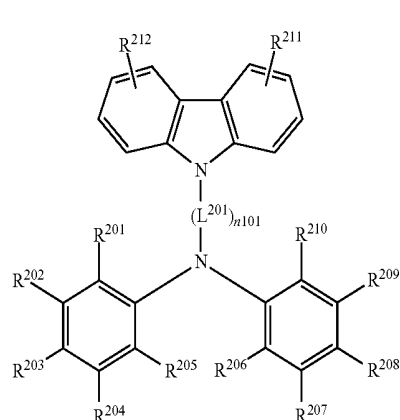
[0295] In some embodiments, the electron transport region may have a structure including an ETL, a HBL/ETL/EIL, or an ETL/EIL, wherein the layers forming the structure of the electron transport region may be sequentially stacked on the EML in the stated order. However, embodiments of the present disclosure are not limited thereto. For example, an

organic light-emitting device according to one embodiment may include at least two electron transport layers in the electron transport region, and in this case, an electron transport layer contacting the emission layer is defined to be an electron transport auxiliary layer.

[0296] The ETL may have a single-layer structure or a multi-layer structure including at least two different materials.

[0297] The electron transport region may include a condensed cyclic compound represented by Formula 1 above. For example, the electron transport region may include an ETL, and the ETL may include the condensed cyclic compound of Formula 1 above. More specifically, the electron transport auxiliary layer may include the condensed cyclic compound represented by the Formula 1.

[0298] The organic light-emitting device may further include a hole transport auxiliary layer including a compound represented by the following Formula 2, with the electron transport layer including the condensed cyclic compound.



[0299] In Formula 2,

[0300]  $L^{201}$  is a substituted or unsubstituted C6 to C30 arylene group, or a substituted or unsubstituted C2 to C30 heteroarylene group,

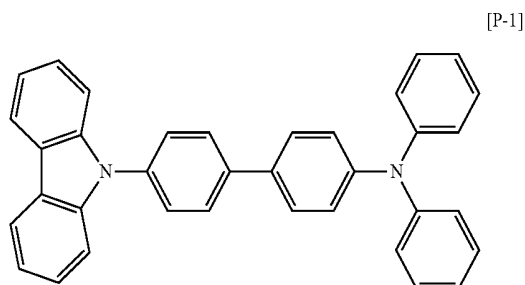
[0301]  $n_{101}$  is an integer of 1 to 5,

[0302]  $R^{201}$  to  $R^{212}$  are each independently hydrogen, a deuterium, a substituted or unsubstituted C1 to C20 alkyl group, a substituted or unsubstituted C6 to C50 aryl group, a substituted or unsubstituted C2 to C50 heteroaryl group or a combination thereof, and

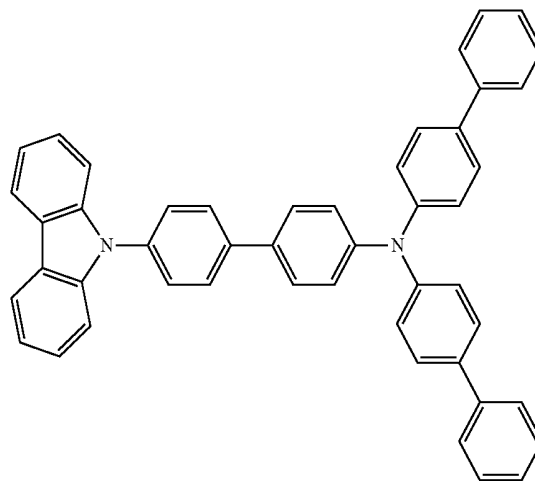
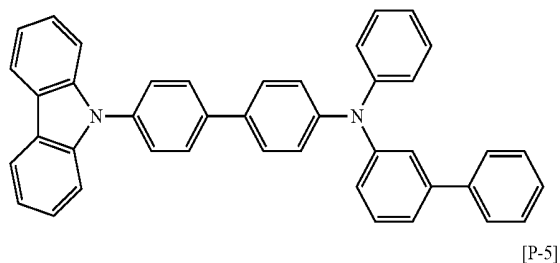
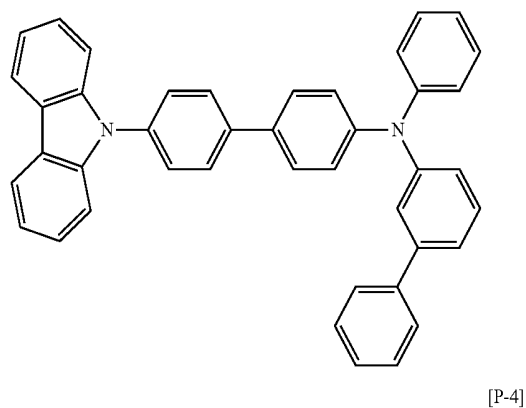
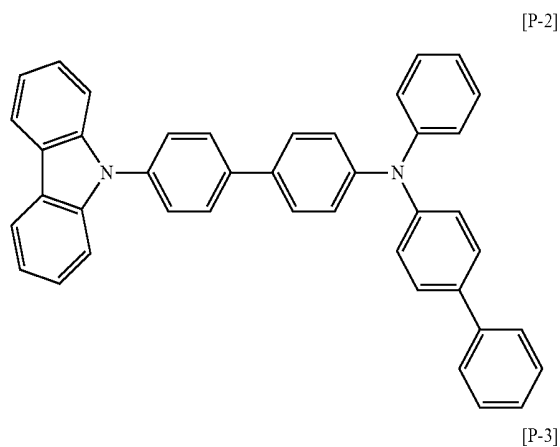
[0303]  $R^{201}$  to  $R^{212}$  are each independently present or are fused to each other to form a ring.

[0304] In Formula 2, “substituted” refers to one substituted with deuterium, a halogen, a hydroxyl group, an amino group, a substituted or unsubstituted C1 to C30 amine group, a nitro group, a substituted or unsubstituted C1 to C40 silyl group, a C1 to C30 alkyl group, a C3 to C30 cycloalkyl group, a C2 to C30 heterocycloalkyl group, a C6 to C30 aryl group, a C2 to C30 heteroaryl group, a C1 to C20 alkoxy group, a fluoro group, a C1 to C10 trifluoroalkyl group or a cyano group, instead of at least one hydrogen.

[0305] A hole transport auxiliary layer according to one embodiment may include one of compounds represented by the following Formula P-1 to P-5.

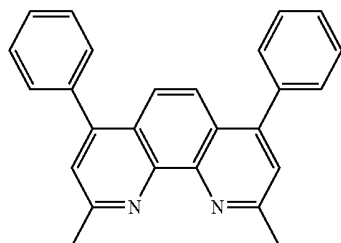


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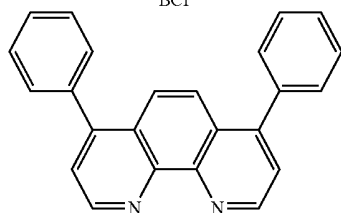


[0306] Conditions for forming the HBL, ETL, and EIL of the electron transport region may be defined based on the above-described formation conditions for the HIL.

[0307] When the electron transport region includes the HBL, the HBL may include at least one of BCP below and Bphen below. However, embodiments of the present disclosure are not limited thereto.



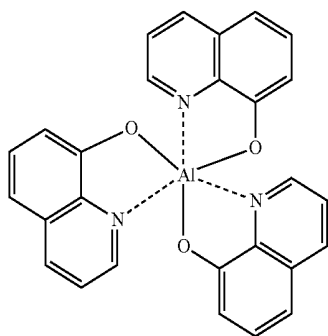
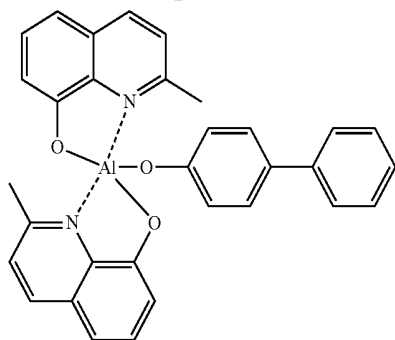
BCP



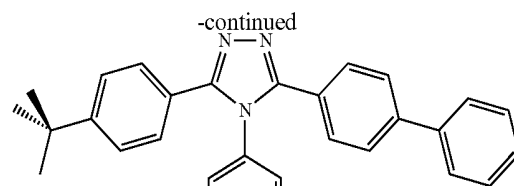
Bphen

[0308] The thickness of the HBL may be from about 20 Å to about 1000 Å, and in some embodiments, from about 30 Å to about 300 Å. When the thickness of the HBL is within these ranges, the HBL may have improved hole blocking ability without a substantial increase in driving voltage.

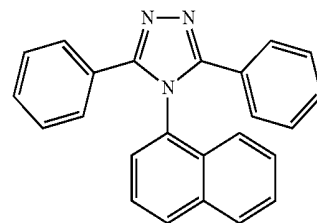
[0309] The ETL may further include at least one of Alq<sub>3</sub>, Balq, TAZ, and NTAZ below, in addition to BCP and Bphen described above.

Alq<sub>3</sub>

Balq



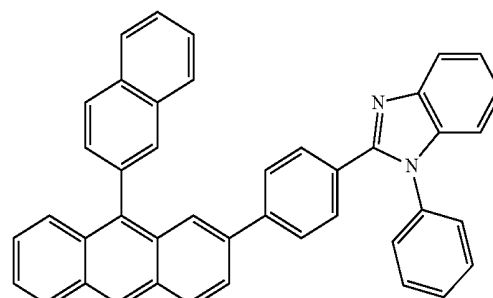
TAZ



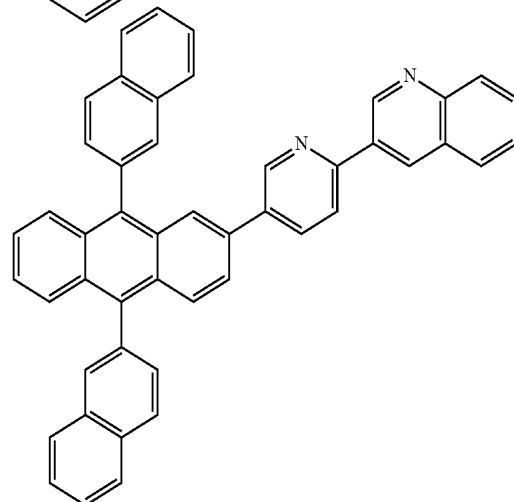
NTAZ

[0310] In some embodiments, the ETL may include at least one of Compounds ET1 and ET2 represented below, but is not limited thereto.

ET1



ET2

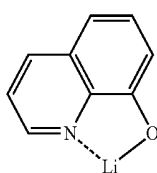


[0311] A thickness of the ETL may be from about 100 Å to about 1000 Å, and in some embodiments, from about 150

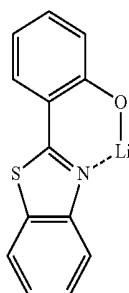
Å to about 500 Å. When the thickness of the ETL is within these ranges, the ETL may have satisfactory electron transporting ability without a substantial increase in driving voltage.

**[0312]** In some embodiments the ETL may further include a metal-containing material, in addition to the above-described materials.

**[0313]** The metal-containing material may include a lithium (Li) complex. Non-limiting examples of the Li complex are compound ET-D1 below (lithium quinolate (LiQ)), or compound ET-D2 below.



ET-D1



ET-D2

**[0314]** The electron transport region may include an EIL that may facilitate injection of electrons from the second electrode **19**. The EIL may include at least one selected from LiF, NaCl, CsF, Li<sub>2</sub>O, and BaO. The thickness of the EIL may be from about 1 Å to about 100 Å, and in some embodiments, from about 3 Å to about 90 Å. When the thickness of the EIL is within these ranges, the EIL may have satisfactory electron injection ability without a substantial increase in driving voltage.

**[0315]** The second electrode **19** is disposed on the organic layer **15**. The second electrode **19** may be a cathode. A material for the second electrode **19** may be a metal, an alloy, or an electrically conductive compound that have a low work function, or a combination thereof. Non-limiting examples of the material for the second electrode **19** are lithium (Li), magnesium (Mg), aluminum (Al), aluminum (Al)-lithium (Li), calcium (Ca), magnesium (Mg)-indium (In), and magnesium (Mg)-silver (Ag), or the like. In some embodiments, to manufacture a top-emission light-emitting device, the second electrode **19** may be formed as a transmissive electrode from, for example, indium tin oxide (ITO) or indium zinc oxide (IZO).

**[0316]** Although the organic light-emitting device of FIG. 1 is described above, embodiments of the present disclosure are not limited thereto.

**[0317]** As used herein, a C<sub>1</sub>-C<sub>60</sub> alkyl group refers to a linear or branched aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms. Non-limiting examples of the C<sub>1</sub>-C<sub>60</sub> alkyl group are a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an iso-amyl group, and a hexyl group.

A C<sub>1</sub>-C<sub>60</sub> alkylene group refers to a divalent group having the same structure as the C<sub>1</sub>-C<sub>60</sub> alkyl.

**[0318]** As used herein, a C<sub>1</sub>-C<sub>60</sub> alkoxy group refers to a monovalent group represented by —OA<sub>101</sub> (where A<sub>101</sub> is a C<sub>1</sub>-C<sub>60</sub> alkyl group as described above. Non-limiting examples of the C<sub>1</sub>-C<sub>60</sub> alkoxy group are a methoxy group, an ethoxy group, and an isopropoxy group.

**[0319]** As used herein, a C<sub>2</sub>-C<sub>60</sub> alkenyl group refers to a structure including at least one carbon double bond in the middle or terminal of the C<sub>2</sub>-C<sub>60</sub> alkyl group. Non-limiting examples of the C<sub>2</sub>-C<sub>60</sub> alkenyl group are an ethenyl group, a propenyl group, and a butenyl group. A C<sub>2</sub>-C<sub>60</sub> alkenylene group refers to a divalent group having the same structure as the C<sub>2</sub>-C<sub>60</sub> alkenyl group.

**[0320]** As used herein, a C<sub>2</sub>-C<sub>60</sub> alkynyl group refers to a structure including at least one carbon triple bond in the middle or terminal of the C<sub>2</sub>-C<sub>60</sub> alkyl group. Non-limiting examples of the C<sub>2</sub>-C<sub>60</sub> alkynyl group are an ethynyl group and a propynyl group. A C<sub>2</sub>-C<sub>60</sub> alkynylene group used herein refers to a divalent group having the same structure as the C<sub>2</sub>-C<sub>60</sub> alkynyl group.

**[0321]** As used herein, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group refers to a monovalent, monocyclic hydrocarbon group having 3 to 10 carbon atoms. Non-limiting examples of the C<sub>3</sub>-C<sub>10</sub> cycloalkyl group are a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. A C<sub>3</sub>-C<sub>10</sub> cycloalkylene group refers to a divalent group having the same structure as the C<sub>3</sub>-C<sub>10</sub> cycloalkyl group.

**[0322]** As used herein, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group refers to a monovalent monocyclic group having 1 to 10 carbon atoms in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom. Non-limiting examples of the C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group are a tetrahydrofuran group and a tetrahydrothiophenyl group. A C<sub>2</sub>-C<sub>10</sub> heterocycloalkylene group refers to a divalent group having the same structure as the C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group.

**[0323]** As used herein, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group refers to a monovalent monocyclic group having 3 to 10 carbon atoms that includes at least one double bond in the ring but does not have aromaticity. Non-limiting examples of the C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group are a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. A C<sub>3</sub>-C<sub>10</sub> cycloalkenylene group refers to a divalent group having the same structure as the C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group.

**[0324]** As used herein, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group used herein refers to a monovalent monocyclic group having 2 to 10 carbon atoms that includes at least one double bond in the ring and in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom. Non-limiting examples of the C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group are a 2,3-dihydrofuran group and a 2,3-dihydrothiophenyl group. A C<sub>2</sub>-C<sub>10</sub> heterocycloalkenylene group used herein refers to a divalent group having the same structure as the C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group.

**[0325]** As used herein, a C<sub>6</sub>-C<sub>60</sub> aryl group refers to a monovalent, aromatic carbocyclic aromatic group having 6 to 60 carbon atoms, and a C<sub>6</sub>-C<sub>60</sub> arylene group refers to a divalent, aromatic carbocyclic group having 6 to 60 carbon atoms. Non-limiting examples of the C<sub>6</sub>-C<sub>60</sub> aryl group are a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl

group. When the C<sub>6</sub>-C<sub>60</sub> aryl group and the C<sub>6</sub>-C<sub>60</sub> arylene group include at least two rings, the rings may be fused to each other.

[0326] As used herein, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group refers to a monovalent, aromatic carbocyclic aromatic group having 2 to 60 carbon atoms in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom, and 2 to 60 carbon atoms. A C<sub>2</sub>-C<sub>60</sub> heteroarylene group refers to a divalent, aromatic carbocyclic group having 2 to 60 carbon atoms in which at least one hetero atom selected from N, O, P, and S is included as a ring-forming atom. Non-limiting examples of the C<sub>2</sub>-C<sub>60</sub> heteroaryl group are a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C<sub>2</sub>-C<sub>60</sub> heteroaryl and the C<sub>2</sub>-C<sub>60</sub> heteroarylene include at least two rings, the rings may be fused to each other.

[0327] As used herein, a C<sub>6</sub>-C<sub>60</sub> aryloxy group indicates —OA<sub>102</sub> (where A<sub>102</sub> is a C<sub>6</sub>-C<sub>60</sub> aryl group as described above), and a C<sub>6</sub>-C<sub>60</sub> arylthio group indicates —SA<sub>103</sub> (where A<sub>103</sub> is a C<sub>6</sub>-C<sub>60</sub> aryl group as described above).

[0328] As used herein, a monovalent non-aromatic condensed polycyclic group refers to a monovalent group having at least two rings condensed to each other, in which only carbon atoms (for example, 8 to 60 carbon atoms) are exclusively included as ring-forming atoms and the entire molecule has non-aromaticity. A non-limiting example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. A divalent non-aromatic condensed polycyclic group refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0329] As used herein, a monovalent non-aromatic condensed heteropolycyclic group refers to a monovalent group having at least two rings condensed to each other, in which carbon atoms (for example, 1 to 60 carbon atoms) and a hetero atom selected from N, O, P, and S are as ring-forming atoms and the entire molecule has non-aromaticity. A non-limiting example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. A divalent non-aromatic condensed heteropolycyclic group refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0330] The acronym “Ph” used herein refers to phenyl, the acronym “Me” used herein refers to methyl, the acronym “Et” used herein refers to ethyl, and the acronym “ter-Bu” or “Bu” used herein refers to tert-butyl.

[0331] The term of “biphenyl” means a phenyl group substituted with a phenyl group.

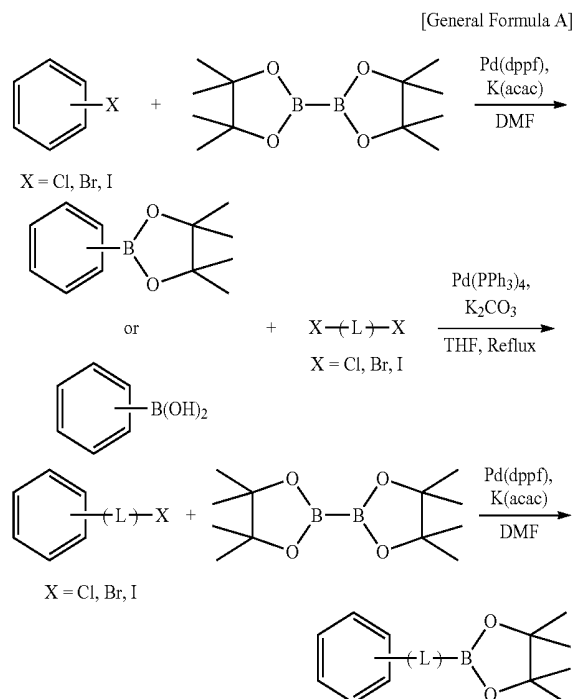
[0332] One or more embodiments of the present disclosure, which include condensed cyclic compounds, and organic light-emitting devices including the same, will now be described in detail with reference to the following examples. However, these examples are only for illustrative purposes and are not intended to limit the scope of the one or more embodiments of the present disclosure. In the following synthesis example, the expression that “‘B’ instead of ‘A’ was used” means that the amounts of ‘B’ and ‘A’ were the same in equivalent amounts.

[0333] Hereinafter, a starting material and a reaction material used in Examples and Synthesis Examples were purchased from Sigma-Aldrich Co. Ltd. or TCI Inc. unless there was particularly mentioned.

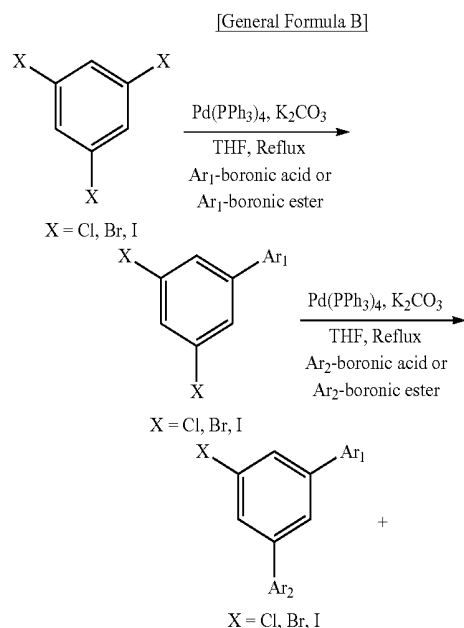
## EXAMPLES

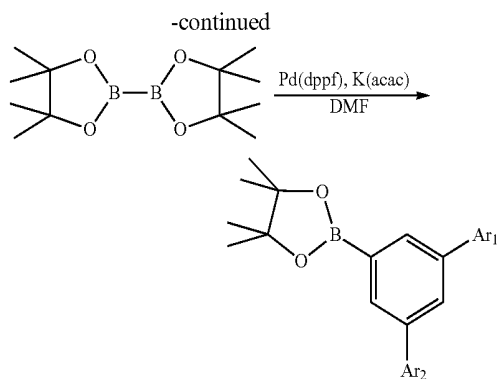
## Synthesis of Boronic Ester

[0334] Boronic ester of the following Synthesis Example was synthesized according to the same method as a synthesis method described on page 35 of KR 10-2014-0135524A, and the reaction scheme of the boronic ester are provided as [General Formula A] and [General Formula B].



[0335] In General Formula A, “L” is a substituted or unsubstituted C<sub>6</sub> to C<sub>60</sub> arylene group and a substituted or unsubstituted C<sub>2</sub> to C<sub>30</sub> heteroarylene group.

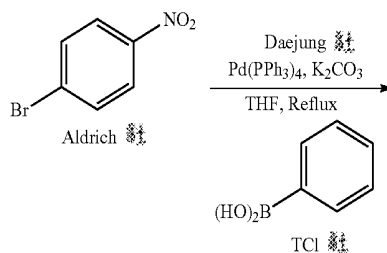
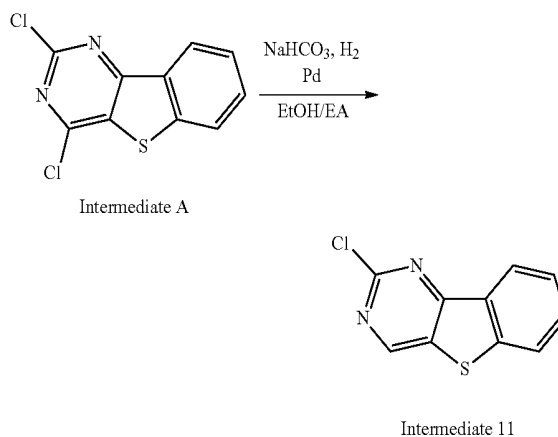
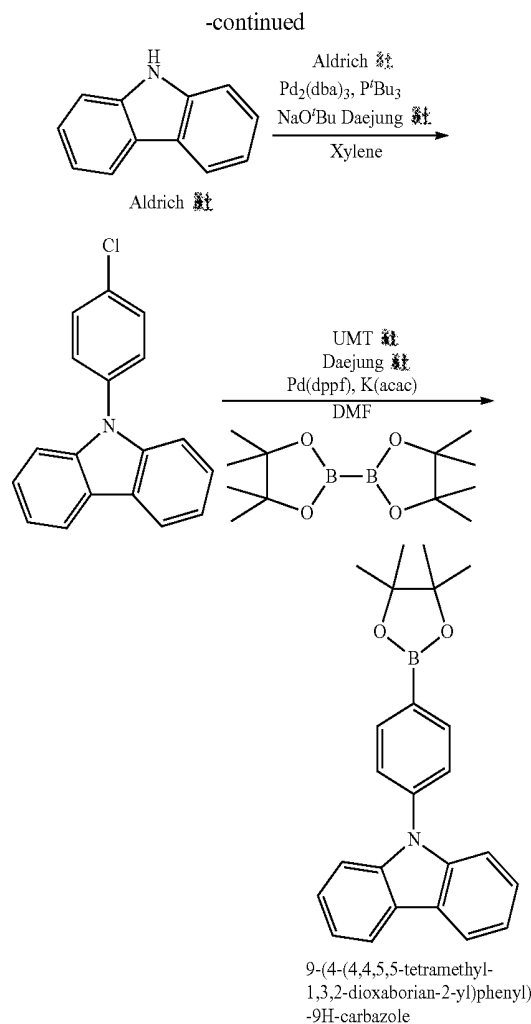
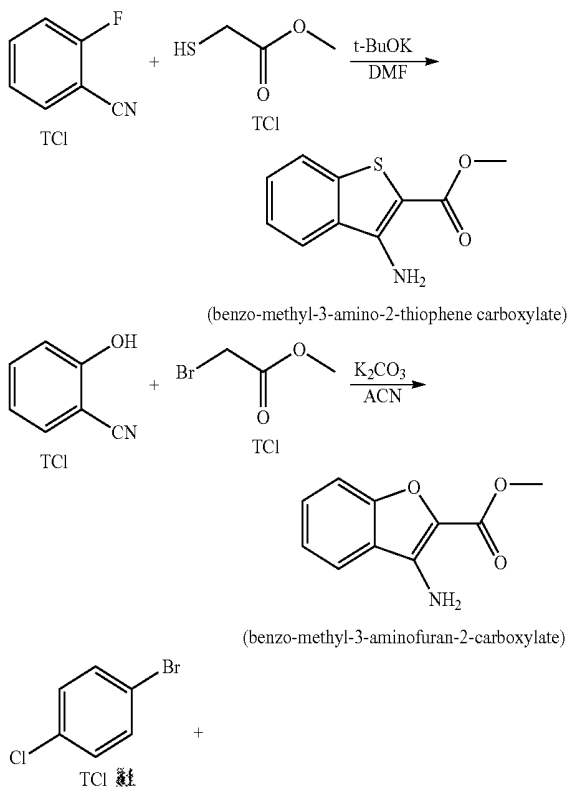


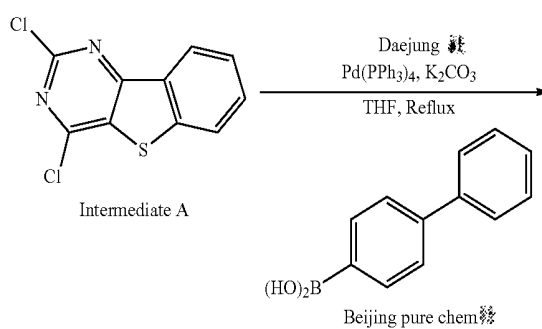
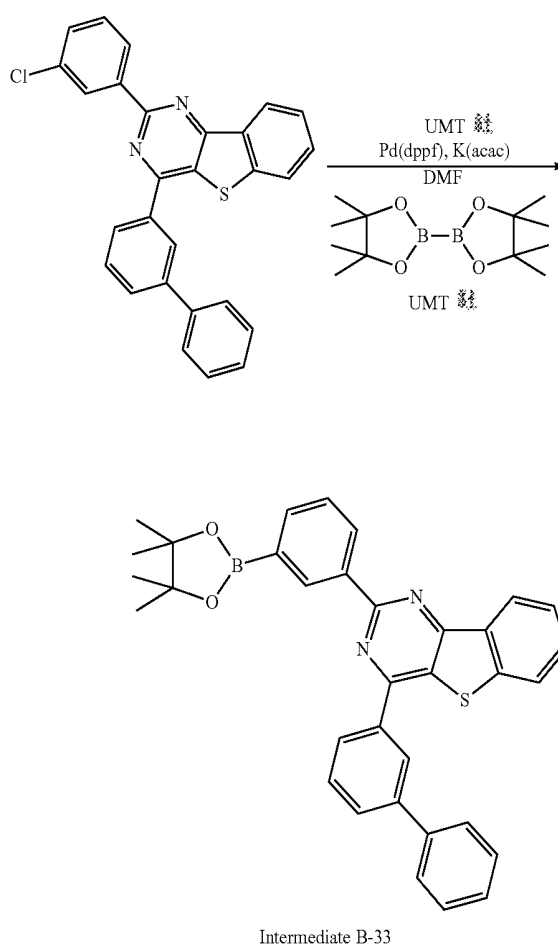
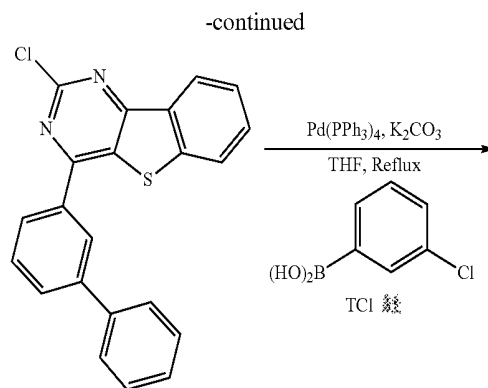
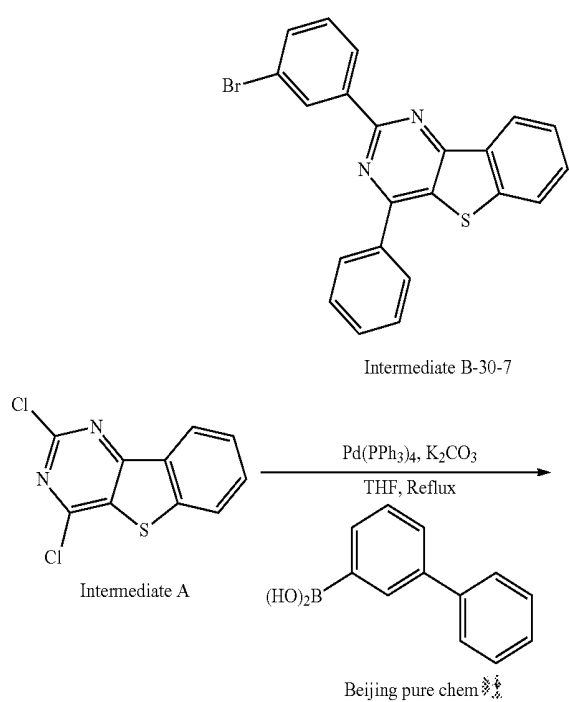
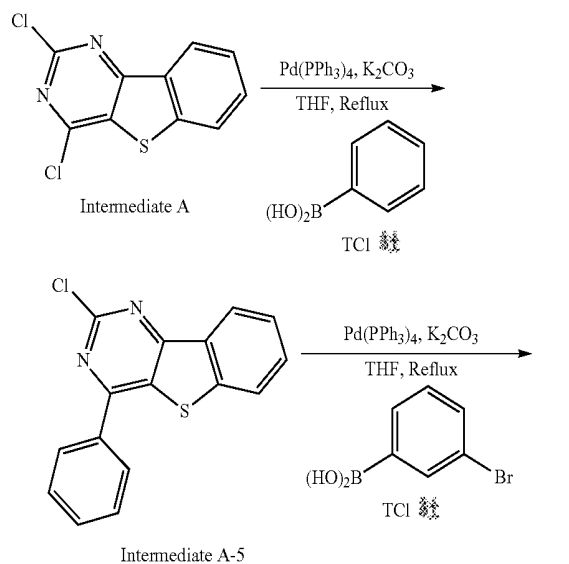
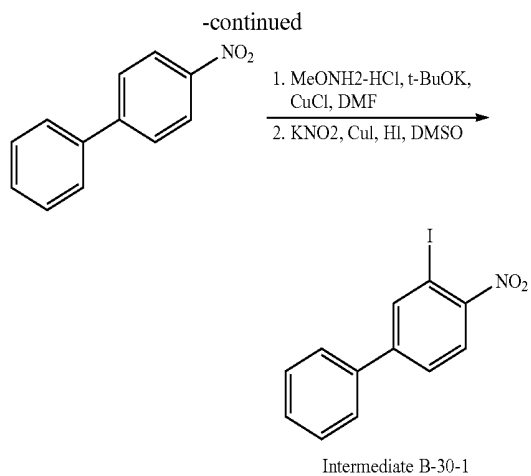


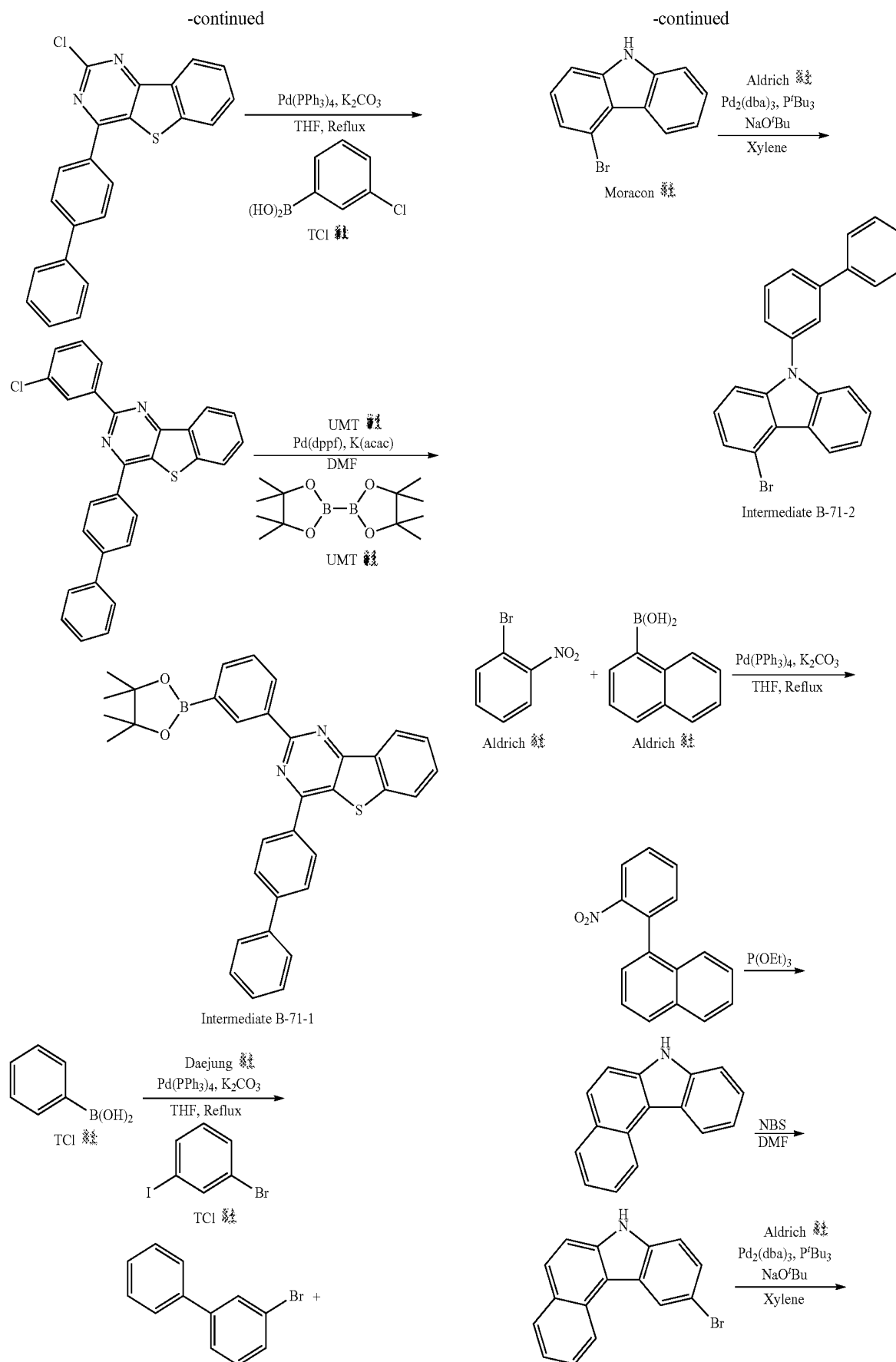
**[0336]** In General Formula B, Ar1 and Ar2 are a substituted or unsubstituted C6 to C30 aryl group, or a substituted or unsubstituted C2 to C30 heteroaryl group, for example, a substituted or unsubstituted phenyl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted terphenyl group, a substituted or unsubstituted quaterphenyl group, naphthyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted fluoranthenyl group, a substituted or unsubstituted chrysenyl group, a substituted or unsubstituted pyridinyl group, a substituted or unsubstituted pyrimidinyl group, a substituted or unsubstituted triazinyl group, and the like.

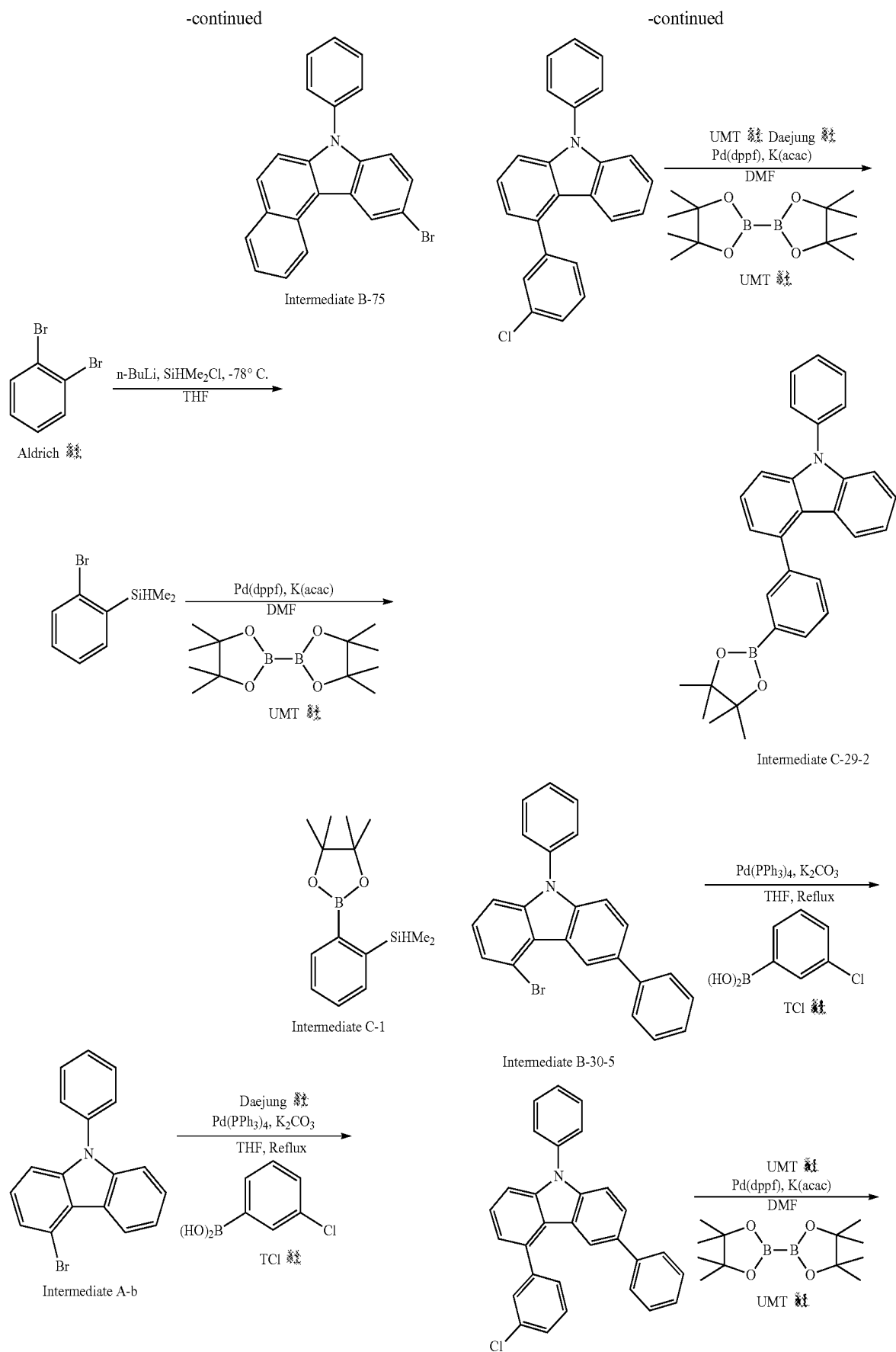
**[0337]** Hereinafter, a method of synthesizing the boronic ester as a reaction material used in the present invention was illustrated by taking an example for better understanding

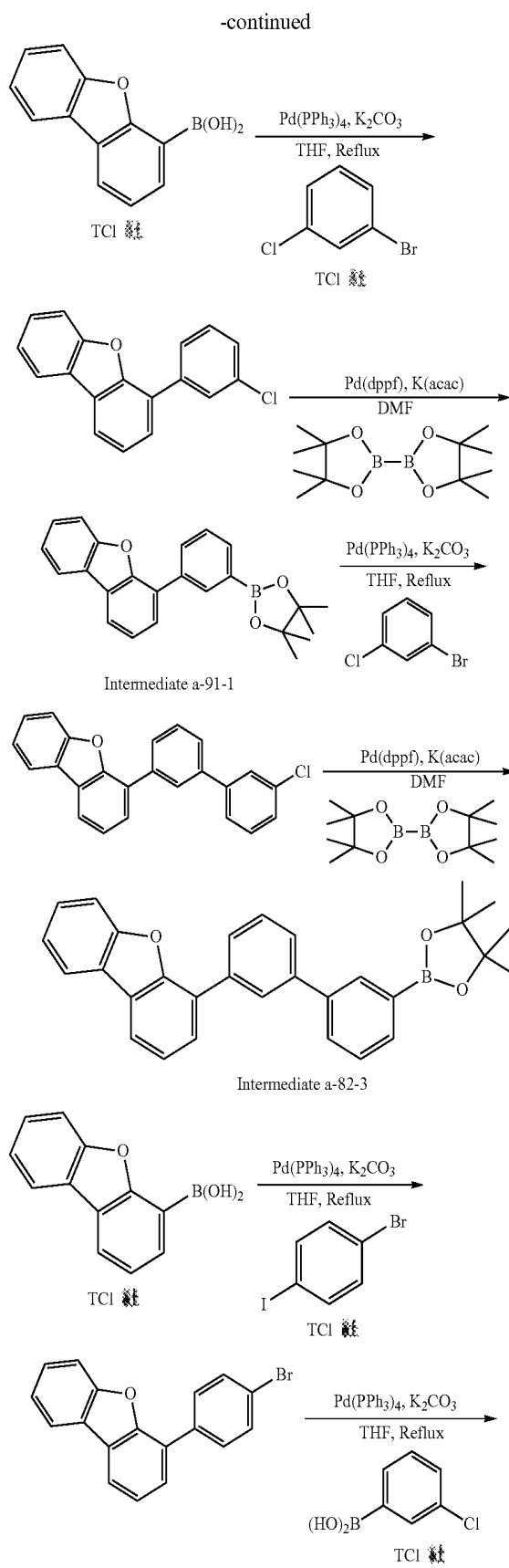
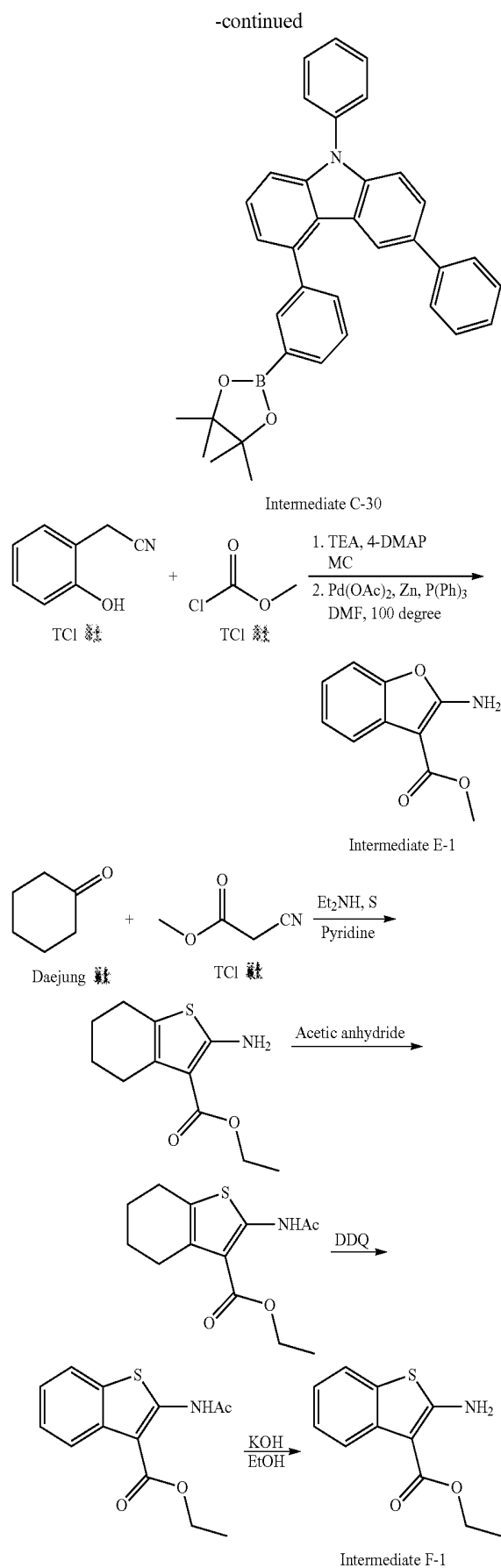
**[0338]** [Synthesis of Intermediate and Boronic Ester]

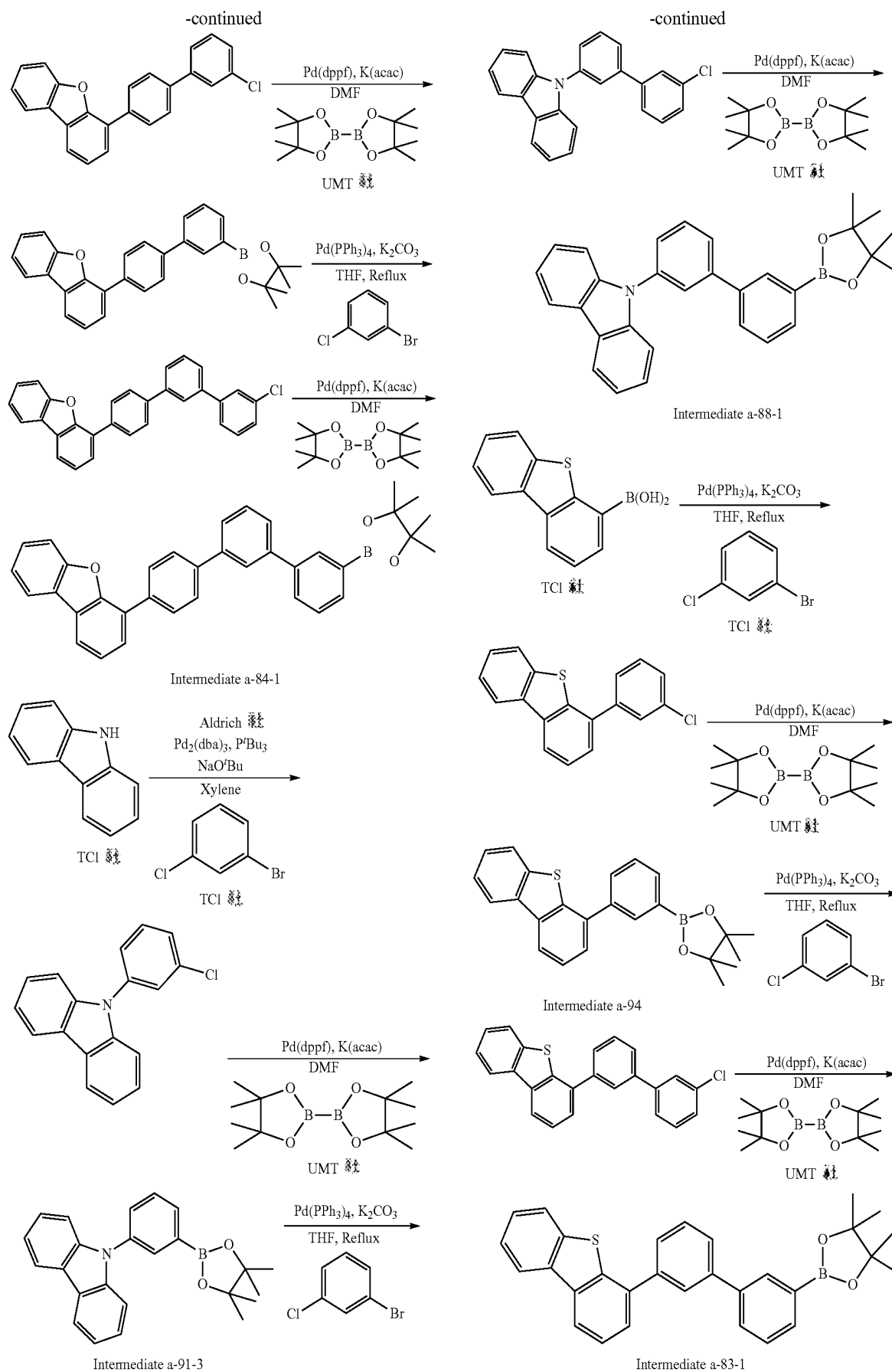






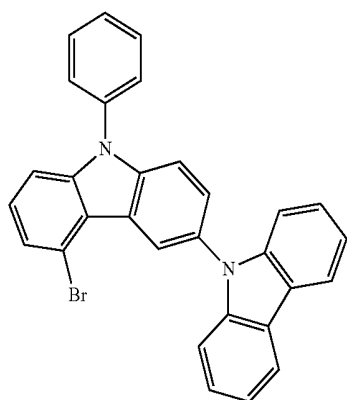
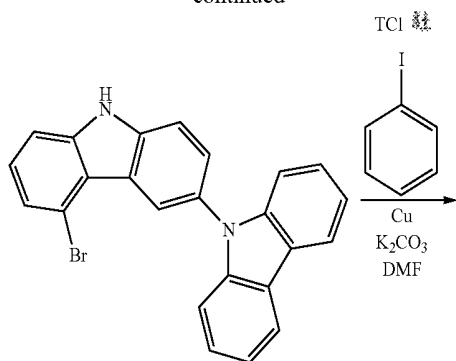




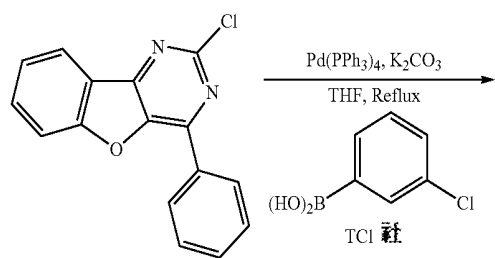




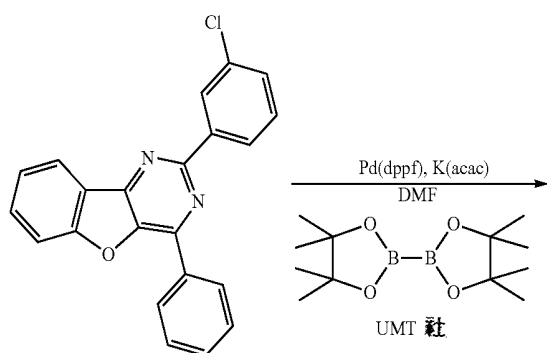
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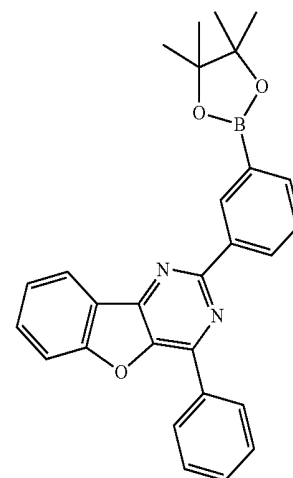
Intermediate 405-1



Intermediate B-37



-continued



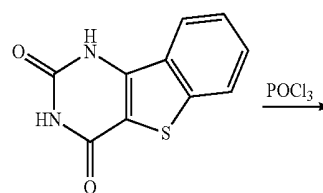
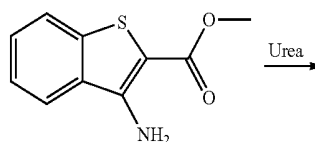
Intermediate 405-2

## Synthesis of First Host Compounds

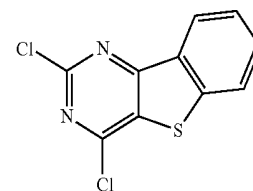
## Synthesis Example 1

## Synthesis of Compound 16

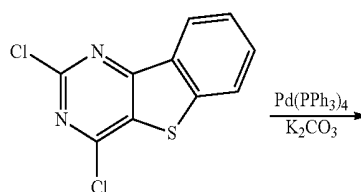
[0339]



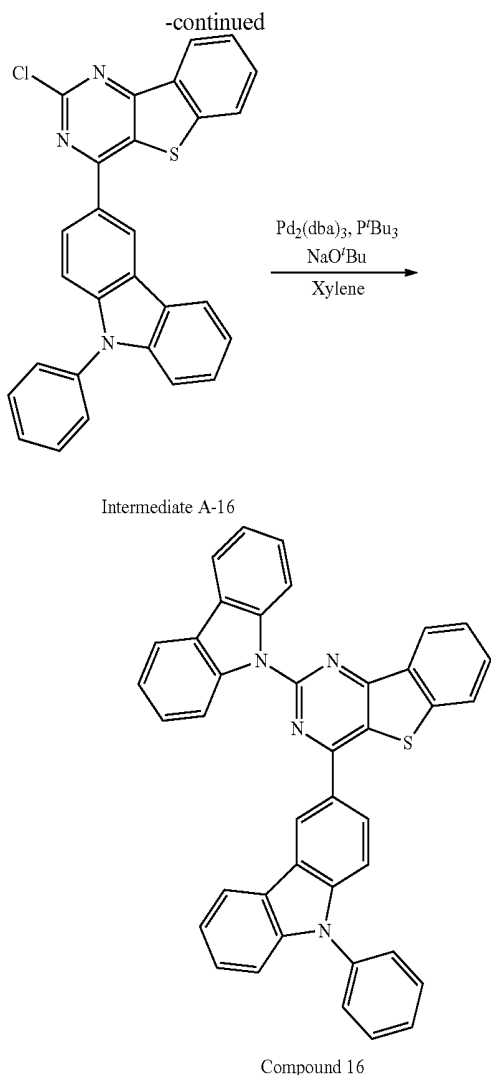
Intermediate (1)



Intermediate A



Intermediate A



Synthesis of Intermediate A (1)  
(benzo-1H-thieno[3,2-d]pyrimidine-2,4-dione)

**[0340]** A mixture of 47.5 g (0.23 mol) of benzo-methyl 3-amino-2-thiophenecarboxylate and 79.4 g (1.15 mol) of urea was stirred in a 2000 mL round-bottom flask at 200° C. for 2 hours. After the high-temperature reaction mixture was cooled down to room temperature, a sodium hydroxide solution was added thereto, followed by filtration to remove impurities and acidification with HCl. The resulting precipitate was dried to obtain the intermediate A(1) (35 g, Yield: 75%).

**[0341]** calcd. C<sub>10</sub>H<sub>6</sub>N<sub>2</sub>O<sub>2</sub>S: C, 55.04; H, 2.77; N, 12.84; O, 14.66; S, 14.69. found: C, 55.01; H, 2.79; N, 12.81; O, 14.69; S, 14.70.

Synthesis of Intermediate A  
(benzo-2,4-dichloro-thieno[3,2-d]pyrimidine)

**[0342]** 35 g (0.16 mol) of the intermediate A(1) (benzo-1H-thieno[3,2-d]pyrimidine-2,4-dione) and 600 mL of phosphorus oxychloride were mixed in a 1000 mL round-bottom flask and stirred under reflux for 6 hours. The reaction mixture was cooled down to room temperature, and poured into ice/water with stirring to obtain a precipitate.

The resulting reaction precipitate was filtered to obtain the intermediate A ((benzo-2,4-dichloro-thieno[3,2-d]pyrimidine) in white solid form (35 g, Yield: 85%). The intermediate A was identified using elemental analysis and nuclear magnetic resonance (NMR). The results are as follows.

**[0343]** calcd. C<sub>10</sub>H<sub>4</sub>Cl<sub>2</sub>N<sub>2</sub>S: C, 47.08; H, 1.58; Cl, 27.79; N, 10.98; S, 12.57. found: C, 47.03; H, 1.61; Cl, 27.81; N, 10.98; S, 12.60.

**[0344]** 300 MHz (CDCl<sub>3</sub>, ppm): 7.63 (t, 1H), 7.76 (t, 4H), 7.95 (d, 1H), 8.53 (d, 1H)

Synthesis of Intermediate A-16

**[0345]** 25.0 g (98.5 mmol) of the intermediate A, 40.01 g (108.35 mmol) of phenyl-3-boronic ester-carbazole, 34.04 g (246.26 mmol) of potassium carbonate, and 5.7 g (4.93 mmol) of tetrakis(triphenylphosphine)palladium(0) (Pd(PPh<sub>3</sub>)<sub>4</sub>) were added to 600 mL of 1,4-dioxane and 300 mL of water in a 2000 mL round-bottom flask, and heated under reflux in a nitrogen atmosphere for 6 hours. The resulting mixture was added to 1500 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in monochlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate A-16 (31.85 g, Yield: 70%).

**[0346]** calcd. C<sub>28</sub>H<sub>16</sub>ClN<sub>3</sub>S: C, 72.80; H, 3.49; Cl, 7.67; N, 9.10; S, 6.94. found: C, 72.43; H, 3.54; Cl, 7.69; N, 9.29; S, 6.70.

Synthesis of Compound 16

**[0347]** 29.6 g (64.04 mmol) of the intermediate A-16, 11.2 g (67.25 mmol) of carbazole, 12.3 g (128.1 mmol) of sodium t-butoxide, 3.7 g (6.4 mmol) of Pd(dba)<sub>2</sub>, and 5.2 mL of tri-t-butylphosphine (50% in toluene) were added to 400 mL of xylene in a 1000 mL round-bottom flask, and heated under reflux in a nitrogen atmosphere for 15 hours. The resulting mixture was added to 1000 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in dichlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain Compound 16 (26.0 g, Yield: 68%). Compound 16 was identified using elemental analysis and nuclear magnetic resonance (NMR). The results are as follows.

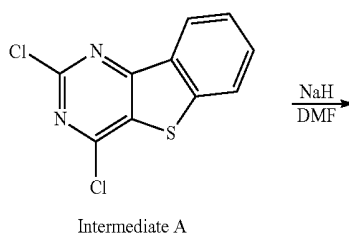
**[0348]** calcd. C<sub>40</sub>H<sub>24</sub>N<sub>4</sub>S: C, 81.06; H, 4.08; N, 9.45; S, 5.41. found: C, 81.00; H, 4.12; N, 9.40.69; S, 5.30.

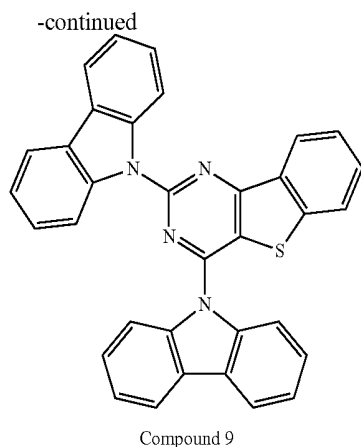
**[0349]** 300 MHz (CDCl<sub>3</sub>, ppm): 7.37-7.70 (m, 15H), 7.93 (d, 1H), 8.12 (d, 2H), 8.28 (d, 1H), 8.45 (dd, 1H), 8.68 (d, 1H), 9.12 (d, 2H), 9.21 (d, 1H)

Synthesis Example 2

Synthesis of Compound 9

**[0350]**





[0351] 100 mL of DMF was put into a 500 mL flask, and 2.8 g (32.2 mmol) of sodium hydride was added thereto. After lowering the internal temperature of the flask to 0° C., 11.8 g (70.5 mmol) of carbazole was slowly added and stirred at 0° C. for 1 hour. 15.0 g (58.8 mmol) of the intermediate A was slowly added, stirred at room temperature for 1 hour, and then heated slowly to room temperature. The reaction mixture was left at room temperature for 1 hour or longer, and quenched in ice/water, followed by extraction with methylene chloride. An organic layer was collected, dried using sodium sulfate, and concentrated in a vacuum. The resulting product was dissolved in methylene chloride, followed by recrystallization with methanol to obtain Compound 9 (13.6 g, Yield: 60%). Compound 9 was identified using elemental analysis and nuclear magnetic resonance (NMR). The results are as follows.

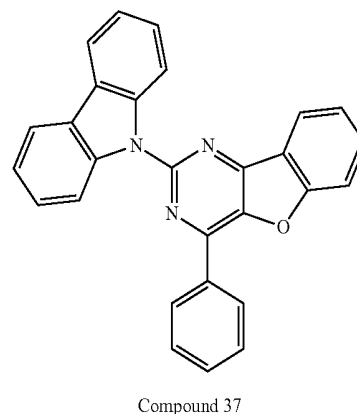
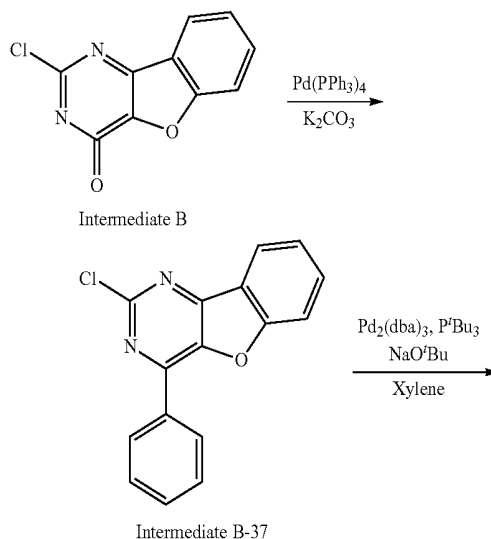
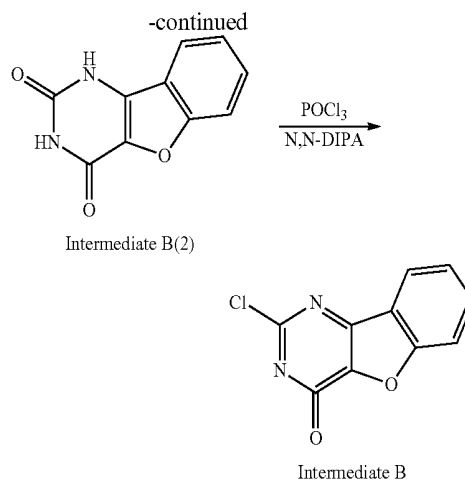
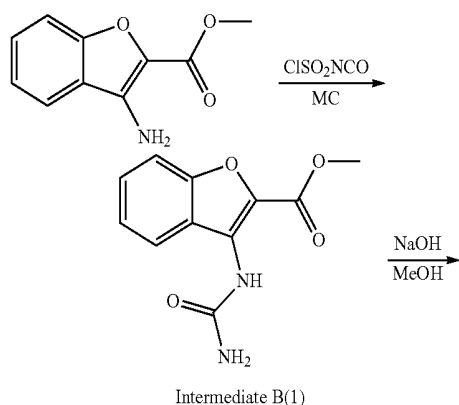
[0352] calcd. C<sub>34</sub>H<sub>20</sub>N<sub>4</sub>S: C, 79.05; H, 3.90; N, 10.84; S, 6.21. found: C, 79.17; H, 3.78; N, 10.73; S, 6.07.

[0353] 300 MHz (CDCl<sub>3</sub>, ppm): 7.38-7.53 (m, 8H), 7.68-7.74 (m, 2H), 7.82-7.89 (m, 3H), 8.13 (d, 2H), 8.22 (dd, 2H), 8.76 (dd, 1H), 9.22 (d, 2H)

### Synthesis Example 3

#### Synthesis of Compound 37

[0354]



#### Synthesis of Intermediate B(1)(benzo-methyl 3-ureidofuran-2-carboxylate)

[0355] 33.4 mL (0.38 mol) of chlorosulfonyl isocyanate was dropwise added to a solution of 49.0 g (0.25 mol) of benzo-methyl 3-aminofuran-2-carboxylate in 1000 mL of dichloromethane in a 1000 mL round-bottom flask at -78° C. The reaction product was heated slowly to room temperature, and stirred for 2 hours. After the reaction product was concentrated, and 100 mL of Conc. HCl was added thereto, and then stirred at 100° C. for 1 hour. The reaction

product was cooled down to room temperature, followed by neutralization with an aqueous saturated  $\text{NaHCO}_3$  solution to precipitate a solid. The resulting solid was filtered to obtain the intermediate B(1) (benzo-methyl 3-ureidofuran-2-carboxylate) in beige solid form (52.1 g, Yield: 87%). calcd.  $\text{C}_{11}\text{H}_{10}\text{N}_2\text{O}_4$ : C, 56.41; H, 4.30; N, 11.96; O, 27.33. found: C, 56.45; H, 4.28; N, 11.94; O, 27.32.

#### Synthesis of Intermediate B(2) (benzo furo[3,2-d]pyrimidine-2,4-diol)

**[0356]** 50.0 g (0.21 mol) of the intermediate B(1) (benzo-ethyl 3-ureidofuran-2-carboxylate) was suspended in 1000 mL of methanol in a 2000 mL round-bottom flask, and then 300 mL of a 2M NaOH was dropwise added thereto. The reaction mixture was stirred under reflux for 3 hours. The reaction mixture was cooled down to room temperature, followed by acidification with Conc. HCl to pH 3. After the reaction mixture was concentrated, methanol was slowly dropwise added to precipitate a solid. The resulting solid was filtered and dried to obtain the intermediate B(2) (benzo furo[3,2-d]pyrimidine-2,4-diol) (38.0 g, Yield: 88%). calcd.  $\text{C}_{10}\text{H}_8\text{N}_2\text{O}_3$ : C, 59.41; H, 2.99; N, 13.86; O, 23.74. found: C, 59.41; H, 2.96; N, 13.81; O, 23.75.

#### Synthesis of Intermediate B (benzo-2,4-dichlorofuro[3,2-d]pyrimidine)

**[0357]** 37.2 g (0.18 mol) of the intermediate B(2) (benzo-furo[3,2-d]pyrimidine-2,4-diol) was dissolved in 500 mL of phosphorous oxychloride in a 1000 mL round-bottom flask. The resulting mixture was cooled down to  $-30^\circ\text{C}$ ., and 52 mL (0.36 mol) of N,N-diisopropylethylamine was slowly added thereto. The reaction product was stirred under reflux for 36 hours, cooled down to room temperature, and then poured into ice/water, followed by extraction with ethyl acetate. An organic layer was collected, washed with an aqueous saturated  $\text{NaHCO}_3$  solution, dried using  $\text{Na}_2\text{SO}_4$ , and then concentrated to obtain the intermediate B (benzo-2,4-dichlorofuro[3,2-d]pyrimidine) (20.4 g, Yield: 46%). Intermediate B was identified using elemental analysis and nuclear magnetic resonance (NMR). The results are as follows. calcd.  $\text{C}_{10}\text{H}_4\text{Cl}_2\text{N}_2\text{O}$ : C, 50.24; H, 1.69; Cl, 29.66; N, 11.72; O, 6.69. found: C, 50.18; H, 1.79; Cl, 29.69; N, 11.69; O, 6.70.

**[0358]** 300 MHz ( $\text{CDCl}_3$ , ppm): 7.55 (t, 1H), 7.71-7.82 (m, 2H), 8.25 (d, 1H)

#### Synthesis of Intermediate B-37

**[0359]** 40.0 g (167.3 mmol) of the intermediate B, 22.4 g (184.1 mmol) of phenylboronic acid, 57.8 g (418.3 mmol) of potassium carbonate, and 9.7 g (8.4 mmol) of tetrakis (triphenylphosphine) palladium(0) ( $\text{Pd}(\text{PPh}_3)_4$ ) were added to 500 mL of 1,4-dioxane and 250 mL of water in a 2000 mL flask, and heated in a nitrogen atmosphere at  $40^\circ\text{C}$ . for 8 hours. The resulting mixture was added to 1500 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in monochlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate B-37 (31.0 g, Yield: 66%). calcd.  $\text{C}_{16}\text{H}_9\text{ClN}_2\text{O}$ : C, 68.46; H, 3.23; Cl, 12.63; N, 9.98; O, 5.70. found: C, 68.95; H, 3.08; Cl, 12.17; N, 10.01; O, 5.62.

#### Synthesis of Compound 37

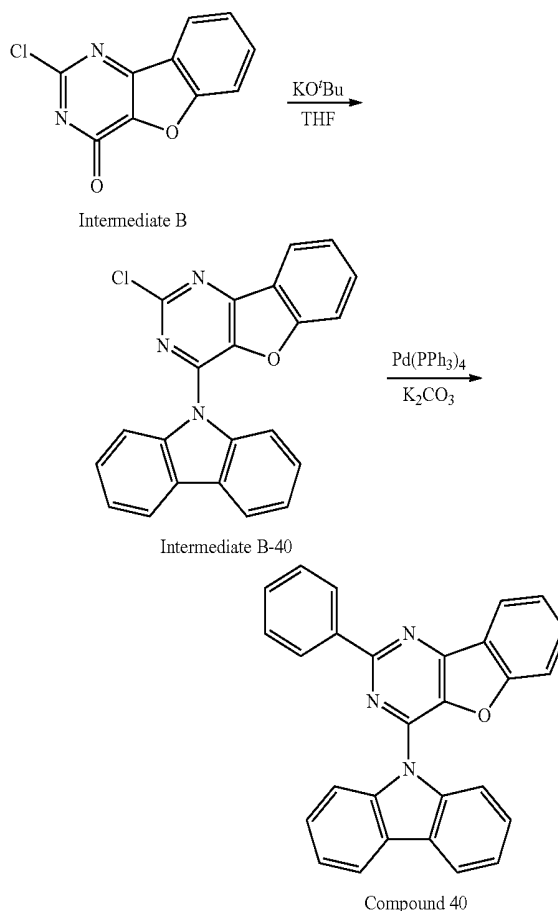
**[0360]** 10.2 g (36.5 mmol) of the intermediate B-37, 6.7 g (40.1 mmol) of carbazole, 7.0 g (72.9 mmol) of sodium t-butoxide, 2.1 g (3.7 mmol) of  $\text{Pd}(\text{dba})_2$ , and 2.9 mL of tri-t-butylphosphine (50% in toluene) were added to 250 mL of xylene in a 500 mL round-bottom flask, and heated under reflux in a nitrogen atmosphere for 15 hours. The resulting mixture was added to 1000 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in dichlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain Compound 37 (9.8 g, Yield: 65%). Compound 37 was identified using elemental analysis and nuclear magnetic resonance (NMR). The results are as follows. calcd.  $\text{C}_{28}\text{H}_{17}\text{N}_3\text{O}$ : C, 81.73; H, 4.16; N, 10.21; O, 3.89. found: C, 82.94; H, 4.08; N, 9.17; S, 4.02.

**[0361]** 300 MHz ( $\text{CDCl}_3$ , ppm): 7.37-7.42 (m, 2H), 7.53-7.77 (m, 8H), 8.13 (d, 2H), 8.39 (dd, 1H), 8.73-8.76 (m, 2H), 8.92 (d, 2H)

#### Synthesis Example 4

#### Synthesis of Compound 40

**[0362]**



#### Synthesis of Intermediate B-40

**[0363]** 4.5 g (46.6 mmol) of sodium-t-butoxide was added to 250 mL of tetrahydrofuran (THF) in a 500 mL flask. After

lowering the internal temperature of the flask to 0° C., 6.8 g (40.8 mmol) of carbazole was slowly added and stirred at 0° C. for 1 hour. 9.0 g (38.9 mmol) of the intermediate B was slowly added, stirred at room temperature for 1 hour at room temperature, and then heated slowly to room temperature. The reaction product was left at room temperature for 1 hour to obtain the intermediate B-40 (11.0 g, Yield: 73%) in solid form. calcd. C<sub>22</sub>H<sub>12</sub>ClN<sub>3</sub>S: C, 68.48; H, 3.13; Cl, 9.19; N, 10.89; S, 8.31. found: C, 68.38; H, 3.03; Cl, 9.30; N, 10.99; S, 8.14.

#### Synthesis of Compound 40

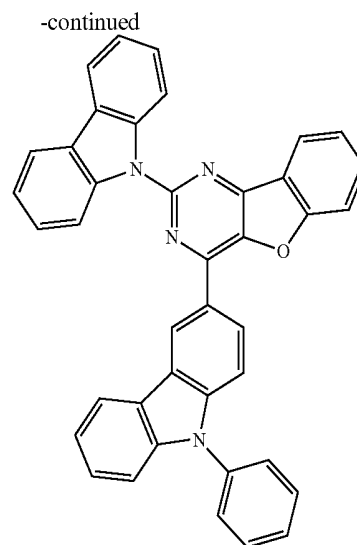
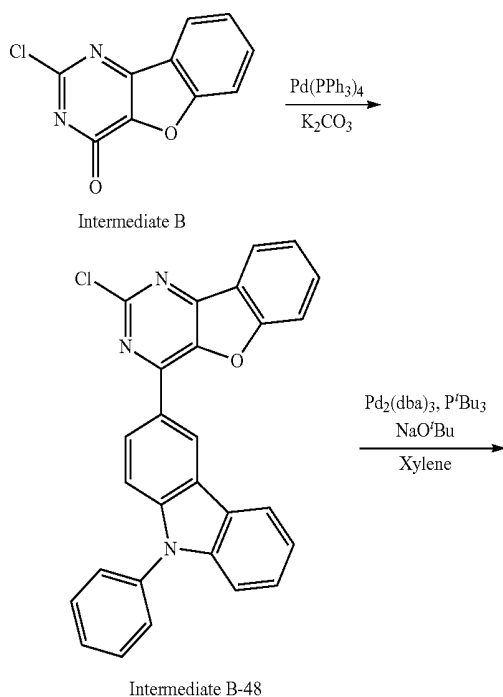
**[0364]** 15.0 g (40.6 mmol) of the intermediate B-40, 5.4 g (44.6 mmol) of phenylboronic acid, 14.0 g (101.41 mmol) of potassium carbonate, and 2.3 g (2.0 mmol) of tetrakis(triphenylphosphine) palladium(0) (Pd(PPh<sub>3</sub>)<sub>4</sub>) were added to 130 mL of 1,4-dioxane and 65 mL of water in a 500 mL flask, and heated under reflux in a nitrogen atmosphere for 6 hours. The resulting mixture was added to 400 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in monochlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain Compound 40 (12.0 g, Yield: 72%). Compound 40 was identified using elemental analysis and nuclear magnetic resonance (NMR). The results are as follows. calcd. C<sub>28</sub>H<sub>17</sub>N<sub>3</sub>S C, 78.66; H, 4.01; N, 9.83; S, 7.50. found: 77.06; H, 3.71; N, 9.87; S, 7.53.

**[0365]** 300 MHz (CDCl<sub>3</sub>, ppm): 7.39-7.74 (m, 10H), 7.91 (d, 2H), 8.17 (d, 2H), 8.41 (dd, 1H), 8.67-8.71 (m, 2H)

#### Synthesis Example 5

#### Synthesis of Compound 48

**[0366]**



Compound 48

#### Synthesis of Intermediate B-48

**[0367]** 15.0 g (62.7 mmol) of the intermediate B, 27.8 g (75.3 mmol) of phenyl-3-boronic ester-carbazole, 21.68 g (156.86 mmol) of potassium carbonate, and 3.6 g (3.1 mmol) of tetrakis(triphenylphosphine)palladium(0) (Pd(PPh<sub>3</sub>)<sub>4</sub>) were added to 400 mL of 1,4-dioxane and 200 mL of water in a 1000 mL flask, and heated under reflux in a nitrogen atmosphere for 6 hours. The resulting mixture was added to 1200 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in monochlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate B-48 (15.39 g, Yield: 55%). Calcd. C<sub>28</sub>H<sub>16</sub>ClN<sub>3</sub>O: C, 75.42; H, 3.62; Cl, 7.95; N, 9.42; O, 3.59. found: C, 75.12; H, 3.48; Cl, 7.90; N, 10.02; O, 3.51.

#### Synthesis of Compound 48

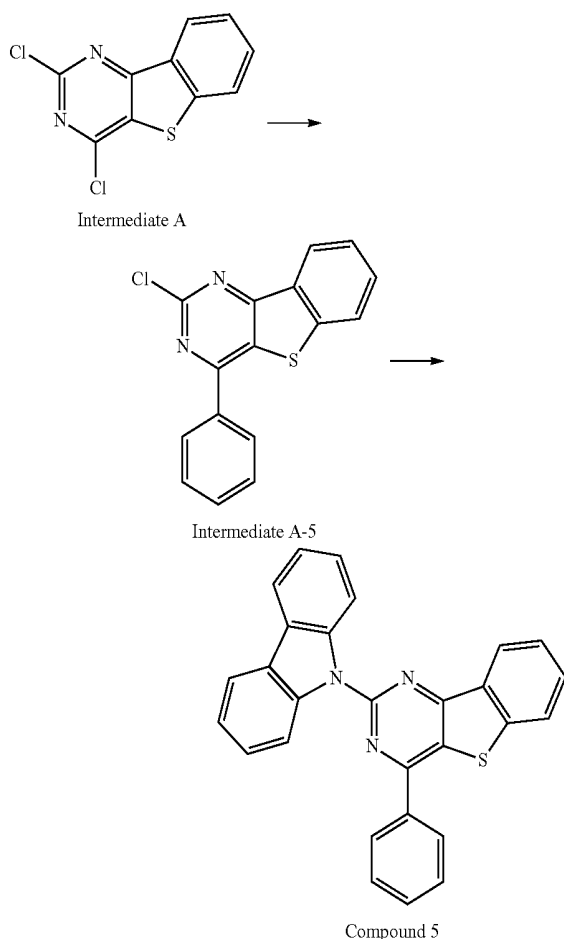
**[0368]** 14.6 g (32.8 mmol) of the intermediate B-48, 6.0 g (36.1 mmol) of carbazole, 6.3 g (65.5 mmol) of sodium t-butoxide, 1.8 g (3.3 mmol) of Pd(dba)<sub>2</sub>, and 2.6 mL of tri-t-butylphosphine (50% in toluene) were added to 200 mL of xylene in a 500 mL round-bottom flask, and heated under reflux in a nitrogen atmosphere for 15 hours. The resulting mixture was added to 600 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in dichlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain Compound 48 (15.0 g, Yield: 79%). Compound 48 was identified using elemental analysis and nuclear magnetic resonance (NMR). The results are as follows. calcd. C<sub>40</sub>H<sub>24</sub>N<sub>4</sub>O: C, 83.31; H, 4.20; N, 9.72; O, 2.77. found: C, 81.13; H, 3.94; N, 9.81; O, 2.79.

**[0369]** 300 MHz (CDCl<sub>3</sub>, ppm): 7.17-7.70 (m, 15H), 7.90 (d, 1H), 8.18 (d, 2H), 8.29 (d, 1H), 8.32 (dd, 1H), 8.73 (d, 1H), 9.19 (d, 2H), 9.31 (d, 1H)

## Synthesis Example 6

## Synthesis of Compound 5

[0370]



## Synthesis of Intermediate A-5

[0371] Intermediate A-5 (13.40 g, Yield: 60%) was synthesized in the same manner as in the synthesis of the intermediate A-16 in Synthesis Example 1, except that phenylboronic acid instead of phenyl-3-boronic ester-carbazole was used. calcd.  $C_{16}H_9ClN_2S$ : C, 64.75; H, 3.06; Cl, 11.95; N, 9.44; S, 10.80. found: C, 62.36; H, 3.16; Cl, 10.37; N, 9.54; S, 10.77.

## Synthesis of Compound 5

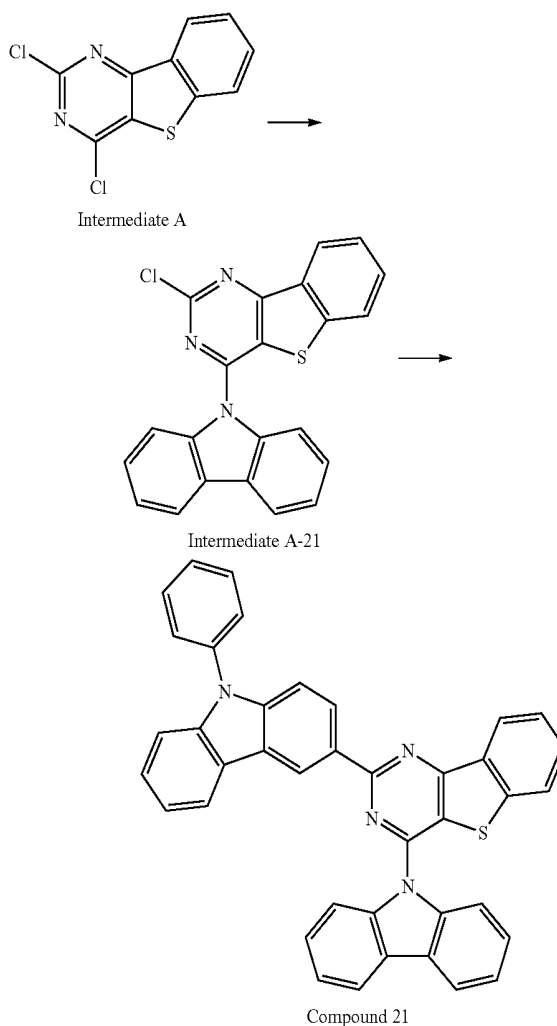
[0372] Compound 5 (10.77 g, Yield: 64%) was synthesized in the same manner as in the synthesis of Compound 16 in Synthesis Example 1, except that the intermediate A-5 instead of the intermediate A-16 was used. calcd.  $C_{28}H_{17}N_3S$ : C, 78.66; H, 4.01; N, 9.83; S, 7.50. found: C, 75.92; H, 3.92; N, 9.03; S, 7.38.

[0373] 300 MHz ( $CDCl_3$ , ppm): 7.39-7.45 (m, 2H), 7.55-7.79 (m, 8H), 8.24 (d, 2H), 8.40 (dd, 1H), 8.71-8.73 (m, 2H), 8.89 (d, 2H)

## Synthesis Example 7

## Synthesis of Compound 21

[0374]



## Synthesis of Intermediate A-21

[0375] Intermediate A-21 (20.15 g, Yield: 53%) was synthesized in the same manner as in the synthesis of the intermediate B-40 in Synthesis Example 4, except that the intermediate A instead of the intermediate B was used. calcd.  $C_{22}H_{12}ClN_3S$ : C, 68.48; H, 3.13; Cl, 9.19; N, 10.89; S, 8.31. found: C, 67.94; H, 3.23; Cl, 8.81; N, 10.36; S, 8.15.

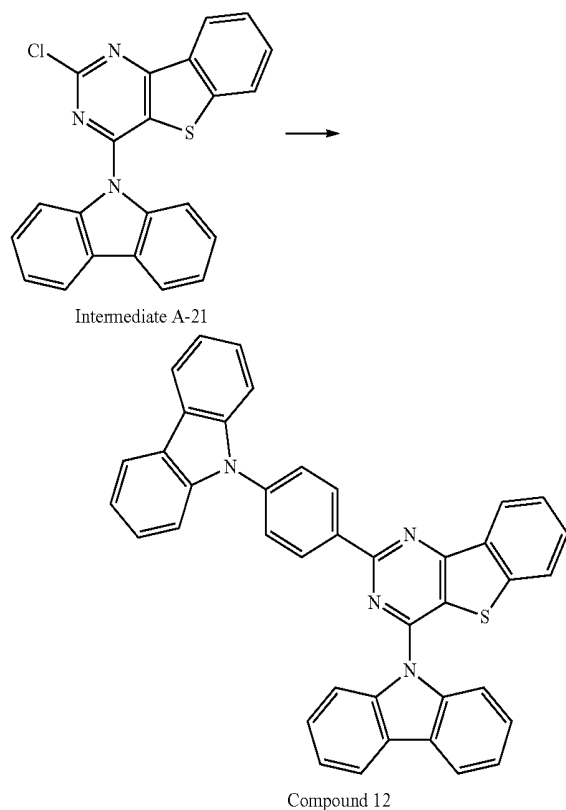
## Synthesis of Compound 21

[0376] Compound 21 (12.47 g, Yield: 67%) was synthesized in the same manner as in the synthesis of Compound 40 in Synthesis Example 4, except that the intermediate A-21 and phenyl-3-boronic ester-carbazole, instead of the intermediate B-40 and phenylboronic acid, respectively, were used. calcd.  $C_{40}H_{24}N_4S$ : C, 81.06; H, 4.08; N, 9.45; S, 5.41. found: C, 80.13; H, 3.74; N, 9.30; S, 5.23.

[0377] 300 MHz ( $CDCl_3$ , ppm): 7.25-7.33 (m, 4H), 7.45-7.64 (m, 11H), 7.77 (s, 1H), 7.94-8.18 (m, 7H), 8.55 (d, 1H)

Synthesis Example 8  
Synthesis of Compound 12

[0378]

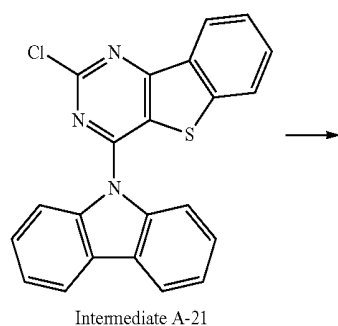


[0379] Compound 12 (17.4 g, Yield: 62%) was synthesized in the same manner as in the synthesis of Compound 21 in Synthesis Example 7, except that 9-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-9H-carbazole instead of phenyl-3-boronic ester-carbazole was used. calcd.  $C_{40}H_{24}N_4S$ : C, 81.06; H, 4.08; N, 9.45; S, 5.41. found: C, 80.21; H, 3.82; N, 9.03; S, 5.17.

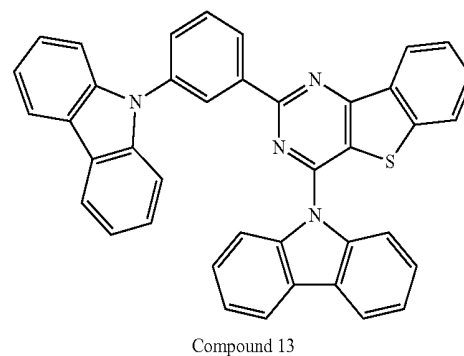
[0380] 300 MHz ( $CDCl_3$ , ppm): 7.25-7.33 (m, 6H), 7.50-7.52 (m, 4H), 7.63-7.68 (m, 4H), 7.79 (d, 2H), 7.94-8.12 (m, 6H), 8.55 (d, 2H)

Synthesis Example 9  
Synthesis of Compound 13

[0381]



-continued



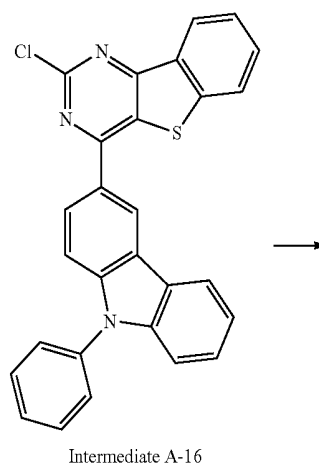
[0382] Compound 13 (7.7 g, Yield: 65%) was synthesized in the same manner as in the synthesis of Compound 21 in Synthesis Example 7, except that 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-9H-carbazole instead of phenyl-3-boronic ester-carbazole was used. calcd.  $C_{40}H_{24}N_4S$ : C, 81.06; H, 4.08; N, 9.45; S, 5.41. found: C, 79.47; H, 3.89; N, 9.37; S, 5.36.

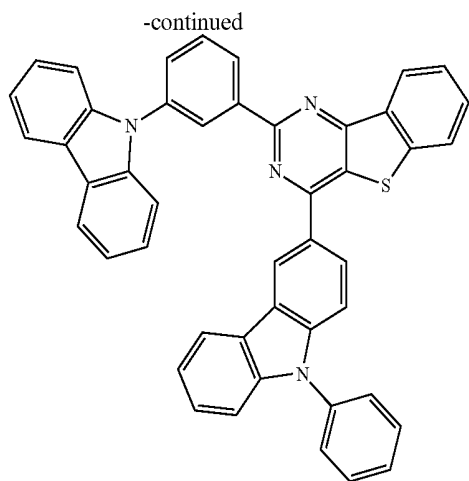
[0383] 300 MHz ( $CDCl_3$ , ppm): 7.25-7.33 (m, 6H), 7.46-7.52 (m, 6H), 7.63 (d, 2H), 7.94-8.12 (m, 7H), 8.28 (d, 1H), 8.55 (d, 2H)

Synthesis Example 10

Synthesis of Compound 18

[0384]





Compound 18

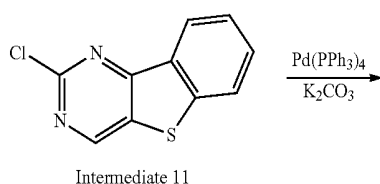
**[0385]** Compound 18 (11.4 g, Yield: 71%) was synthesized in the same manner as in the synthesis of Compound 16 in Synthesis Example 1, except that 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-9H-carbazole, instead of carbazole, was used. calcd.  $C_{46}H_{28}N_4S$ : C, 82.61; H, 4.22; N, 8.38; S, 4.79. found: C, 78.97; H, 4.01; N, 7.78; S, 4.42.

**[0386]** 300 MHz ( $CDCl_3$ , ppm): 7.25-7.33 (m, 5H), 7.45-7.69 (m, 12H), 7.77 (s, 1H), 7.87-8.12 (m, 7H), 8.28 (d, 1H), 8.55 (d, 2H)

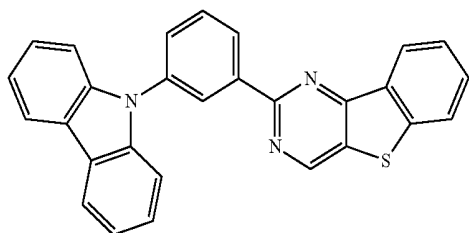
## Synthesis Example 11

## Synthesis of Compound 11

**[0387]**



Intermediate 11



Compound 11

**[0388]** 8.38 g (37.9 mmol) of the intermediate 11, 14.02 g (37.9 mmol) of 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-9H-carbazole, 13.1 g (94.93 mmol) of

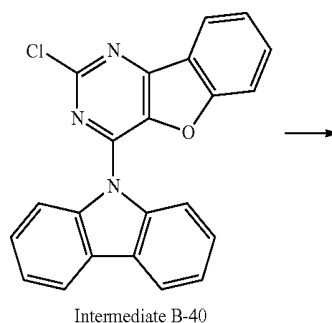
potassium carbonate, and 2.19 g (1.90 mmol) of tetrakis (triphenylphosphine)palladium(0) ( $Pd(PPh_3)_4$ ) were added to 140 mL of 1,4-dioxane and 70 mL of water in a 500 mL flask, and heated under reflux in a nitrogen atmosphere for 6 hours. The resulting mixture was added to 500 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in monochlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain Compound 11 (10.9 g, Yield: 67%). Compound 11 was identified using elemental analysis and nuclear magnetic resonance (NMR). The results are as follows. calcd.  $C_{28}H_{17}N_3S$ : C, 78.66; H, 4.01; N, 9.83; S, 7.50. found: C, 76.55; H, 3.76; N, 9.36; S, 7.42.

**[0389]** 300 MHz ( $CDCl_3$ , ppm): 7.25-7.33 (m, 3H), 7.46-7.52 (m, 5H), 7.63 (d, 1H), 7.94-8.12 (m, 5H), 8.28 (d, 1H), 8.50 (s, 1H), 8.55 (d, 1H)

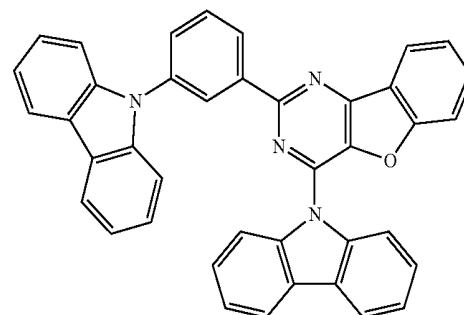
## Synthesis Example 12

## Synthesis of Compound 45

**[0390]**



Intermediate B-40



Compound 45

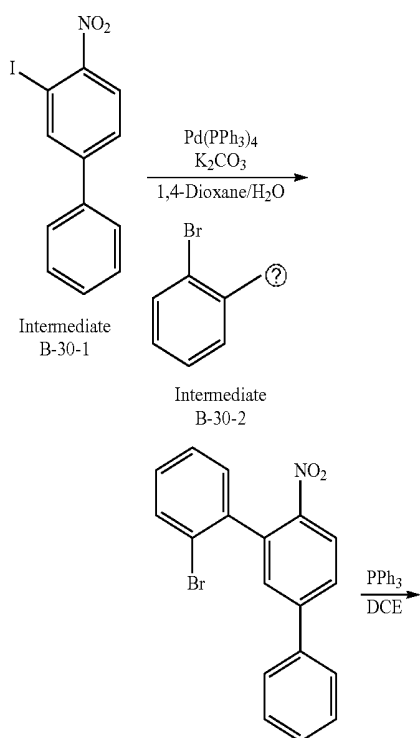
**[0391]** Compound 45 (8.6 g, Yield: 70%) was synthesized in the same manner as in the synthesis of Compound 40 in Synthesis Example 4, except that 9-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-9H-carbazole, instead of phenylboronic acid, was used. calcd.  $C_{40}H_{24}N_4O$ : C, 83.31; H, 4.20; N, 9.72; O, 2.77. found: C, 82.16; H, 3.94; N, 9.83; O, 2.64.

[0392] 300 MHz (CDCl<sub>3</sub>, ppm): 7.25-7.51 (m, 12H), 7.63-7.70 (m, 4H), 7.94 (d, 2H), 8.09-8.12 (m, 3H), 8.28 (d, 1H), 8.55 (d, 2H)

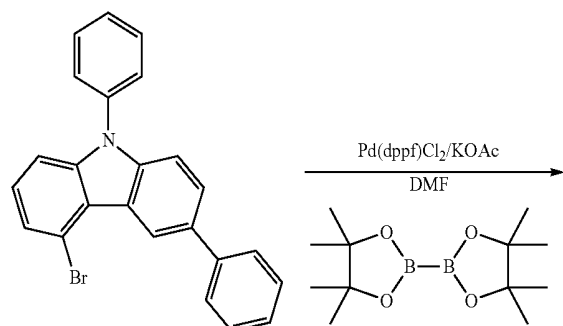
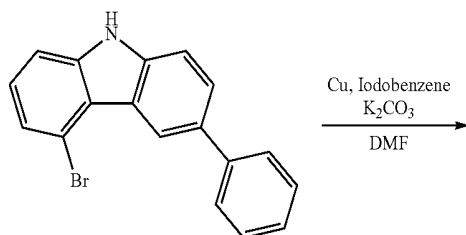
## Synthesis Example 13

## Synthesis of Compound a-10

[0393]

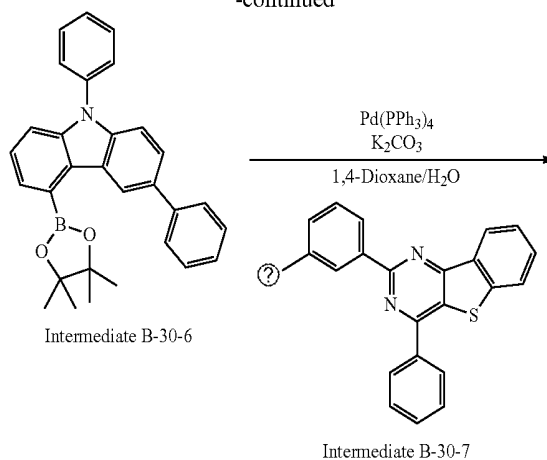


Intermediate B-30-3



Intermediate B-30-5

-continued



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## Synthesis of Intermediate B-30-3

[0394] 3-iodo-4-nitro-1,1'-biphenyl (intermediate B-30-1, 20.1 g, 61.8 mmol), (2-bromophenyl)boronic acid (Manufacturer: TCI Inc., 18.6 g, 92.7 mmol), triphenylphosphine, (2.4 g, 9.2 mmol), tetrakis(triphenylphosphine) palladium(0) (Pd(PPh<sub>3</sub>)<sub>4</sub>, 0.7 g, 3.1 mmol), and potassium carbonate (K<sub>2</sub>CO<sub>3</sub>, 17.1 g, 123.7 mmol) were added to 800 mL of toluene and 80 mL of H<sub>2</sub>O in a 2-neck flask, then exchanged with argon and refluxed for 12 hours. Then, the resultant was cooled down to room temperature and was extracted with ethyl acetate (EA), the moisture was removed from the resultant organic layer using magnesium sulfate (MgSO<sub>4</sub>) followed by concentrating the resultant, and the resultant was purified using column chromatography (hexane/EA=10/1) to obtain the intermediate B-30-3 47 g (Yield: 75%).

[0395] <sup>1</sup>H NMR (CDCl<sub>3</sub>, 300 MHz): 8.22 (d, 1H), 7.78 (dd, 1H), 7.70~7.64 (m, 3H), 7.56 (d, 1H), 7.52~7.39 (m, 4H), 7.33~7.26 (m, 2H).

## Synthesis of Intermediate B-30-4

[0396] The intermediate B-30-3 (25.8 g, 72.9 mmol) and PPh<sub>3</sub> (57.4 g, 218.8 mmol) were added, and 80 mL of 1,2-dichlorobenzene (DCB) was added to a 1-neck flask, then exchanged with argon and refluxed at 150° C. for 12 hours. DCB was removed by distillation, then the resultant was cooled down to room temperature and was dissolved in

a small amount of toluene, and the resultant was purified using column chromatography (hexane) to obtain the intermediate B-30-4 15 g (Yield: 64%).

[0397]  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz): 8.99 (s, 1H), 8.20 (b, 1H), 7.75~7.72 (m, 3H), 7.51~7.46 (m, 3H), 7.43~7.27 (m, 4H).

#### Synthesis of Intermediate B-30-5

[0398] The intermediate B-30-4 (32.0 g, 99.3 mmol), Cu (0.63 g, 9.9 mmol), and  $\text{K}_2\text{CO}_3$  (27.1 g, 198.6 mmol) were added to 320 mL of dimethylformamide (DMF) in a 2-neck flask, and then exchanged with argon and iodobenzene (22.5 ml, 198.6 mmol) was added. Then, the resultant was refluxed for 12 hours, and then cooled down to room temperature, the moisture was removed from the organic layer extracted with EA using  $\text{MgSO}_4$  followed by concentrating the resultant, and the resultant was purified using column chromatography (hexane) to obtain 25 g (Yield: 64%) of a white solid (3). The intermediate B-30-5 was identified using  $^1\text{H}$ -NMR and LC/MS (Liquid chromatography-mass spectrometry).

[0399]  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz): 9.07 (d, 1H), 7.75~7.71 (m, 3H), 7.69~7.61 (m, 2H), 7.55~7.40 (m, 7H), 7.37~7.31 (m, 2H), 7.26~7.22 (dd, 1H)

[0400] LC/MS, calcd.:  $\text{C}_{24}\text{H}_{16}\text{BrN}$ =398.29, measured:  $m/z$ =398.1 (M+, 100%)

#### Synthesis of Intermediate B-30-6

[0401] The intermediate B-30-5 (33 g, 83 mmol), 4,4,4', 4',5,5,5',5'-octamethyl-1,2'-bi(1,3,2-dioxaborolane) (25 g, 100 mmol), potassium acetate (KOAc, 21 g, 210 mmol), and 1,1'-bis(diphenylphosphino)ferrocene-palladium(II) dichloride ( $\text{PdCl}_2(\text{dppf})_2$ , 3.4 g, 4.2 mmol) were in THF (200 mL) in a 2-neck flask, and then stirred at 70° C. for 24 hours. After the reaction was terminated, the reaction solution was extracted with water and EA (ethyl acetate), the moisture was removed from the resultant organic layer using  $\text{MgSO}_4$  followed by concentrating the resultant, and the resultant was purified using column chromatography (methylene chloride/n-hexane=3/2, silica gel) to obtain a white solid, the intermediate B-30-6 (26 g, Yield: 60%).

[0402]  $^1\text{H}$  NMR ( $\text{CDCl}_3$ , 300 MHz): 9.52 (s, 1H), 7.79~7.32 (m, 15H), 1.50 (s, 12H).

#### Synthesis of Compound a-10

[0403] The intermediate B-30-6 (16.0 g, 36 mmol), B-30-7 (15.0 g, 36 mmol),  $\text{K}_2\text{CO}_3$  (12 g, 89.8 mmol) and  $\text{Pd}(\text{PPh}_3)_4$  (2.1 g, 1.8 mmol) were added to toluene (50 mL) and  $\text{H}_2\text{O}$  (20 ml), and then stirred at 120° C. for 24 hours. After the reaction was terminated, the mixture was added to water followed by agitating and filtering the resultant, the obtained dark grey solid was dissolved in hot toluene and filtered. The obtained toluene solution was precipitated using methanol and filtered, and the obtained solid was recrystallized using 1-chlorobenzene to obtain the compound a-10, a yellow crystal (14.0 g, Yield: 60%). The structure of the obtained compound a-10 was identified using LC/MS.

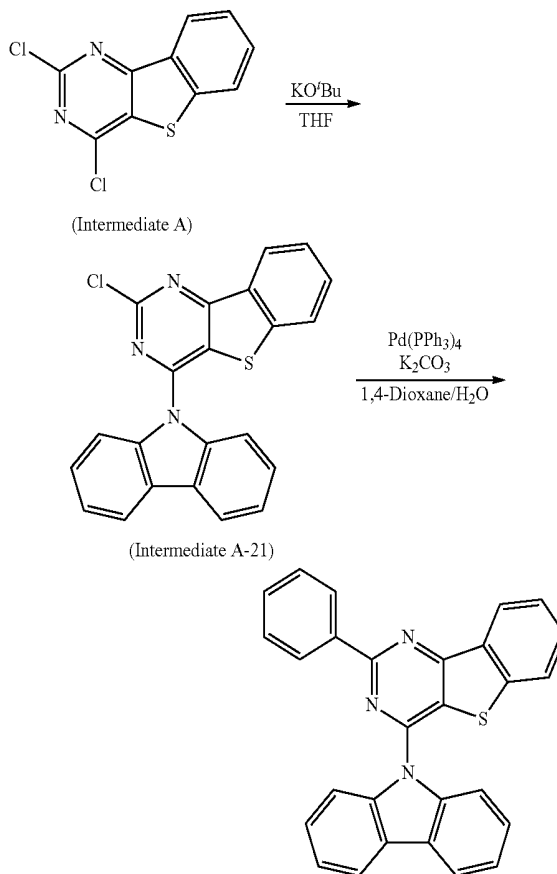
[0404] LC/MS, calcd.:  $\text{C}_{46}\text{H}_{29}\text{N}_3\text{S}$ =655.21 measured:  $m/z$ =655.20 (M+, 100%)

[0405] calcd.  $\text{C}_{46}\text{H}_{29}\text{N}_3\text{S}$ : C, 84.25; H, 4.46; N, 6.41; S, 4.89. found: C, 84.23; H, 4.44; N, 6.40; S, 4.85.

#### Synthesis Example ad-1

##### Synthesis of Compound 8

[0406]



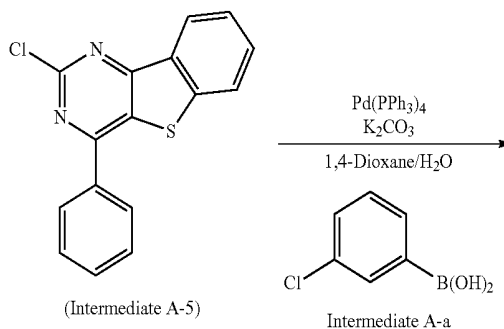
[0407] The compound 8 (8.45 g, Yield: 66%) was synthesized in the same method as in the synthesis of the compound 40 in Synthesis Example 4, except that the intermediate A instead of the intermediate B was used.

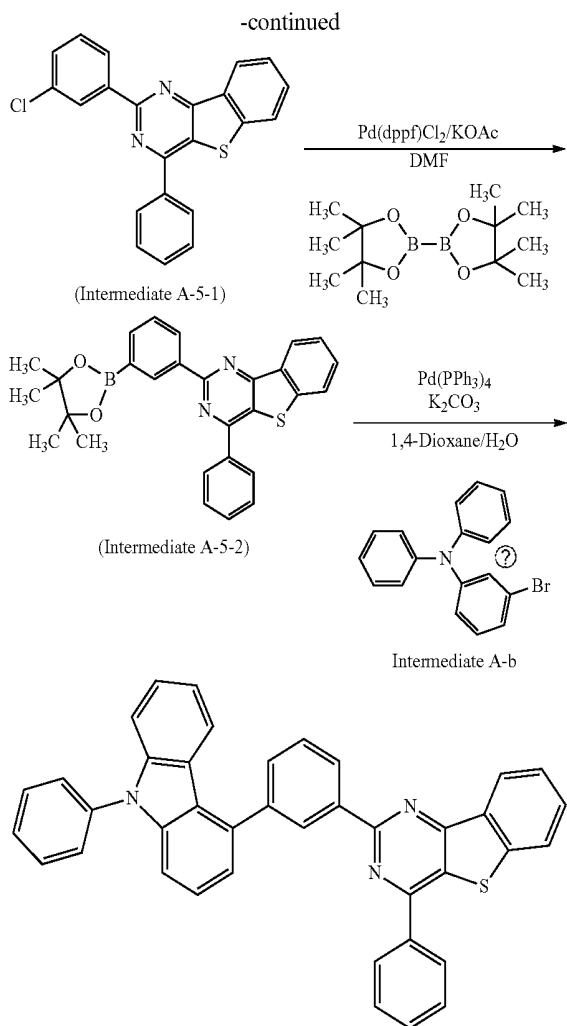
[0408] calcd.  $\text{C}_{28}\text{H}_{17}\text{N}_3\text{S}$  C, 78.66; H, 4.01; N, 9.83; S, 7.50. found: C, 78.62; H, 4.01; N, 9.82; S, 7.47.

#### Synthesis Example ad-2

##### Synthesis of Compound a-9

[0409]





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#### Synthesis of Intermediate A-5-1

[0410] 70.0 g (235.9 mmol) of the intermediate A-5, 40.6 g (259.5 mmol) of the intermediate A-a (Manufacturer: TCI Inc.), 81.5 g (589.7 mmol) of potassium carbonate, and 13.6 g (11.8 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 700 mL of 1,4-dioxane and 350 mL of water in a 2 L round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture

was added to 2500 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate A-5-1 (65.9 g, Yield: 75%).

[0411] calcd. C<sub>22</sub>H<sub>13</sub>CIN<sub>2</sub>S: C, 70.87; H, 3.51; Cl, 9.51; N, 7.51; S, 8.60. found: C, 70.84; H, 3.50; Cl, 9.51; N, 7.46; S, 8.57.

#### Synthesis of Intermediate A-5-2

[0412] The intermediate A-5-1 (65.0 g, 174.3 mmol), 4,4,4',4',5,5,5',5'-octamethyl-2,2'-bi(1,3,2-dioxaborolane) (53.1 g, 209.2 mmol), potassium acetate (KOAc, 51.3 g, 523.0 mmol) and 1,1'-bis(diphenylphosphino) ferrocene-palladium(II) dichloride (8.5 g, 10.5 mmol), and tricyclohexyl phosphine (7.3 g, 26.1 mmol) were in 500 mL of N,N-dimethylformamide 500 mL in a 1 L flask, and then stirred at 130° C. for 24 hours. After the reaction was terminated, the reaction solution was extracted with water and EA, the moisture was removed from the resultant organic layer using magnesium sulfate followed by concentrating the resultant, and the resultant was purified using column chromatography to obtain a white solid, the intermediate A-5-2 (61 g, Yield: 75%).

[0413] calcd. C<sub>28</sub>H<sub>25</sub>BN<sub>2</sub>O<sub>2</sub>S: C, 72.42; H, 5.43; B, 2.33; N, 6.03; O, 6.89; S, 6.90. found: C, 72.41; H, 5.40; B, 2.33; N, 6.02; O, 6.85; S, 6.89.

#### Synthesis of Compound a-9

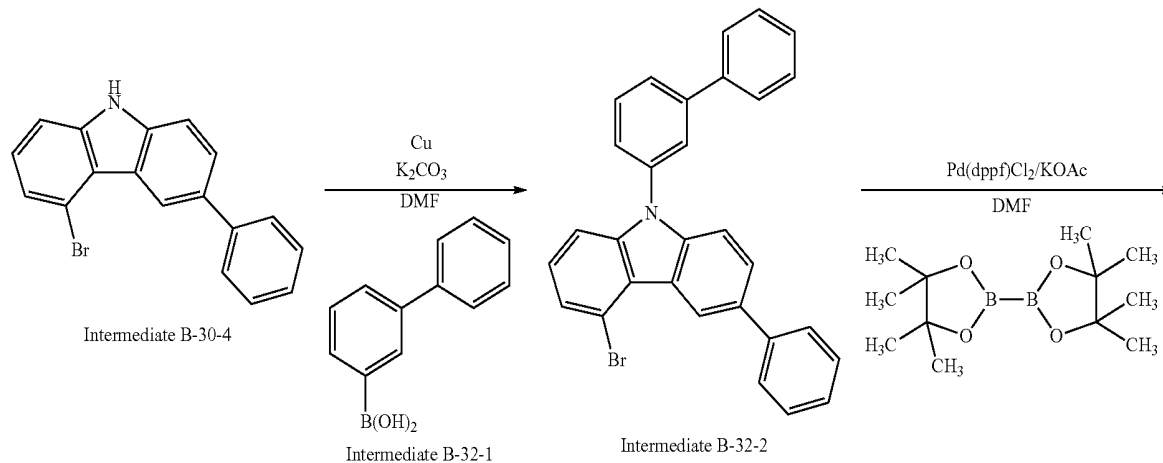
[0414] 10.0 g (21.5 mmol) of the intermediate A-5-2, 6.9 g (21.5 mmol) of the intermediate A-b, 7.4 g (53.8 mmol) of potassium carbonate, and 1.2 g (1.1 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 60 mL of 1,4-dioxane and 30 mL of water in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 200 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound a-9 (8.7 g, Yield: 70%).

[0415] calcd. C<sub>40</sub>H<sub>25</sub>N<sub>3</sub>S: C, 82.87; H, 4.35; N, 7.25; S, 5.53. found: C, 82.84; H, 4.35; N, 7.23; S, 5.51.

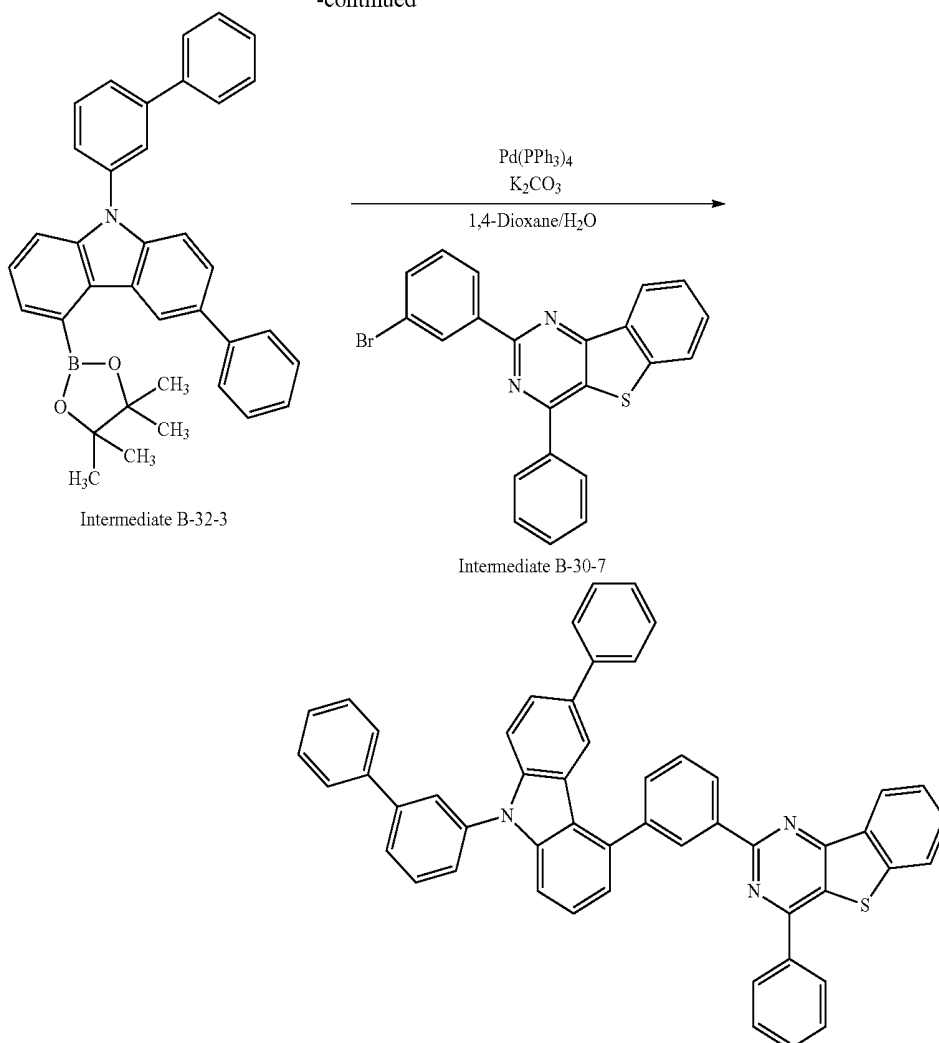
#### Synthesis Example ad-3

#### Synthesis of Compound a-12

[0416]



-continued



#### Synthesis of Intermediate B-32-2

**[0417]** The intermediate B-30-4 (15.0 g, 46.6 mmol), Cu (0.3 g, 4.7 mmol), and potassium carbonate (12.9 g, 93.1 mmol) were added to 200 mL of dimethylformamide (DMF) in a 500 mL flask, then exchanged with argon, and the intermediate B-32-1 (Manufacturer: Beijing pure chem, 13.8 g, 69.8 mmol) was added thereto. Then, the resultant was refluxed for 12 hours, and then cooled down to room temperature, the moisture was removed from the organic layer extracted with EA using MgSO<sub>4</sub> followed by concentrating the resultant, and the resultant was purified using column chromatography (EA/Hexane) to obtain a white solid, the intermediate B-32-2 (15.5 g, 70%).

**[0418]** calcd. C<sub>30</sub>H<sub>20</sub>BrN: C, 75.95; H, 4.25; Br, 16.84; N, 2.95. found: C, 75.94; H, 4.25; Br, 16.81; N, 2.92.

#### Synthesis of Intermediate B-32-3

**[0419]** The intermediate B-32-2 (15.0 g, 31.6 mmol), 4,4,4',4',5,5,5',5'-octamethyl-2,2'-bi(1,3,2-dioxaborolane) (9.6 g, 37.9 mmol), potassium acetate (9.3 g, 94.9 mmol) and 1,1'-bis(diphenylphosphino) ferrocene-palladium(II) dichloride (1.6 g, 1.9 mmol) were added to dimethylformamide (150 mL) in a 250 mL flask, and then stirred at 70° C. for 24 hours. After the reaction was terminated, the reaction

solution was extracted with water and ethyl acetate, the moisture was removed from the resultant organic layer using magnesium sulfate followed by concentrating the resultant, and the resultant was purified using column chromatography (methylene chloride/n-hexane, silica gel) to obtain a white solid, the intermediate B-32-3 (11.5 g, 70%).

**[0420]** calcd. C<sub>36</sub>H<sub>32</sub>BNO<sub>2</sub>: C, 82.92; H, 6.19; B, 2.07; N, 2.69; O, 6.14. found: C, 82.88; H, 6.18; B, 2.01; N, 2.65; O, 6.12.

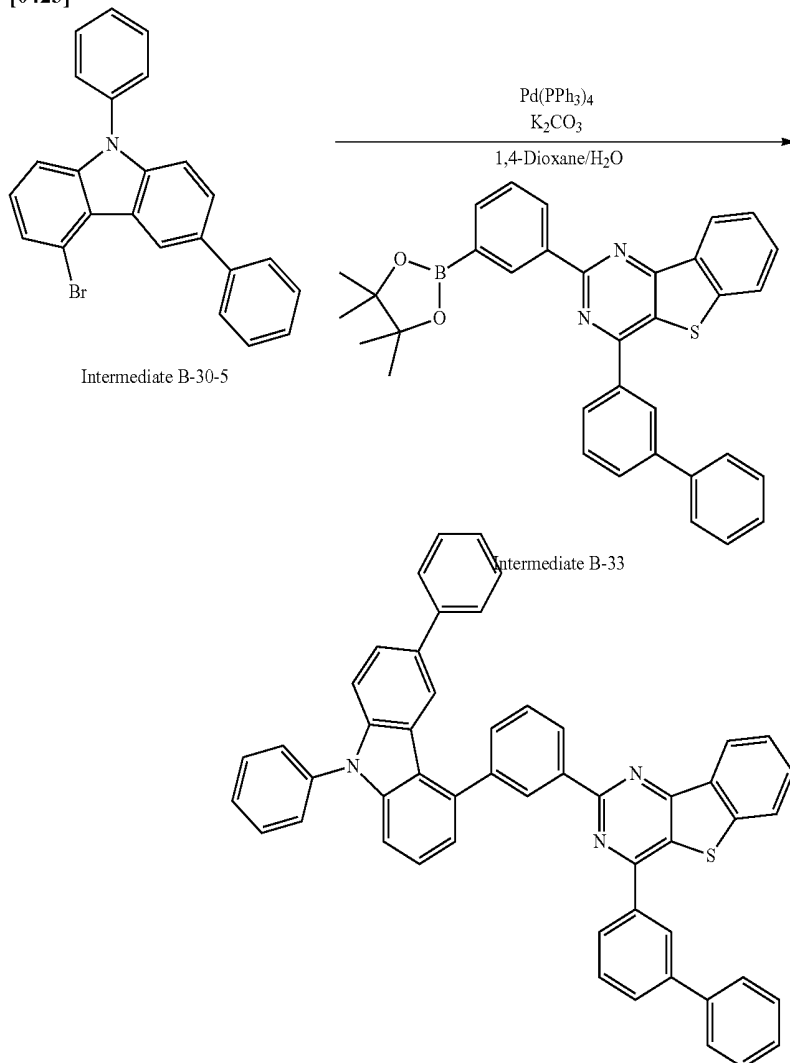
#### Synthesis of Compound a-12

**[0421]** 11.0 g (21.1 mmol) of the intermediate B-32-3, 8.8 g (21.1 mmol) of the intermediate B-30-7, 7.3 g (52.7 mmol) of potassium carbonate, and 1.2 g (1.1 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 60 mL of 1,4-dioxane and 30 mL of water in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 200 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound a-12 (10.5 g, Yield: 68%).

**[0422]** calcd. C<sub>52</sub>H<sub>33</sub>N<sub>3</sub>S: C, 85.33; H, 4.54; N, 5.74; S, 4.38. found: C, 85.30; H, 4.52; N, 5.73; S, 4.33.

Synthesis Example ad-4  
Synthesis of Compound a-13

[0423]

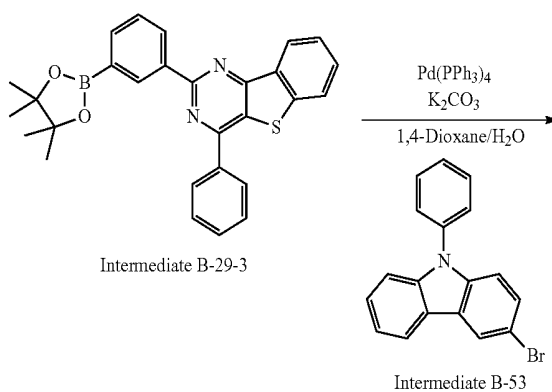


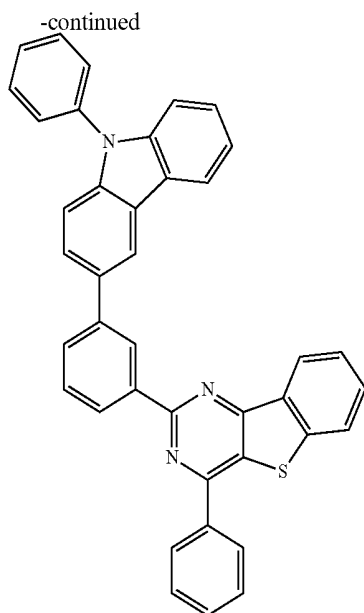
[0424] 5.0 g (12.6 mmol) of the intermediate B-30-5, 6.8 g (12.6 mmol) of the intermediate B-33, 4.3 g (31.4 mmol) of potassium carbonate, and 0.7 g (0.6 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 40 mL of 1,4-dioxane and 20 mL of water in a 100 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 120 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound a-13 (5.9 g, Yield: 64%).

[0425] calcd. C<sub>52</sub>H<sub>33</sub>N<sub>3</sub>S: C, 85.33; H, 4.54; N, 5.74; S, 4.38. found: C, 85.28; H, 4.53; N, 5.71; S, 4.30.

Synthesis Example ad-5  
Synthesis of Compound a-31

[0426]



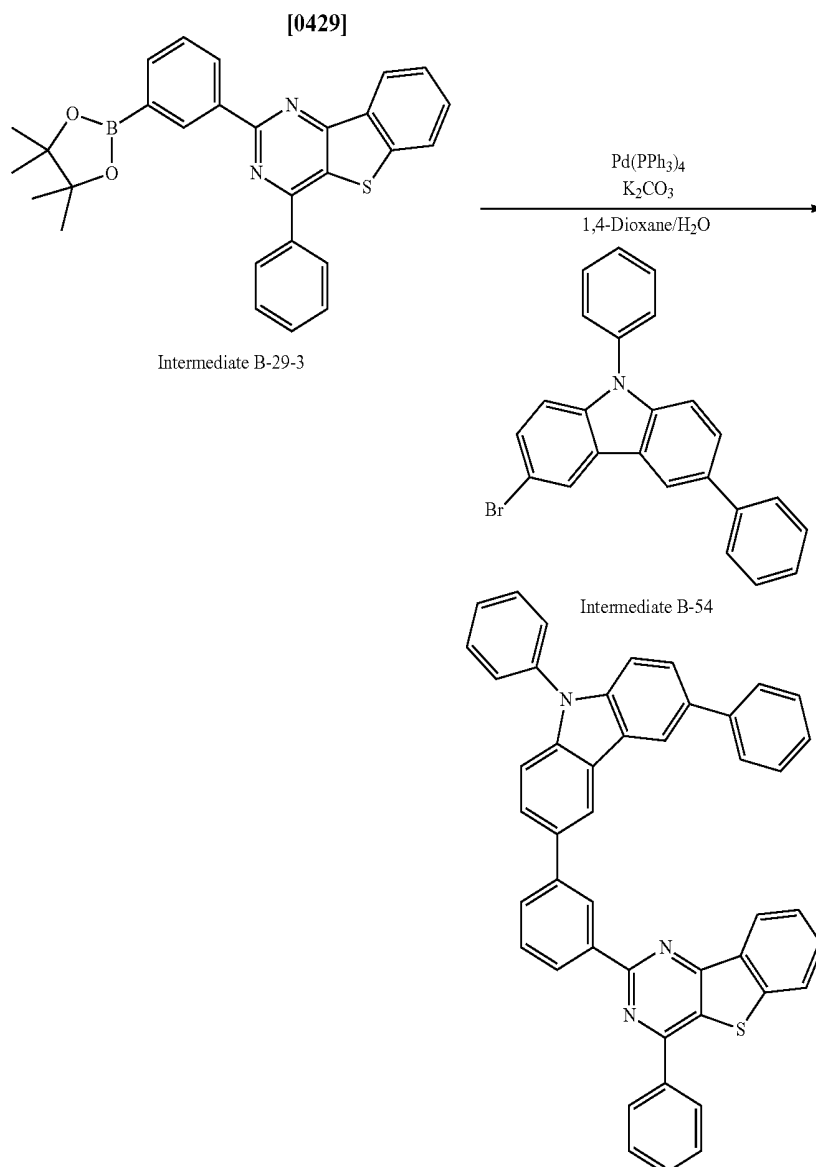


**[0427]** 5.0 g (10.8 mmol) of the intermediate B-29-3 (=intermediate A-5-2), 3.5 g (10.8 mmol) of the intermediate B-53, 3.7 g (53.8 mmol) of potassium carbonate, and 0.6 g (0.5 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 40 mL of 1,4-dioxane and 20 mL of water in a 100 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 120 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound a-31 (4.2 g, Yield: 67%).

**[0428]** calcd. C<sub>40</sub>H<sub>25</sub>N<sub>3</sub>S: C, 82.87; H, 4.35; N, 7.25; S, 5.53. found: C, 82.84; H, 4.34; N, 7.25; S, 5.50.

Synthesis Example ad-6

Synthesis of Compound a-32



## Synthesis of Compound a-32

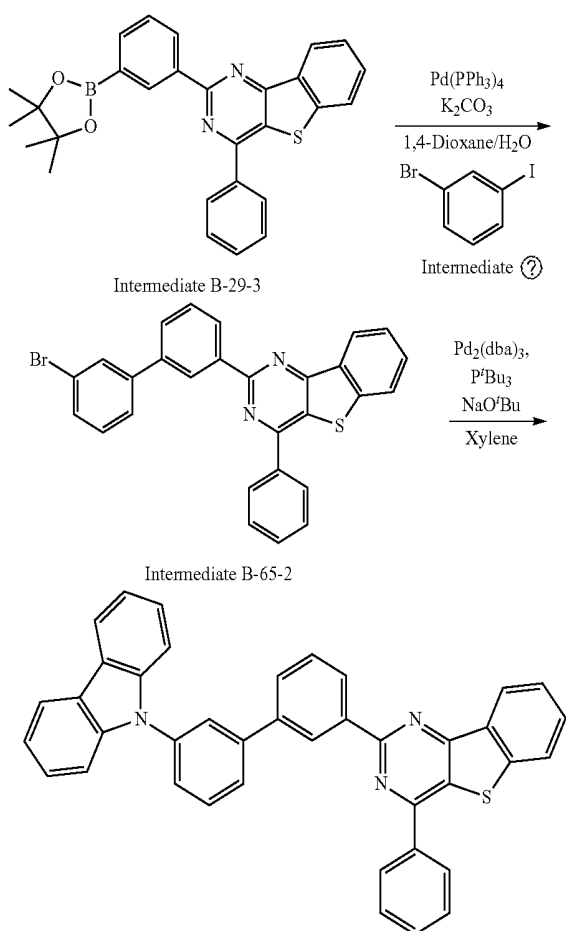
[0430] The compound a-32 (9.7 g, Yield: 69%) was synthesized in the same manner as in the synthesis of the compound a-31 in Synthesis Example ad-5, except that the intermediate B-54, instead of the intermediate B-53, was used.

[0431] calcd. C<sub>46</sub>H<sub>29</sub>N<sub>3</sub>S C, 84.25; H, 4.46; N, 6.41; S, 4.89. found: C, 84.23; H, 4.41; N, 6.40; S, 4.88.

## Synthesis Example ad-7

## Synthesis of Compound a-41

[0432]



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## Synthesis of Intermediate B-65-2

[0433] 10.0 g (21.5 mmol) of the intermediate B-29-3, 6.1 g (21.5 mmol) of the intermediate B-65-1, 7.4 g (53.8 mmol) of potassium carbonate, and 1.2 g (1.1 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 60 mL of 1,4-dioxane and 30 mL of water in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 200 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound B-65-2 (7.0 g, Yield: 66%).

[0434] calcd. C<sub>28</sub>H<sub>17</sub>BrN<sub>2</sub>S: C, 68.16; H, 3.47; Br, 16.19; N, 5.68; S, 6.50. found: C, 68.14; H, 3.45; Br, 16.18; N, 5.66; S, 6.48.

## Synthesis of Compound a-41

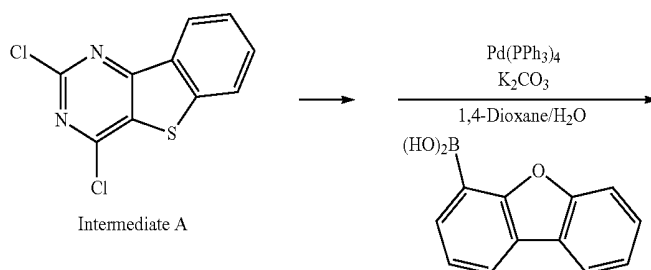
[0435] 7.0 g (14.2 mmol) of the intermediate B-65-2, 2.4 g (14.2 mmol) of carbazole, 2.7 g (28.4 mmol) of sodium t-butoxide, 0.8 g (1.4 mmol) of tris(dibenzylideneacetone) dipalladium(0), and 2.8 mL (50% in toluene) of tri t-butylphosphine were added to 100 mL of xylene in a 250 mL round-bottom flask, and heated under reflux in a nitrogen atmosphere for 15 hours. The obtained mixture was added to 300 mL of methanol, and a solid crystallized therein was filtered, dissolved in dichlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound B-65 (6.0 g, Yield: 73%). The elemental analysis of the produced compound a-41 was as follows.

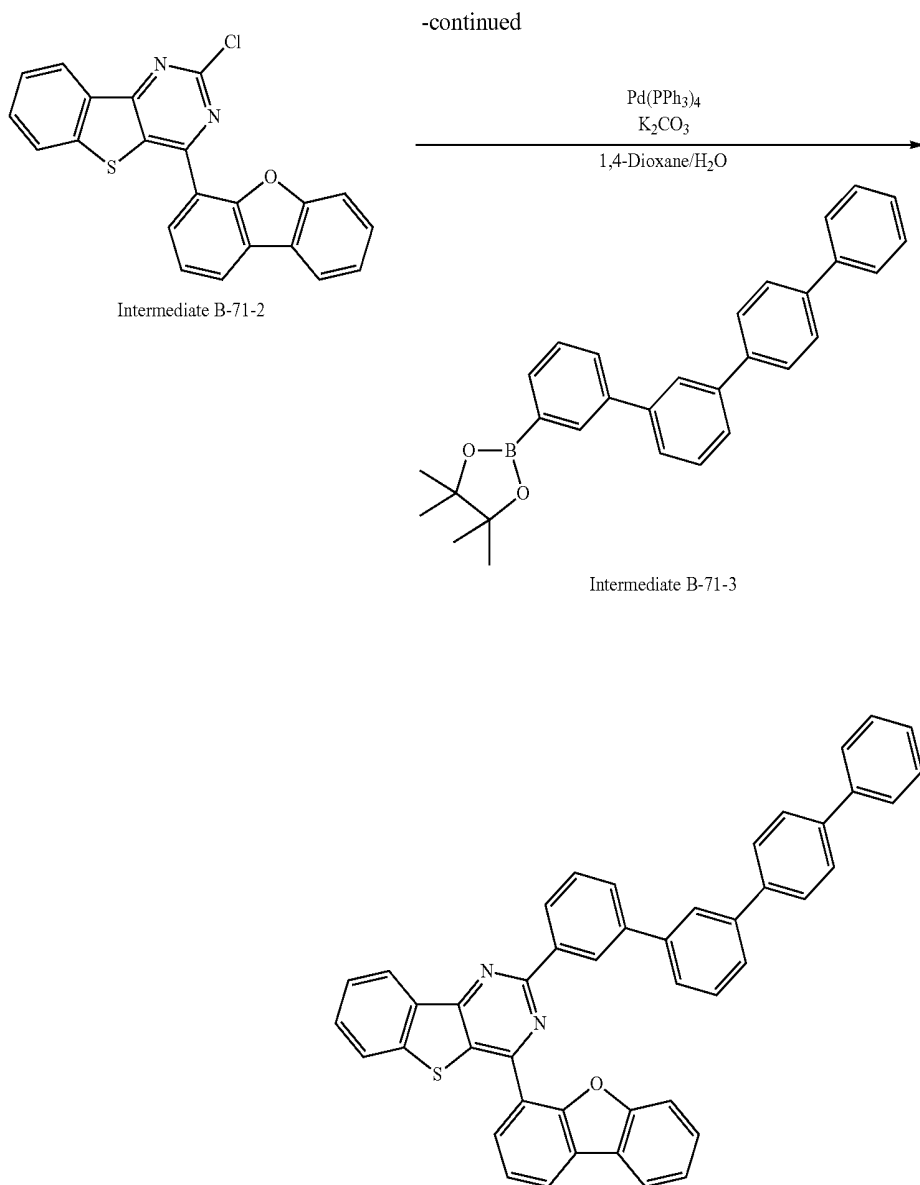
[0436] calcd. C<sub>40</sub>H<sub>25</sub>N<sub>3</sub>S: C, 82.87; H, 4.35; N, 7.25; S, 5.53. found: C, 82.81; H, 4.34; N, 7.23; S, 5.50.

## Synthesis Example ad-8

## Synthesis of Compound a-45

[0437]





#### Synthesis of Intermediate B-71-2

**[0438]** 10.0 g (39.2 mmol) of the intermediate A, 8.3 g (39.2 mmol) of dibenzo[b,d]furanyl-4-yl boronic acid (Manufacturer: TCI Inc), 13.5 g (98.0 mmol) of potassium carbonate, and 2.3 g (2.0 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 140 mL of 1,4-dioxane and 70 mL of water in a 500 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 450 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate B-71-2 (10.2 g, Yield: 67%).

**[0439]** calcd. C<sub>22</sub>H<sub>11</sub>CIN<sub>2</sub>OS: C, 68.30; H, 2.87; Cl, 9.16; N, 7.24; O, 4.14; S, 8.29. found: C, 68.28; H, 2.84; Cl, 9.11; N, 7.22; O, 4.13; S, 8.26.

#### Synthesis of Compound a-45

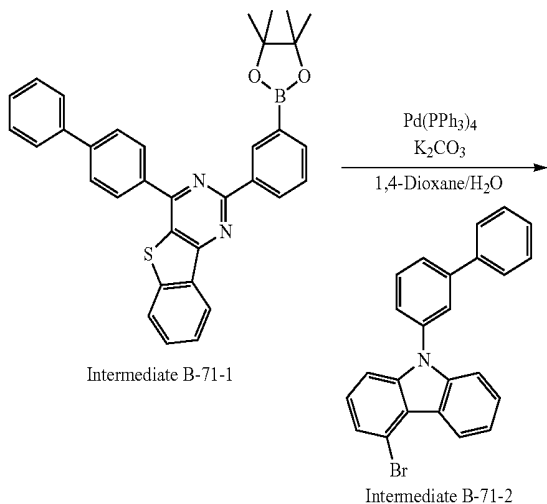
**[0440]** 5.0 g (12.9 mmol) of the intermediate B-71-2, 5.6 g (12.9 mmol) of the intermediate B-71-3, 4.5 g (32.3 mmol) of potassium carbonate, and 0.8 g (0.7 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 40 mL of 1,4-dioxane and 20 mL of water in a 100 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 120 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound a-45 (5.9 g, Yield: 69%).

**[0441]** calcd. C<sub>46</sub>H<sub>28</sub>N<sub>2</sub>O<sub>2</sub>S: C, 84.12; H, 4.30; N, 4.27; O, 2.44; S, 4.88. found: C, 84.11; H, 4.30; N, 4.24; O, 2.43; S, 4.85.

## Synthesis Example ad-9

## Synthesis of Compound a-47

[0442]



## Synthesis of Compound a-47

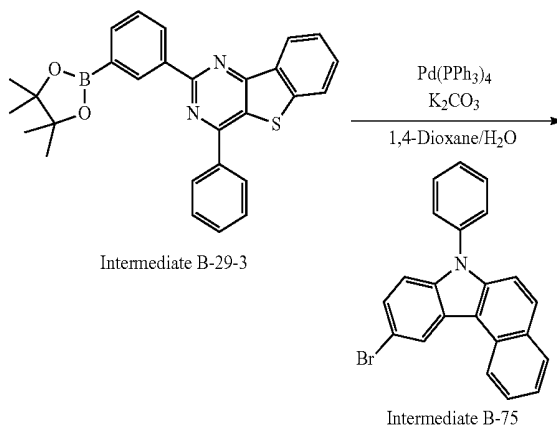
[0443] The compound a-47 (5.7 g, Yield: 66%) was synthesized in the same manner as in the synthesis of the compound a-31 in Synthesis Example ad-5, except that the intermediate B-71-1 and the intermediate B-71-2, instead of the intermediate B-29-3 and the intermediate B-53, were used.

[0444] calcd. C<sub>52</sub>H<sub>33</sub>N<sub>3</sub>S C, 85.33; H, 4.54; N, 5.74; S, 4.38. found: C, 85.32; H, 4.53; N, 5.70; S, 4.34.

## Synthesis Example ad-10

## Synthesis of Compound a-49

[0445]



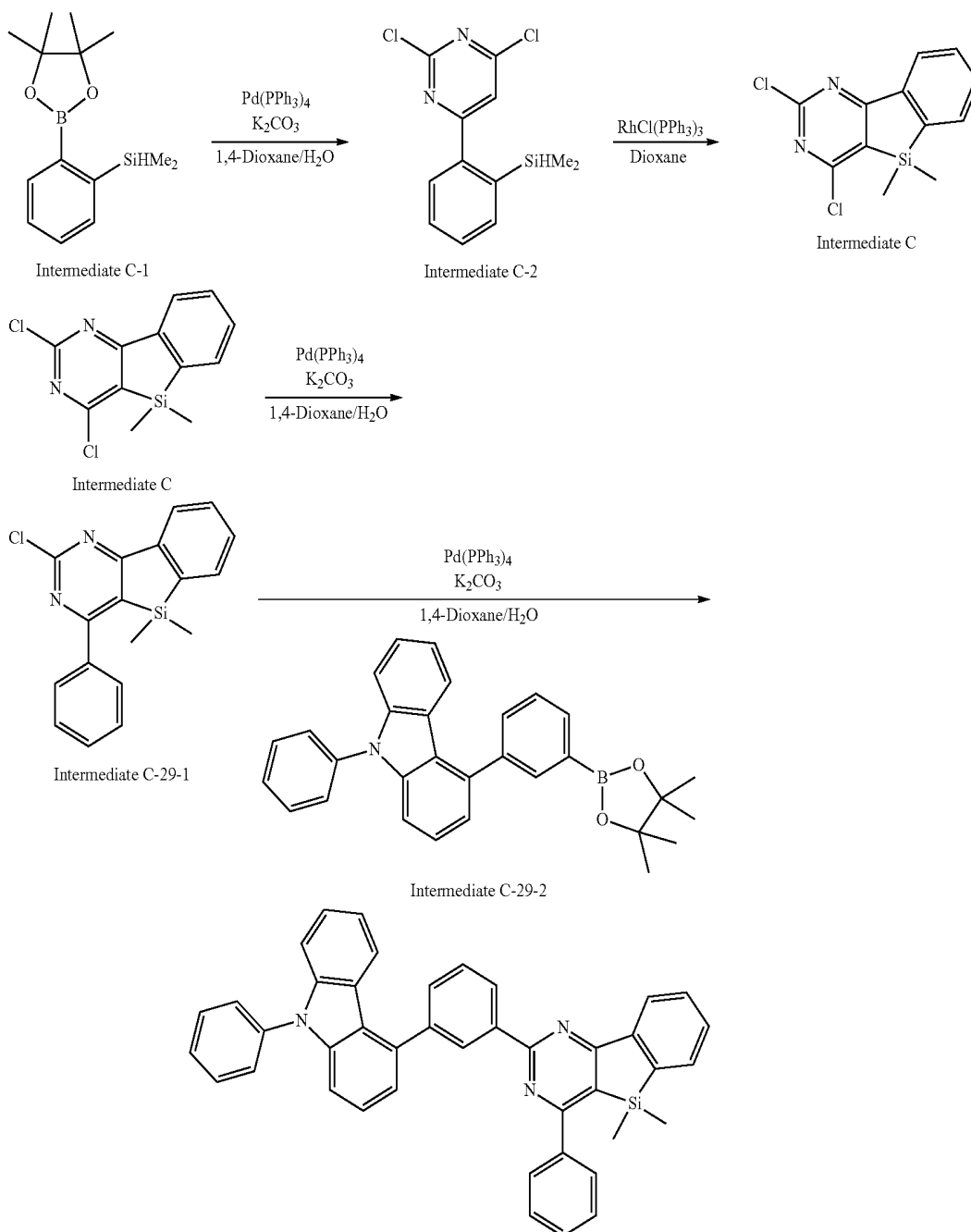
## Synthesis of Compound a-49

[0446] The compound a-49 (6.8 g, Yield: 70%) was synthesized in the same manner as in the synthesis of the compound a-31 in Synthesis Example ad-5, except that the intermediate B-75, instead of the intermediate B-53, were used.

[0447] calcd. C<sub>44</sub>H<sub>27</sub>N<sub>3</sub>S C, 83.91; H, 4.32; N, 6.67; S, 5.09. found: C, 83.90; H, 4.31; N, 6.65; S, 5.07.

Synthesis Example ad-11  
Synthesis of Compound c-9

[0448]



[0449] First Step: Synthesis of Intermediate C-2

[0450] 45.0 g (171.7 mmol) of the intermediate C-1, 30.0 g (163.5 mmol) of 2,4,6-trichloropyrimidine, 56.5 g (408.9 mmol) of potassium carbonate, and 9.5 g (8.2 mmol) of tetrakis (triphenylphosphine) palladium were added to 540 mL of 1,4-dioxane and 270 mL of water in a 2000 mL flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 1000 mL of methanol, and a solid crystallized therein was filtered,

dissolved in toluene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate C-2 (37.0 g, Yield: 76%).

[0451] Calcd.  $\text{C}_{12}\text{H}_{12}\text{Cl}_2\text{N}_2\text{Si}$ : C, 50.89; H, 4.27; Cl, 25.03; N, 9.89; Si, 9.92. found: C, 50.32; H, 4.22; Cl, 24.98; N, 9.73; Si, 9.84.

[0452] Second Step: Synthesis of Intermediate C

[0453] 37.0 g (130.6 mmol) of the intermediate C-2, and 2.4 g (2.6 mmol) of chlorotris(triphenylphosphine)rhodium

(I) were added to a 1000 mL flask, 600 mL of 1,4-dioxane were dropwise added, and the mixture was heated under reflux in a nitrogen atmosphere for 8 hours. After the reaction was terminated, an organic layer was removed, and Intermediate C (20.2 g, Yield: 55%) was obtained using column chromatography.

[0454] calcd. C<sub>12</sub>H<sub>10</sub>Cl<sub>2</sub>N<sub>2</sub>Si: C, 51.25; H, 3.58; Cl, 25.21; N, 9.96; Si, 9.99. found: C, 51.15; H, 3.53; Cl, 25.16; N, 9.90; Si, 9.93.

#### Synthesis of Intermediate C-29-1

[0455] 10.0 g (35.6 mmol) of the intermediate C, 4.3 g (35.6 mmol) of phenylboronic acid, 12.3 g (88.9 mmol) of potassium carbonate, and 2.1 g (1.8 mmol) of tetrakis(triphenylphosphine)palladium(0) were added to 120 mL of 1,4-dioxane and 60 mL of water in a 500 mL flask, and heated under reflux in a nitrogen atmosphere at 55° C. for 16 hours. The obtained mixture was added to 400 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate C-29-1 (7.7 g, Yield: 67%).

[0456] calcd. C<sub>18</sub>H<sub>15</sub>ClN<sub>2</sub>Si: C, 66.96; H, 4.68; Cl, 10.98; N, 8.68; Si, 8.70. found: C, 66.92; H, 4.63; Cl, 10.96; N, 8.67; Si, 8.65.

#### Synthesis of Compound c-9

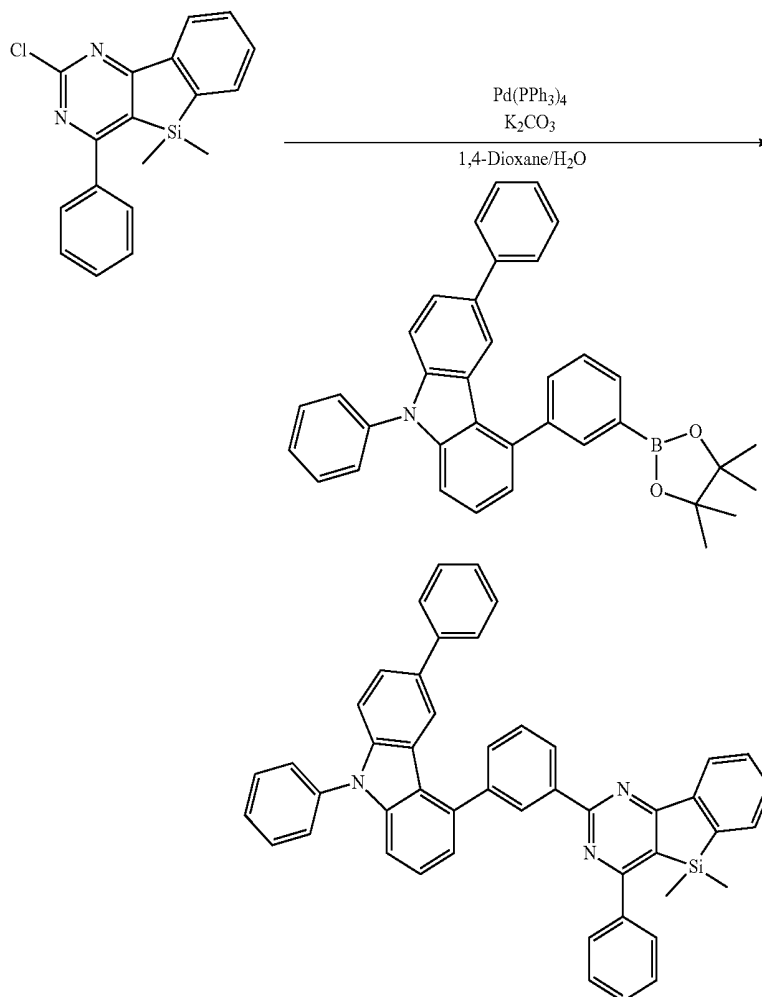
[0457] 5.0 g (15.5 mmol) of the intermediate C-29-1, 6.9 g (15.5 mmol) of the intermediate C-29-2, 5.4 g (38.7 mmol) of potassium carbonate, and 0.9 g (0.8 mmol) of tetrakis(triphenylphosphine)palladium(0) were 50 mL of 1,4-dioxane and 25 mL of water in a 100 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 8 hours. The obtained mixture was added to 150 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound c-9 (6.7 g, Yield: 71%). The elemental analysis of the produced compound c-9 was as follows.

[0458] calcd. C<sub>42</sub>H<sub>31</sub>N<sub>3</sub>Si: C, 83.27; H, 5.16; N, 6.94; Si, 4.64. found: C, 83.23; H, 5.11; N, 6.92; Si, 4.63.

#### Synthesis Example ad-12

#### Synthesis of Compound c-10

[0459]





## Synthesis of Intermediate D-2

**[0464]** 50.0 g (222.2 mmol) of the intermediate D-1, 50.1 g (233.3 mmol) of 4,4,5,5-tetramethyl-2-(2-nitrophenyl)-1,3,2-dioxaborane, 76.8 g (555.4 mmol) of potassium carbonate, and 12.8 g (11.1 mmol) of tetrakis (triphenylphosphine) palladium were added to 700 mL of 1,4-dioxane and 350 mL of water in a 2000 mL flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 2000 mL of methanol, and a solid crystallized therein was filtered, dissolved in toluene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate D-2 (54.5 g, Yield: 75%).

**[0465]** Calcd. C<sub>16</sub>H<sub>10</sub>ClN<sub>3</sub>O<sub>2</sub>: C, 61.65; H, 3.23; Cl, 11.37; N, 13.48; O, 10.27. found: C, 61.23; H, 3.15; Cl, 11.37; N, 13.21; O, 10.20.

## Synthesis of Intermediate D-3

**[0466]** 20.0 g (64.2 mmol) of the intermediate D-2, 28.6 g (64.2 mmol) of the intermediate C-29-2, 22.2 g (160.4 mmol) of potassium carbonate, and 3.7 g (3.2 mmol) of tetrakis (triphenylphosphine) palladium were added to 200 mL of 1,4-dioxane and 100 mL of water in a 500 mL flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 600 mL of methanol, and a solid crystallized therein was filtered, dissolved in toluene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate D-3 (20.3 g, Yield: 71%).

**[0467]** Calcd. C<sub>40</sub>H<sub>26</sub>N<sub>4</sub>O<sub>2</sub>: C, 80.79; H, 4.41; N, 9.42; O, 5.38. found: C, 80.74; H, 4.40; N, 9.38; O, 5.37.

## Synthesis of Intermediate D-4

**[0468]** The intermediate D-3 (20.0 g, 33.6 mmol) and triphenylphosphine (26.5 g, 100.9 mmol) were added to 80 mL of 1,2-dichlorobenzene (DCB) in a 250 mL flask, then exchanged with nitrogen, and then stirred at 150° C. for 12 hours. 1,2-dichlorobenzene was removed by distillation, then the resultant was cooled down to room temperature and was dissolved in a small amount of toluene, and the resultant was purified using column chromatography (hexane) to obtain the intermediate D-4 (9.5 g, Yield: 50%).

**[0469]** Calcd. C<sub>40</sub>H<sub>26</sub>N<sub>4</sub>: C, 85.38; H, 4.66; N, 9.96. found: C, 85.34; H, 4.63; N, 9.97.

## Synthesis of Compound d-23

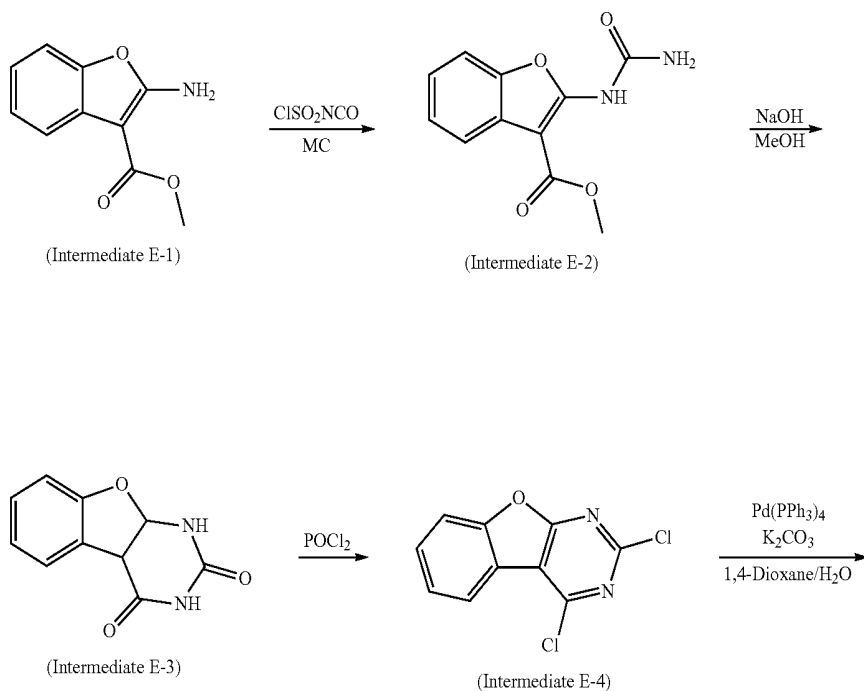
**[0470]** 9.0 g (12.9 mmol) of the intermediate D-4, 2.0 g (12.9 mmol) of bromobenzene, 2.5 g (25.8 mmol) of sodium t-butoxide, 0.7 g (1.3 mmol) of Pd(dba)<sub>2</sub>, and 2.6 mL (50% in toluene) of tri t-butylphosphine were added to 90 mL of xylene in a 500 mL round-bottom flask, and heated under reflux in a nitrogen atmosphere for 15 hours. The obtained mixture was added to 200 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound d-23 (6.0 g, Yield: 73%). The elemental analysis of the produced compound d-23 was as follows.

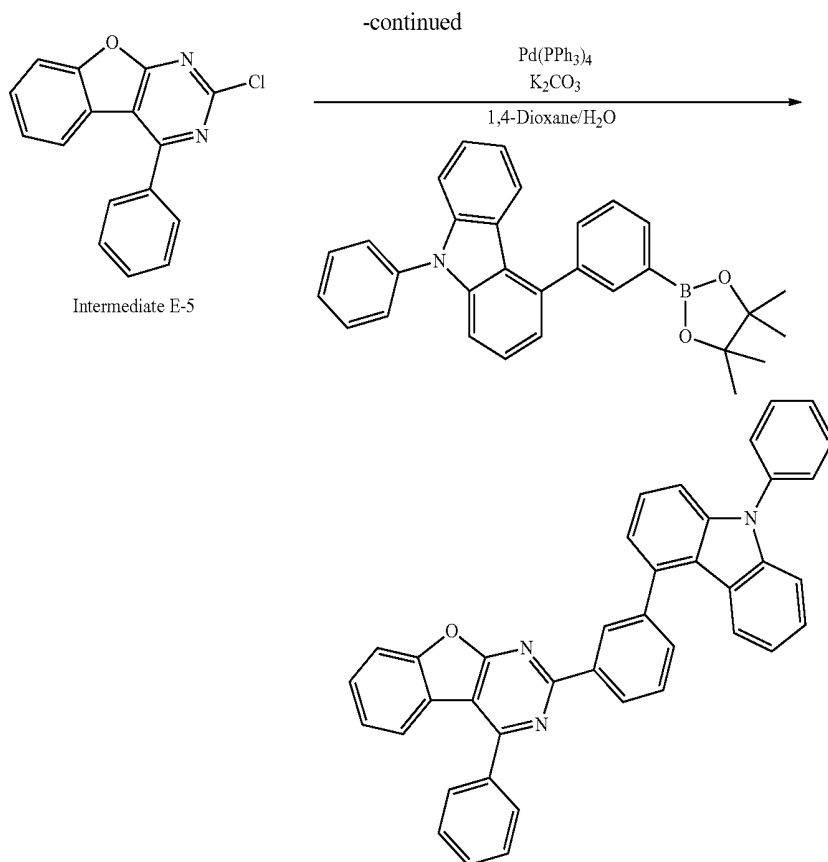
**[0471]** calcd. C<sub>46</sub>H<sub>30</sub>N<sub>4</sub>: C, 86.49; H, 4.73; N, 8.77. found: C, 86.47; H, 4.72; N, 8.76.

## Synthesis Example ad-14

## Synthesis of Compound e-9

**[0472]**





**[0473]** (Intermediate C-29-2)

**[0474]** First Step: Synthesis of Intermediate E-2

**[0475]** Chlorosulfonyl isocyanate (23.7 ml, 274.6 mmol) was dropwise added to an intermediate E-1 (35.0 g, 183.1 mmol) solution in dichloromethane (1000 mL) at  $-78^{\circ}\text{C}$ . in a 2000 mL round-bottom flask. The reactants were heated to room temperature slowly, and stirred for 2 hours. The reactants were concentrated, 6N (300 ml) HCl was added to the residues, and the mixture was stirred at  $100^{\circ}\text{C}$ . for 1 hour. The reaction mixture was cooled down to room temperature, and was neutralized with a saturated NaHCO<sub>3</sub> aqueous solution. The produced solid was filtered to obtain the intermediate E-2 (43.2 g, 88%).

**[0476]** calcd. C<sub>10</sub>H<sub>9</sub>NO<sub>3</sub>: C, 62.82; H, 4.74; N, 7.33; O, 25.11. found: C, 62.82; H, 4.74; N, 7.33; O, 25.11.

**[0477]** Second Step: Synthesis of Intermediate E-3

**[0478]** The intermediate E-2 (40.0 g, 0.19 mol) was suspended in 1000 mL of methanol in a 1000 mL round-bottom flask, and 2 M NaOH (300 mL) was dropwise added. The reaction mixture was stirred under reflux for 3 hours. The reaction mixture was cooled down to room temperature, followed by acidification with Conc. HCl to pH 3. After the reaction mixture was concentrated, methanol was slowly dropwise added to precipitate a solid. The resulting solid was filtered and dried to obtain the intermediate E-3 (39.0 g, 85%).

**[0479]** calcd. C<sub>11</sub>H<sub>10</sub>N<sub>2</sub>O<sub>4</sub>: C, 56.41; H, 4.30; N, 11.96; O, 27.33. found: C, 56.40; H, 4.20; N, 11.92; O, 27.31.

**[0480]** Third Step: Synthesis of Intermediate E-4

**[0481]** A mixture of the intermediate E-3 (39.0 g, 191.0 mmol) and 200 mL of phosphorus oxychloride stirred under

reflux for 8 hours in a 500 mL round-bottom flask. The reaction mixture was cooled down to room temperature, and poured into ice/water with stirring to obtain a precipitate. The resulting reaction precipitate was filtered to obtain the intermediate E-4. (40.7 g, 89%, white solid)

**[0482]** calcd. C<sub>10</sub>H<sub>4</sub>Cl<sub>2</sub>N<sub>2</sub>O: C, 50.24; H, 1.69; Cl, 29.66; N, 11.72; O, 6.69. found: C, 50.21; H, 1.65; Cl, 29.63; N, 11.64; O, 6.62.

**[0483]** Four Step: Synthesis of Intermediate E-5

**[0484]** 10.0 g (41.8 mmol) of the intermediate E-4, 5.4 g (43.9 mmol) of phenylboronic acid, 14.5 g (104.6 mmol) of potassium carbonate, and 2.4 g (2.1 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 140 mL of 1,4-dioxane and 70 mL of water in a 500 mL flask, and heated under reflux in a nitrogen atmosphere at  $60^{\circ}\text{C}$ . for 10 hours. The obtained mixture was added to 450 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate E-5 (8.0 g, Yield: 65%).

**[0485]** calcd. C<sub>16</sub>H<sub>9</sub>CIN<sub>2</sub>O: C, 68.46; H, 3.23; Cl, 12.63; N, 9.98; O, 5.70. found: C, 68.40; H, 3.22; Cl, 12.61; N, 9.94; O, 5.70.

#### Synthesis of Compound e-9

**[0486]** 5.0 g (17.8 mmol) of the intermediate E-5, 7.9 (18.7 mmol) of the intermediate C-29-2, 6.2 g (44.5 mmol) of potassium carbonate, and 1.0 g (0.9 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 60 mL of 1,4-dioxane and 30 mL of water in a 250 mL round-bottom

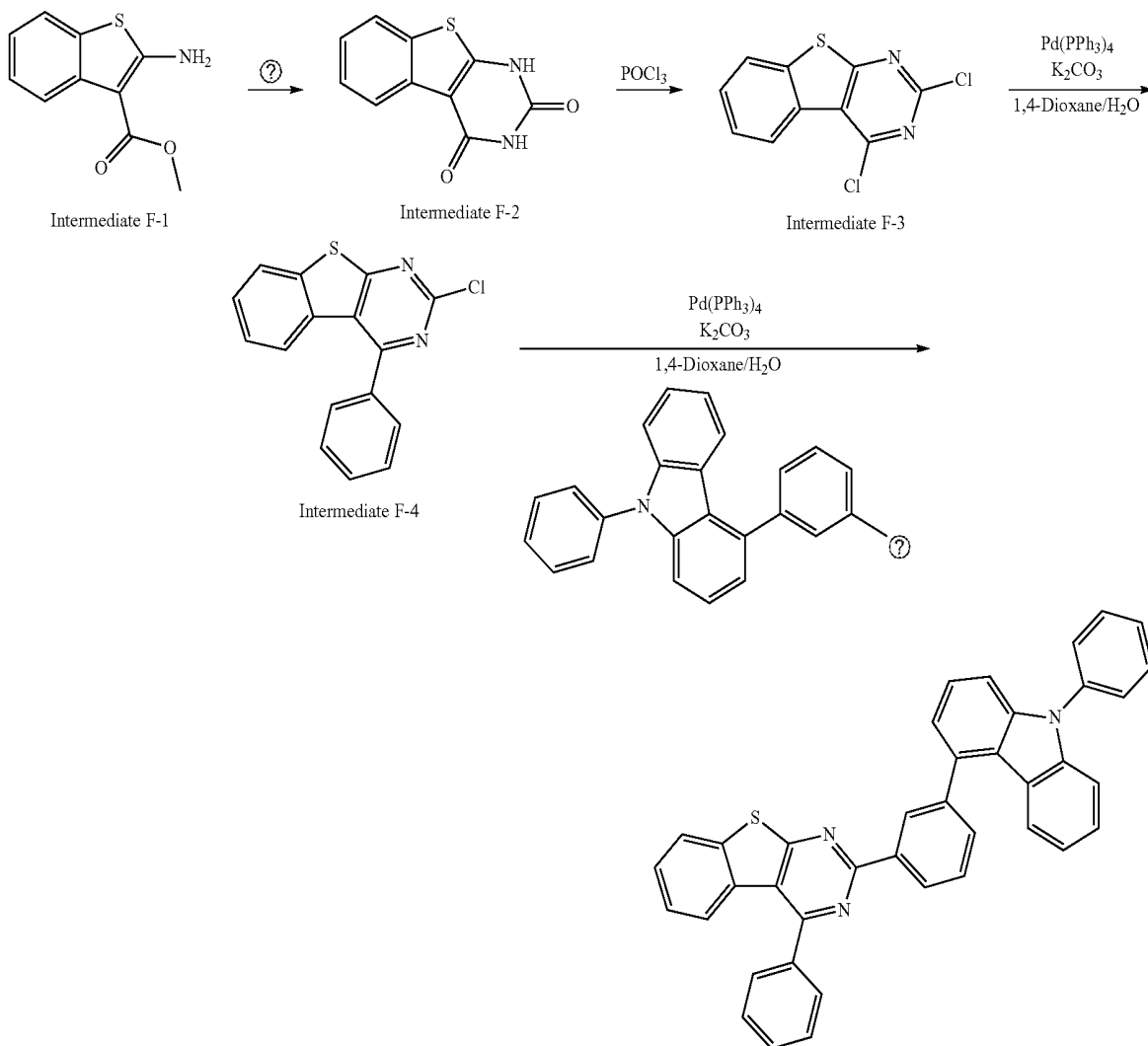
flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 200 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound e-9 (7.2 g, Yield: 69%). The elemental analysis of the produced compound e-9 was as follows.

[0487] calcd. C<sub>40</sub>H<sub>25</sub>N<sub>3</sub>O: C, 85.24; H, 4.47; N, 7.46; O, 2.84. found: C, 85.20; H, 4.47; N, 7.45; O, 2.83.

#### Synthesis Example ad-15

#### Synthesis of Compound F-9

[0488]



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[0489] First Step: Synthesis of Intermediate F-2

[0490] A mixture of the intermediate F-1 (35.0 g, 0.17 mol) and urea (50.7 g, 0.84 mol) was stirred at 200° C. for 2 hours in a 250 mL round-bottom flask. The high-temperature reaction mixture was cooled down to room temperature, a sodium hydroxide solution was added thereto, followed by

filtration to remove impurities and acidification (HCl, 2N). The resulting precipitate was dried to obtain the intermediate F-2 (18.9 g, 51%).

[0491] calcd. C<sub>10</sub>H<sub>6</sub>N<sub>2</sub>O<sub>2</sub>S: C, 55.04; H, 2.77; N, 12.84; O, 14.66; S, 14.69. found: C, 55.01; H, 2.77; N, 12.83; O, 14.65; S, 14.63.

[0492] Second Step: Synthesis of Intermediate F-3

[0493] A mixture of the intermediate F-2 (18.9 g, 99.2 mmol) and phosphorus oxychloride (100 mL) were under reflux for 6 hours in a 250 mL round-bottom flask. The reaction mixture was cooled down to room temperature, and poured into ice/water with stirring to obtain a precipitate. The resulting reaction precipitate was filtered to obtain the intermediate F-3. (17.5 g, 85%, white solid)

[0494] calcd. C<sub>10</sub>H<sub>4</sub>Cl<sub>2</sub>N<sub>2</sub>S: C, 47.08; H, 1.58; Cl, 27.79; N, 10.98; S, 12.57. found: C, 47.04; H, 1.53; Cl, 27.74; N, 10.96; S, 12.44.

[0495] Third Step: Synthesis of Intermediate F-4

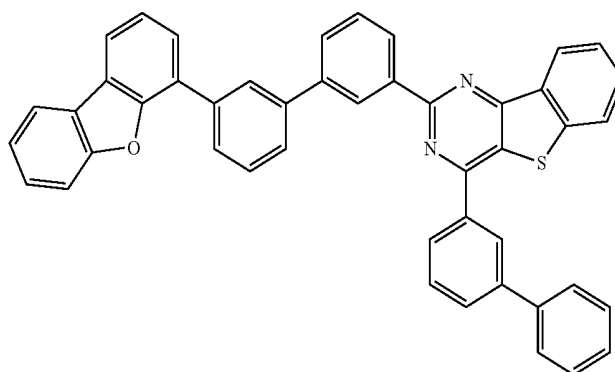
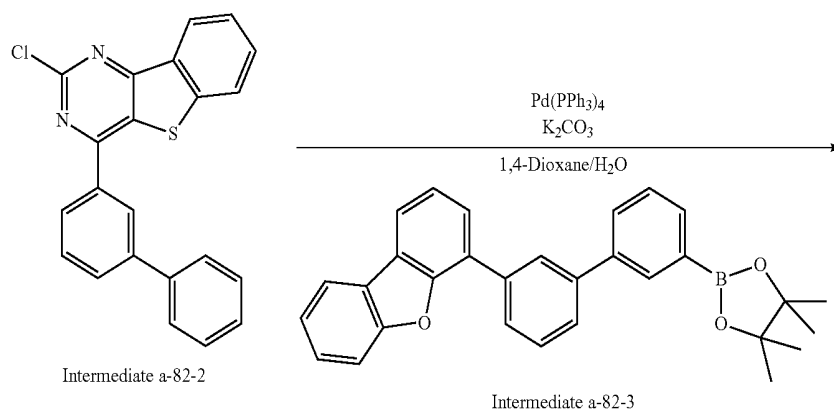
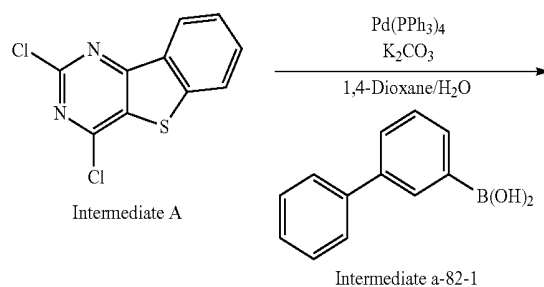
[0496] 10.0 g (39.2 mmol) of the intermediate F-3, 5.3 g (43.1 mmol) of phenylboronic acid, 13.5 g (98.0 mmol) of

potassium carbonate, and 2.3 g (2.0 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 140 mL of 1,4-dioxane and 70 mL of water in a 500 mL flask, and heated under reflux in a nitrogen atmosphere at 60° C. for 10 hours. The obtained mixture was added to 450 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate F-4 (8.0 g, Yield: 69%).

[0497] calcd. C<sub>16</sub>H<sub>9</sub>ClN<sub>2</sub>S: C, 64.75; H, 3.06; Cl, 11.95; N, 9.44; S, 10.80. found: C, 64.72; H, 3.06; Cl, 11.94; N, 9.42; S, 10.77.

#### Synthesis of Compound f-9

[0498] 5.0 g (16.9 mmol) of the intermediate F-4, 7.5 g (16.9 mmol) of the intermediate C-29-2, 5.8 g (42.1 mmol)



of potassium carbonate, and 1.0 g (0.8 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 60 mL of 1,4-dioxane and 30 mL of water in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 200 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound f-9 (6.4 g, Yield: 65%). The elemental analysis of the produced compound f-9 was as follows.

[0499] calcd. C<sub>40</sub>H<sub>25</sub>N<sub>3</sub>S C, 82.87; H, 4.35; N, 7.25; S, 5.53. found: C, 82.81; H, 4.34; N, 7.22; S, 5.52.

#### Synthesis Example ad-16

#### Synthesis of Compound a-73

[0500]

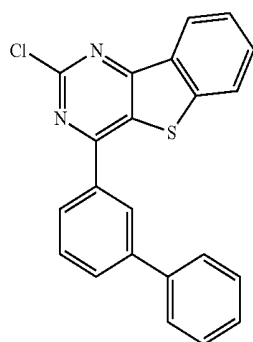
## Synthesis of Intermediate a-82-2

**[0501]** 10.0 g (39.2 mmol) of the intermediate A, 7.8 g (39.2 mmol) of the intermediate a-82-1 (Manufacturer: Beijing pure chem), 13.5 g (98.0 mmol) of potassium carbonate, and 2.3 g (2.0 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 140 mL of 1,4-dioxane and 70 mL of water in a 500 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere at 55° C. for 12 hours. The obtained mixture was added to 500 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate a-82-2 (10.1 g, Yield: 69%).

**[0502]** calcd. C<sub>22</sub>H<sub>13</sub>ClN<sub>2</sub>S: C, 70.87; H, 3.51; Cl, 9.51; N, 7.51; S, 8.60. found: C, 70.84; H, 3.49; Cl, 9.47; N, 7.50; S, 8.54.

## Synthesis of Compound a-73

**[0503]** 10.0 g (26.8 mmol) of the intermediate a-82-2, 11.9 g (26.8 mmol) of the intermediate a-82-3, 9.3 g (67.1 mmol)



Intermediate a-82-2

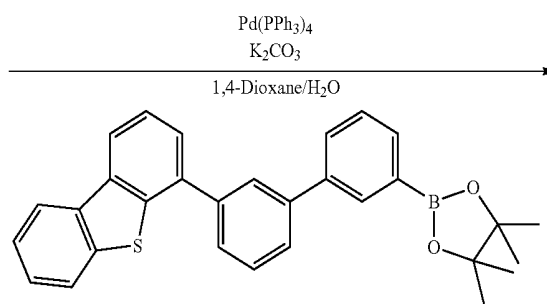
of potassium carbonate, and 1.6 g (1.3 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 80 mL of 1,4-dioxane and 40 mL of water in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 250 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound a-73 (11.5 g, Yield: 65%).

**[0504]** calcd. C<sub>46</sub>H<sub>28</sub>N<sub>2</sub>O<sub>2</sub>S: C, 84.12; H, 4.30; N, 4.27; O, 2.44; S, 4.88. found: C, 84.11; H, 4.27; N, 4.25; O, 2.43; S, 4.86.

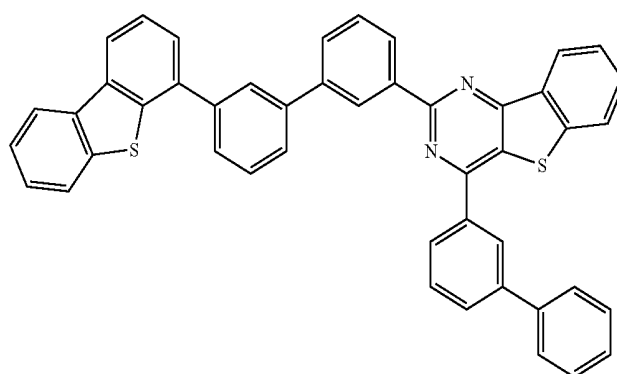
## Synthesis Example ad-17

## Synthesis of Compound a-74

**[0505]**



Intermediate a-83-1



## Synthesis of Compound a-74

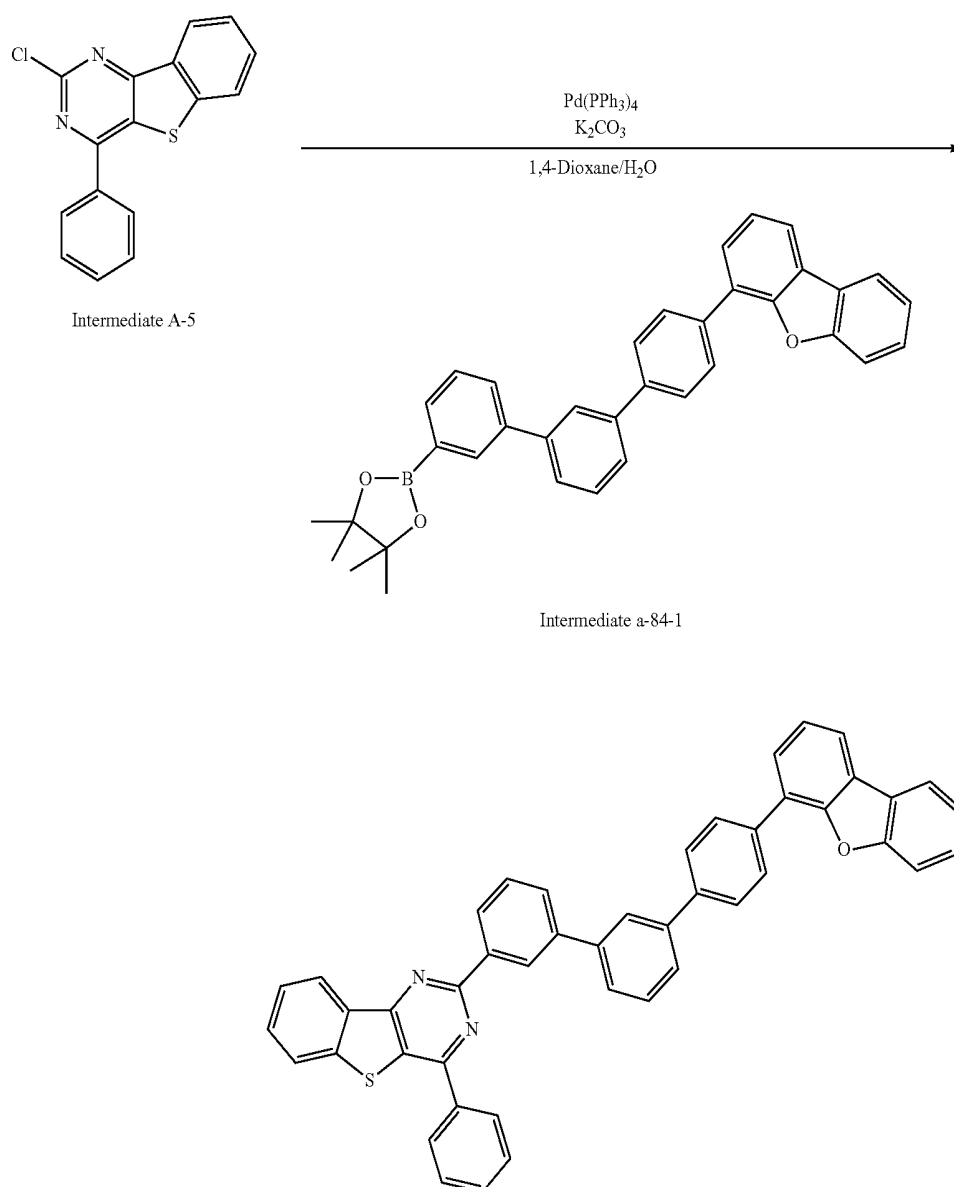
[0506] The compound a-74 (8.8 g, Yield: 68%) was synthesized in the same manner as in the synthesis of the compound a-73 in Synthesis Example ad-16, except that the intermediate a-83-1, instead of the intermediate a-82-3, was used.

[0507] calcd. C<sub>46</sub>H<sub>28</sub>N<sub>2</sub>S<sub>2</sub>: C, 82.11; H, 4.19; N, 4.16; S, 9.53. found: C, 82.10; H, 4.17; N, 4.12; S, 9.52.

## Synthesis Example ad-18

## Synthesis of Compound a-75

[0508]



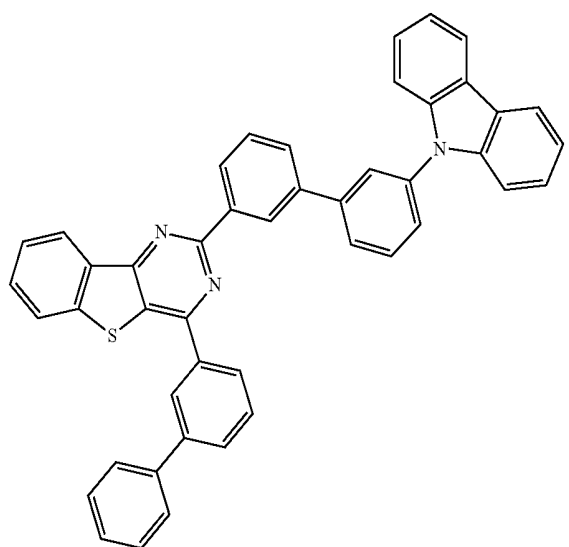
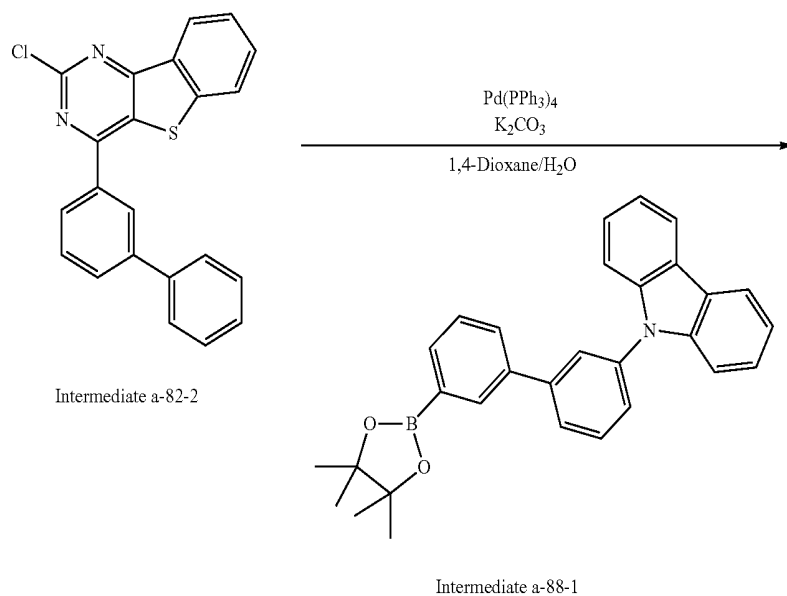
## Synthesis of Compound a-75

[0509] The compound a-75 (10.3 g, Yield: 71%) was synthesized in the same manner as in the synthesis of the compound a-73 in Synthesis Example ad-16, except that the

intermediate A-5 and the intermediate a-84-1, instead of the intermediate a-82-2 and the intermediate a-82-3, was used.  
 [0510] calcd. C<sub>46</sub>H<sub>28</sub>N<sub>2</sub>O<sub>2</sub>S: C, 84.12; H, 4.30; N, 4.27; O, 2.44; S, 4.88. found: C, 84.07; H, 4.30; N, 4.27; O, 2.40; S, 4.86.

Synthesis Example ad-19  
Synthesis of Compound a-79

[0511]



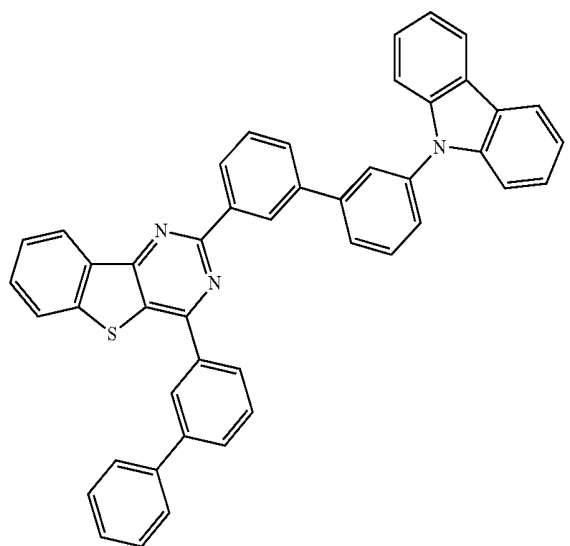
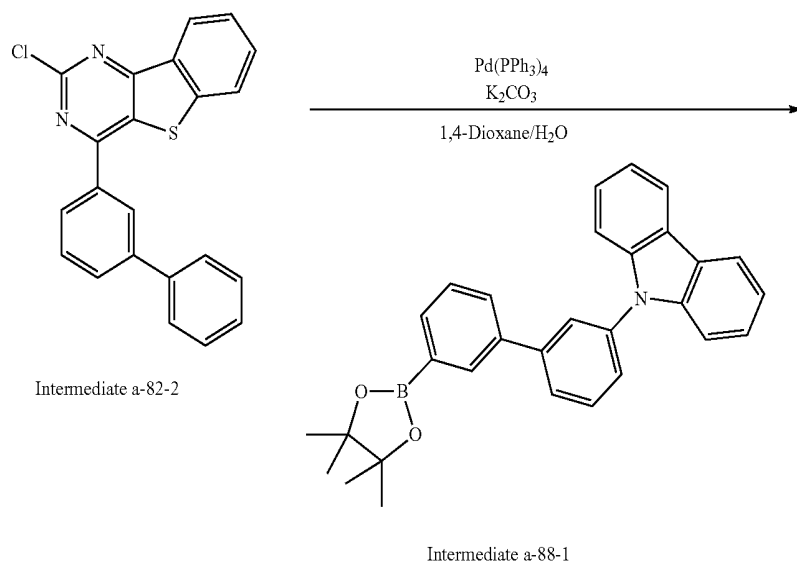
Synthesis of Compound a-79

[0512] The compound a-79 (13.1 g, Yield: 73%) was synthesized in the same manner as in the synthesis of the compound a-73 in Synthesis Example ad-16, except that the intermediate a-88-1, instead of the intermediate a-82-3, was used.

[0513] calcd. C<sub>46</sub>H<sub>29</sub>N<sub>3</sub>S: C, 84.25; H, 4.46; N, 6.41; S, 4.89. found: C, 84.23; H, 4.41; N, 6.40; S, 4.86.

Synthesis Example ad-20  
Synthesis of Compound a-82

[0514]



## Synthesis of Intermediate a-91-2

[0515] The intermediate a-91-2 (14.2 g, Yield: 70%) was synthesized in the same manner as in the synthesis of the intermediate a-82-2 in Synthesis Example ad-16, except that the intermediate a-91-1, instead of the intermediate a-82-1, was used.

[0516] calcd. C<sub>28</sub>H<sub>15</sub>ClN<sub>2</sub>O<sub>2</sub>S: C, 72.64; H, 3.27; Cl, 7.66; N, 6.05; O, 3.46; S, 6.93. found: C, 72.63; H, 3.23; Cl, 7.66; N, 6.04; O, 3.44; S, 6.91.

## Synthesis of Compound a-82

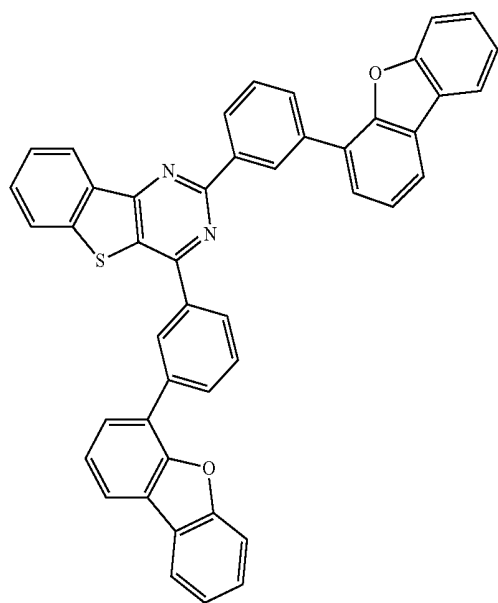
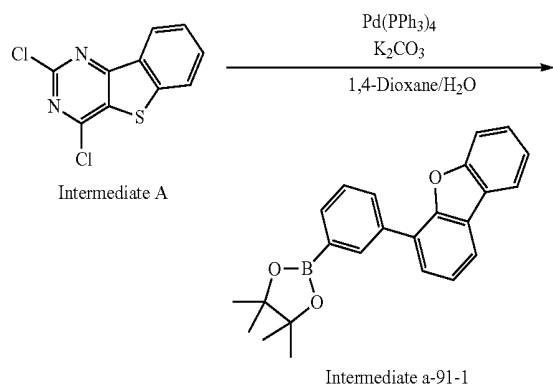
[0517] The compound a-82 (12.5 g, Yield: 73%) was synthesized in the same manner as in the synthesis of the compound a-73 in Synthesis Example ad-16, except that the intermediate a-91-2 and intermediate a-91-3, instead of the intermediate a-82-2 and the intermediate a-82-3, were used.

[0518] calcd. C<sub>46</sub>H<sub>27</sub>N<sub>3</sub>O<sub>3</sub>S: C, 82.49; H, 4.06; N, 6.27; O, 2.39; S, 4.79. found: C, 82.47; H, 4.04; N, 6.27; O, 2.36; S, 4.77.

## Synthesis Example ad-21

## Synthesis of Compound a-84

[0519]



## Synthesis of Compound a-84

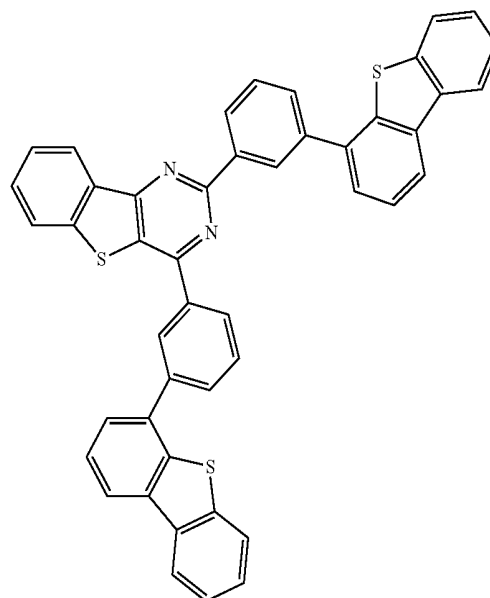
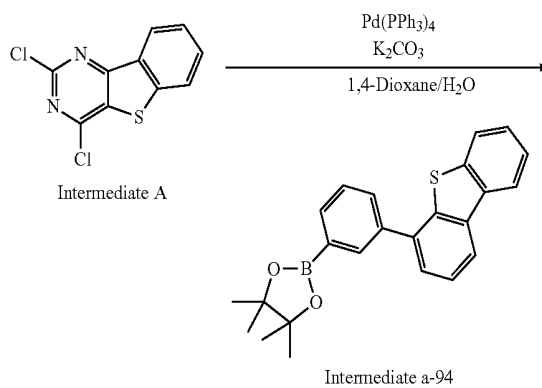
[0520] The compound a-84 (12.8 g, Yield: 70%) was synthesized in the same manner as in the synthesis of the compound a-73 in Synthesis Example ad-16, except that the intermediate A and the intermediate a-91-1, instead of the intermediate a-82-2 and the intermediate a-82-3, were used.

[0521] calcd. C<sub>46</sub>H<sub>26</sub>N<sub>2</sub>O<sub>2</sub>S: C, 82.37; H, 3.91; N, 4.18; O, 4.77; S, 4.78. found: C, 82.34; H, 3.90; N, 4.14; O, 4.75; S, 4.76.

## Synthesis Example ad-22

## Synthesis of Compound a-85

[0522]



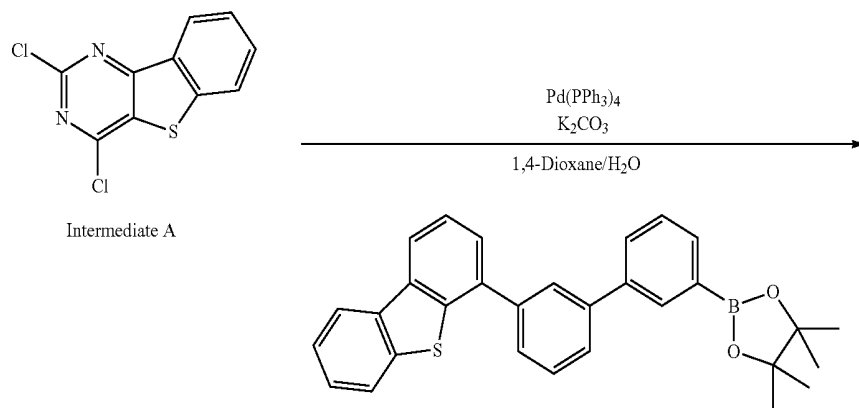
## Synthesis of Compound a-85

[0523] The compound a-85 (9.6 g, Yield: 69%) was synthesized in the same manner as in the synthesis of the compound a-73 in Synthesis Example ad-16, except that the intermediate A and the intermediate a-94, instead of the intermediate a-82-2 and the intermediate a-82-3, were used.

[0524] calcd. C<sub>46</sub>H<sub>26</sub>N<sub>2</sub>S<sub>3</sub>: C, 78.60; H, 3.73; N, 3.99; S, 13.69. found: C, 78.57; H, 3.71; N, 3.98; S, 13.67.

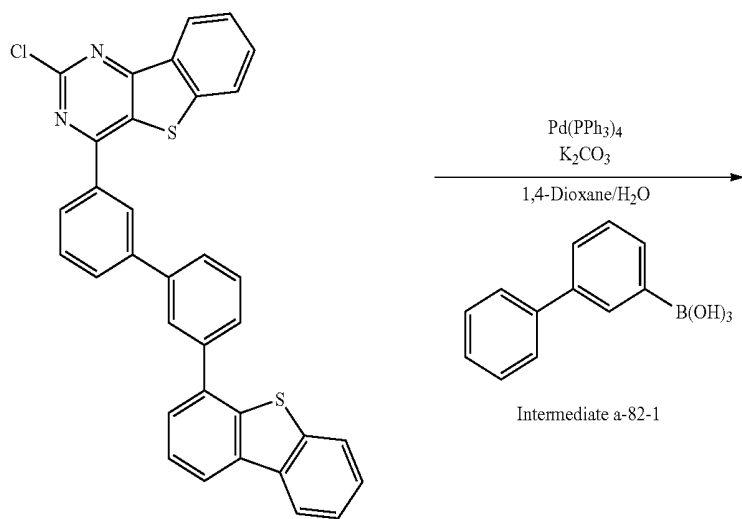
Synthesis Example ad-23  
Synthesis of Compound a-87

[0525]



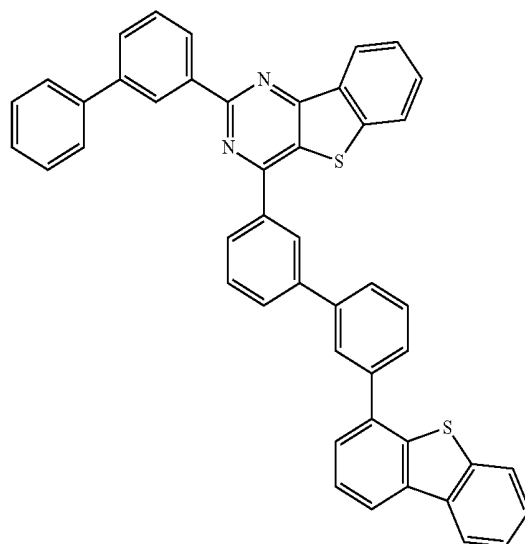
Intermediate A

Intermediate a-83-1



Intermediate a-96-1

Intermediate a-82-1



## Synthesis of Intermediate a-96-1

[0526] The intermediate a-96-1 (13.5 g, Yield: 74%) was synthesized in the same manner as in the synthesis of the intermediate a-82-2 in Synthesis Example ad-16, except that the intermediate a-83-1, instead of the intermediate a-82-1, was used.

[0527] calcd. C<sub>34</sub>H<sub>19</sub>ClN<sub>2</sub>S<sub>2</sub>: C, 73.56; H, 3.45; Cl, 6.39; N, 5.05; S, 11.55. found: C, 73.56; H, 3.44; Cl, 6.37; N, 5.01; S, 11.53.

## Synthesis of Compound a-87

[0528] The compound a-87 (12.7 g, Yield: 70%) was synthesized in the same manner as in the synthesis of the

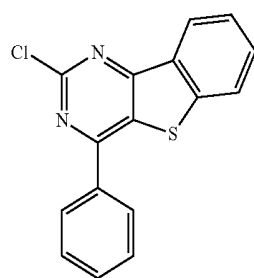
compound a-73 in Synthesis Example ad-16, except that the intermediate a-96-1 and intermediate a-82-1, instead of the intermediate a-82-2 and the intermediate a-82-3, were used.

[0529] calcd. C<sub>46</sub>H<sub>28</sub>N<sub>2</sub>S<sub>2</sub>: C, 82.11; H, 4.19; N, 4.16; S, 9.53. found: C, 82.08; H, 4.17; N, 4.13; S, 9.52.

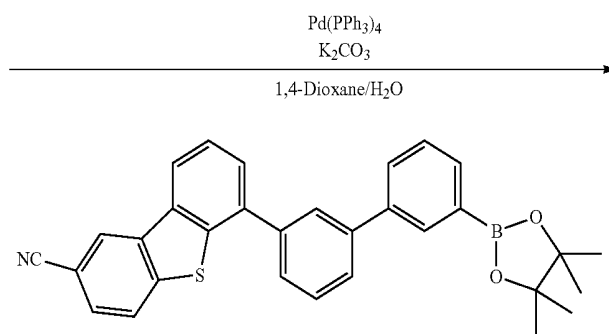
## Synthesis Example ad-24

## Synthesis of Compound a-91

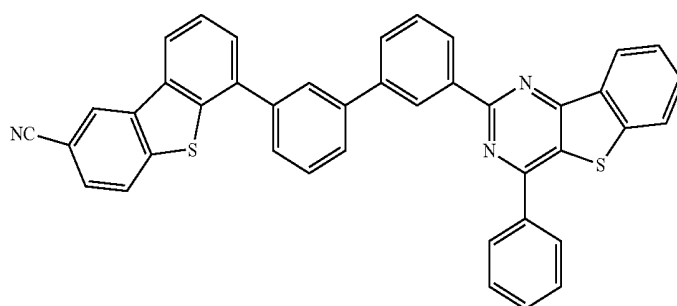
[0530]



Intermediate A-5



Intermediate a-100-1



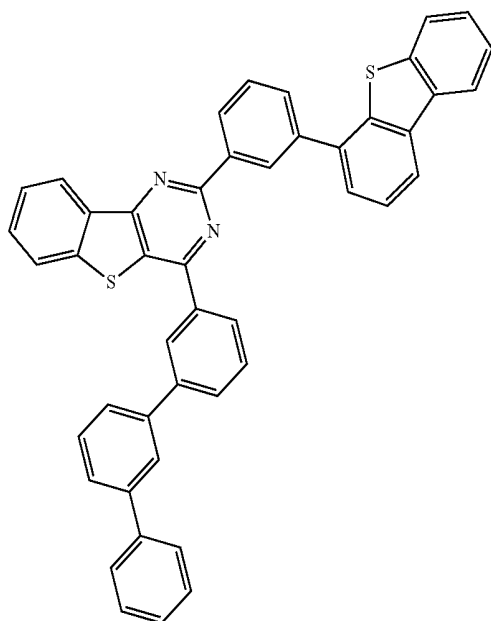
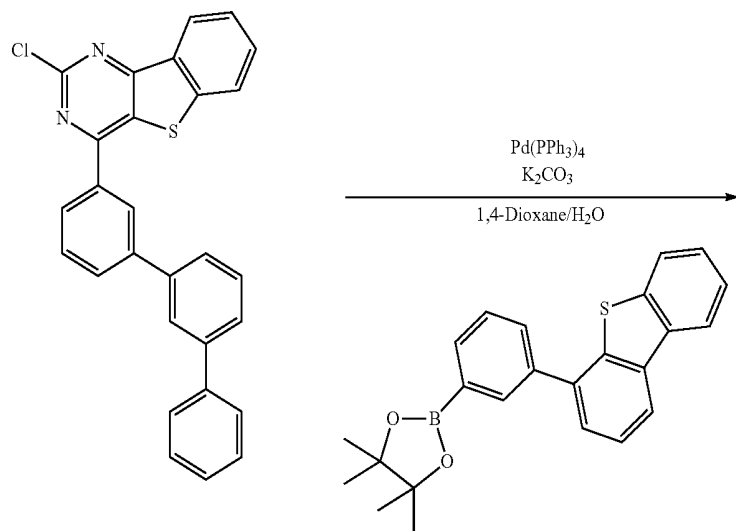
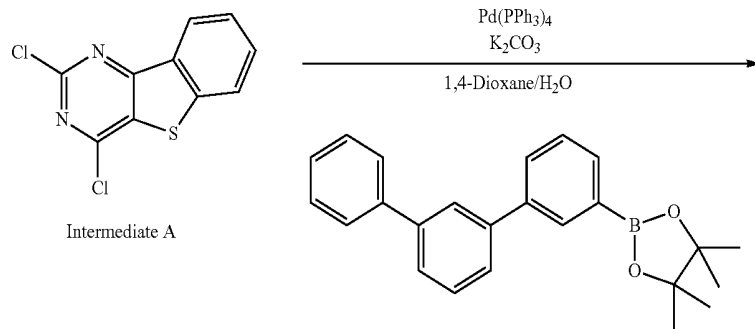
## Synthesis of Compound a-100

[0531] The compound a-91 (10.9 g, Yield: 69%) was synthesized in the same manner as in the synthesis of the compound a-75 in Synthesis Example ad-18, except that the intermediate a-100-1, instead of the intermediate a-84-1, was used.

[0532] calcd. C<sub>41</sub>H<sub>23</sub>N<sub>3</sub>S<sub>2</sub>: C, 79.20; H, 3.73; N, 6.76; S, 10.31. found: C, 79.19; H, 3.72; N, 6.73; S, 10.30.

Synthesis Example ad-25  
Synthesis of Compound a-95

[0533]



## Synthesis of Intermediate a-104-2

**[0534]** The intermediate a-104-2 (10.7 g, Yield: 72%) was synthesized in the same manner as in the synthesis of the intermediate a-82-2 in Synthesis Example ad-16, except that the intermediate a-104-1, instead of the intermediate a-82-1, was used.

**[0535]** calcd. C<sub>28</sub>H<sub>17</sub>ClN<sub>2</sub>S: C, 74.91; H, 3.82; Cl, 7.90; N, 6.24; S, 7.14. found: C, 74.89; H, 3.81; Cl, 7.88; N, 6.21; S, 7.13.

## Synthesis of Compound a-95

**[0536]** The compound a-95 (14.2 g, Yield: 73%) was synthesized in the same manner as in the synthesis of the

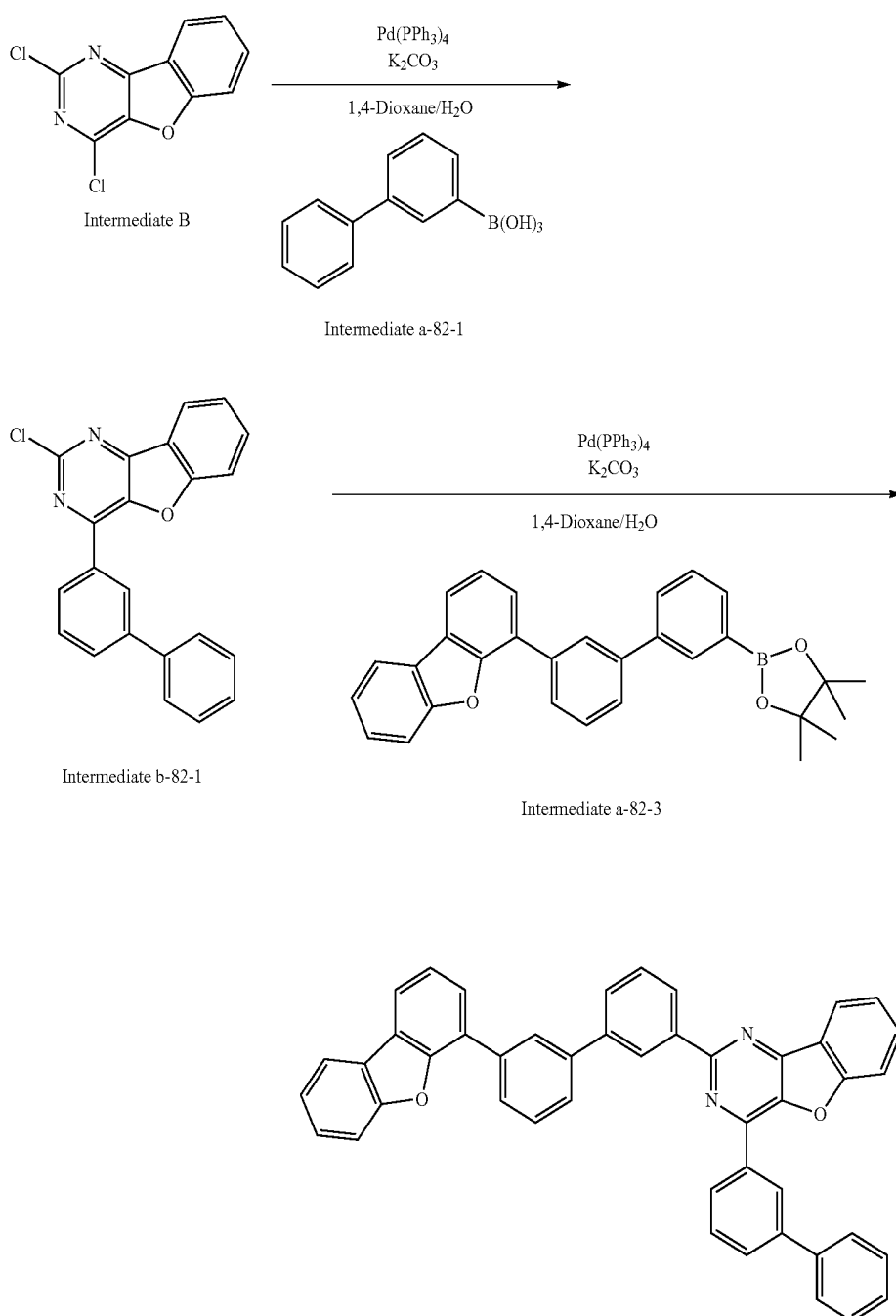
compound a-73 in Synthesis Example ad-16, except that the intermediate a-104-2 and the intermediate a-94, instead of the intermediate a-82-2 and the intermediate a-82-3, were used.

**[0537]** calcd. C<sub>46</sub>H<sub>28</sub>N<sub>2</sub>S<sub>2</sub>: C, 82.11; H, 4.19; N, 4.16; S, 9.53. found: C, 82.07; H, 4.19; N, 4.13; S, 9.50.

## Synthesis Example ad-26

## Synthesis of Compound b-77

**[0538]**



## Synthesis of Intermediate b-82-1

[0539] The intermediate b-82-1 (16.3 g, Yield: 76%) was synthesized in the same manner as in the synthesis of the intermediate a-82-2 in Synthesis Example ad-16, except that the intermediate B, instead of the intermediate A, were used.

[0540] calcd. C<sub>22</sub>H<sub>13</sub>ClN<sub>2</sub>O: C, 74.06; H, 3.67; Cl, 9.94; N, 7.85; O, 4.48. found: C, 74.05; H, 3.65; Cl, 9.91; N, 7.84; O, 4.45.

## Synthesis of Compound b-77

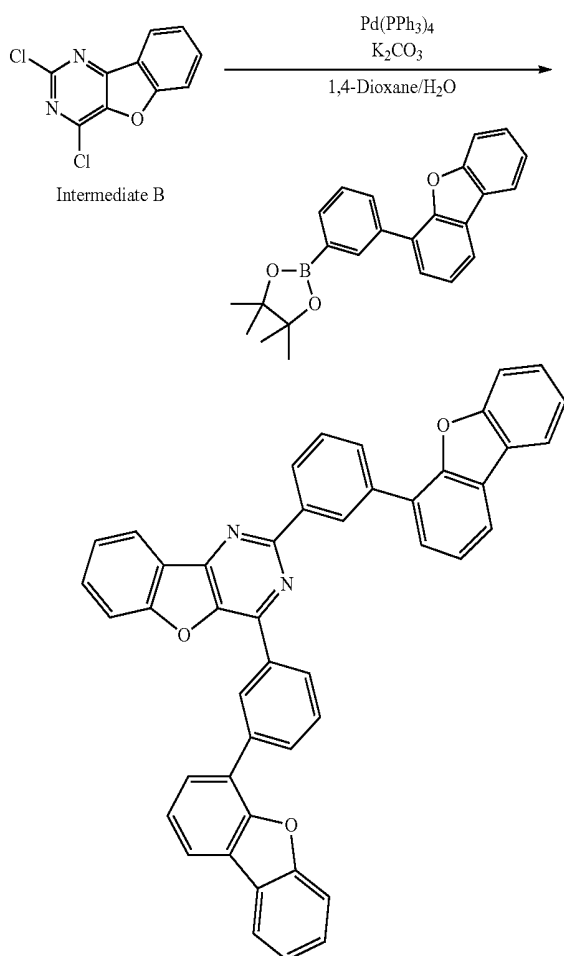
[0541] The compound b-77 (15.5 g, Yield: 71%) was synthesized in the same manner as in the synthesis of the compound a-73 in Synthesis Example ad-16, except that the intermediate b-82-1, instead of the intermediate a-82-2, was used.

[0542] calcd. C<sub>46</sub>H<sub>28</sub>N<sub>2</sub>O<sub>2</sub>: C, 86.23; H, 4.40; N, 4.37; O, 4.99. found: C, 86.21; H, 4.39; N, 4.35; O, 4.99.

## Synthesis Example ad-27

## Synthesis of Compound b-84

[0543]



## Synthesis of Compound b-84

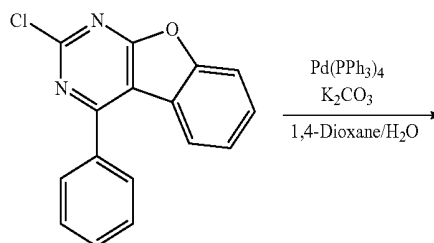
[0544] The compound b-84 (8.7 g, Yield: 66%) was synthesized in the same manner as in the synthesis of the compound a-73 in Synthesis Example ad-16, except that the intermediate B and the intermediate a-91-1, instead of the intermediate a-82-2 and the intermediate a-82-3, were used.

[0545] calcd. C<sub>46</sub>H<sub>26</sub>N<sub>2</sub>O<sub>3</sub>: C, 84.39; H, 4.00; N, 4.28; O, 7.33. found: C, 84.38; H, 3.99; N, 4.25; O, 7.30.

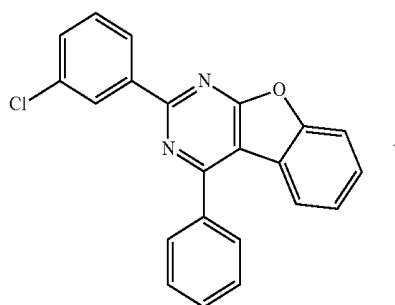
## Synthesis Example ad-28

## Synthesis of Compound e-10

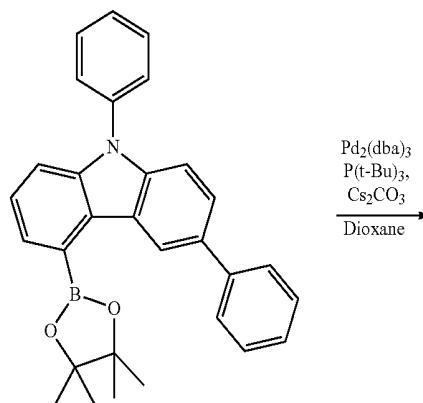
[0546]



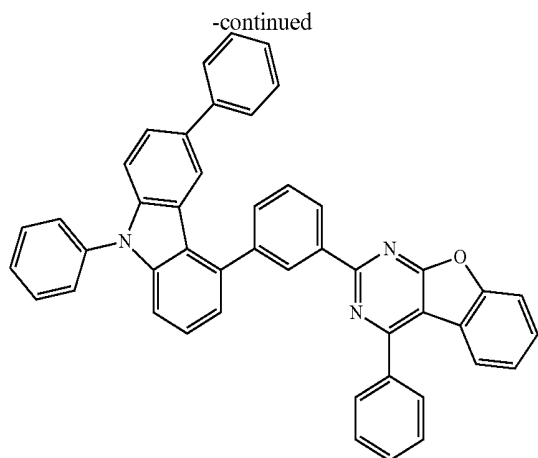
Intermediate E-5



Intermediate e-11



Intermediate B-30-6



#### Synthesis of Intermediate e-11

**[0547]** 10.0 g (35.6 mmol) of the intermediate E-5, 6.1 g (39.2 mmol) of 3-chlorophenylboronic acid, 12.3 g (89.1 mmol) of potassium carbonate, and 2.1 g (1.8 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 120 mL of 1,4-dioxane and 60 mL of water in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 500 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate e-11 (8.8 g, Yield: 69%).

**[0548]** calcd. C<sub>22</sub>H<sub>13</sub>CIN<sub>2</sub>O: C, 74.06; H, 3.67; Cl, 9.94; N, 7.85; O, 4.48. found: C, 74.03; H, 3.64; Cl, 9.93; N, 7.81; O, 4.47.

#### Synthesis of Compound e-10

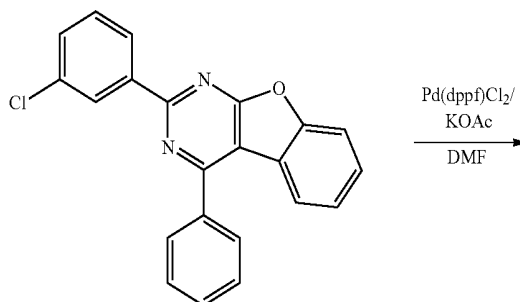
**[0549]** 8.0 g (22.4 mmol) of the intermediate e-10, 11.0 g (24.7 mmol) of intermediate B-30-6, 14.6 g (44.8 mmol) of cesium carbonate, tris(dibenzylidene acetone)dipalladium (0) 0.6 g (0.7 mmol), and 2.0 mL of tri-tert-butylphosphine were added to 110 mL of 1,4-dioxane in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 24 hours. The obtained mixture was added to 500 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound e-10 (6.9 g, Yield: 48%).

**[0550]** calcd. C<sub>46</sub>H<sub>29</sub>N<sub>3</sub>O: C, 86.36; H, 4.57; N, 6.57; O, 2.50. found: C, 86.35; H, 4.55; N, 6.53; O, 2.48.

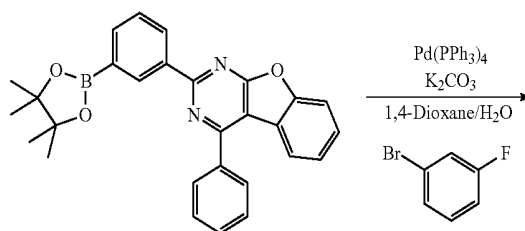
#### Synthesis Example ad-29

#### Synthesis of Compound e-15

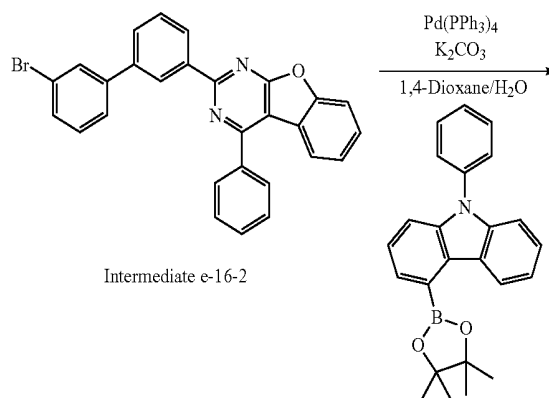
**[0551]**



Intermediate e-11

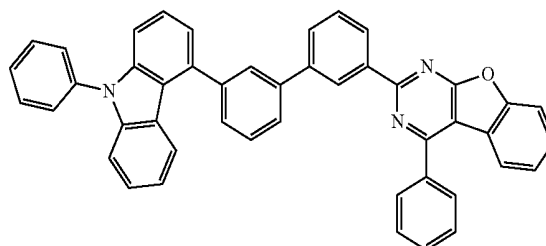


Intermediate e-16-1



Intermediate e-16-2

Intermediate e-16-3



## Synthesis of Intermediate e-16-1

[0552] The intermediate e-11 (10.0 g, 28.0 mmol), 4,4,4',4',5,5,5',5'-octamethyl-2,2'-bi(1,3,2-dioxaborolane) (Manufacturer: UMT) (8.5 g, 33.6 mmol), potassium acetate (8.3 g, 84.1 mmol), 1,1'-bis(diphenylphosphino) ferrocene-palladium(II) dichloride (1.4 g, 1.7 mmol), and tricyclohexyl phosphine (0.94 g, 3.36 mmol) were added to dimethylformamide (140 mL) in a 250 mL flask, and were stirred at 140° C. for 24 hours. After the reaction was terminated, the reaction solution was extracted with water and ethyl acetate, the moisture was removed from the resultant organic layer using magnesium sulfate followed by concentrating the resultant, and the resultant was purified using column chromatography (methylene chloride/n-hexane, silica gel) to obtain a white solid, the intermediate e-16-1 (9.5 g, 76%).

[0553] calcd. C<sub>28</sub>H<sub>25</sub>BN<sub>2</sub>O<sub>3</sub>: C, 75.01; H, 5.62; B, 2.41; N, 6.25; O, 10.71. found: C, 75.00; H, 5.58; B, 2.39; N, 6.22; O, 10.70.

## Synthesis of Intermediate e-16-2

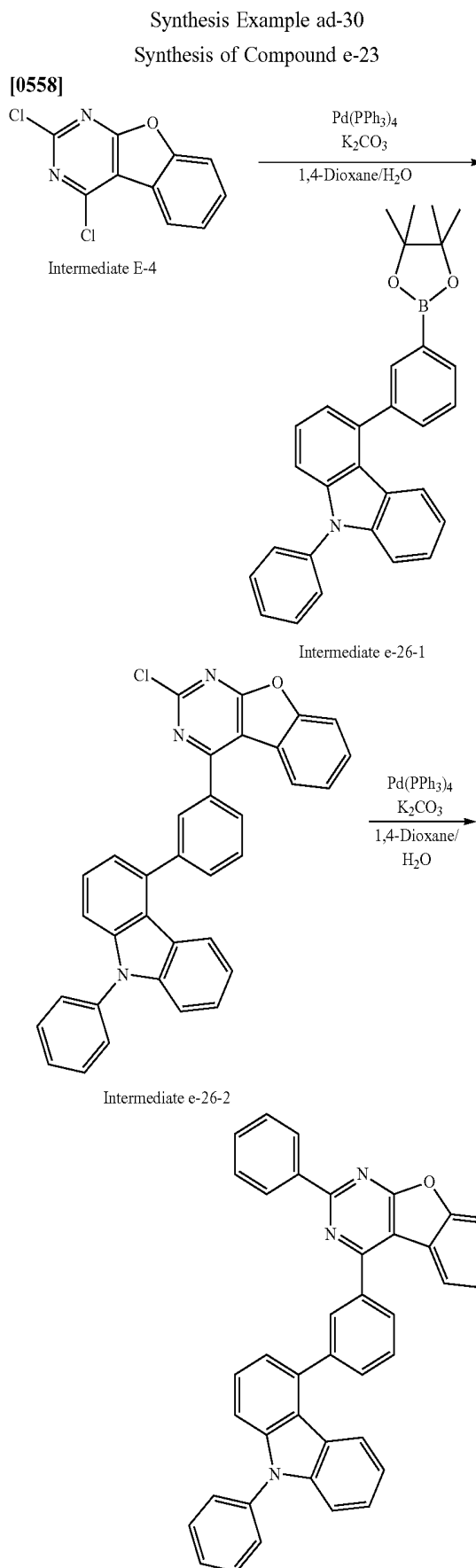
[0554] 9.0 g (20.1 mmol) of the intermediate e-16-1, 5.7 g (20.1 mmol) of 1-bromo-3-iodobenzene, 6.9 g (50.2 mmol) of potassium carbonate, and 1.2 g (1.0 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 60 mL of 1,4-dioxane and 30 mL of water in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 24 hours. The obtained mixture was added to 300 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate e-16-2 (7.0 g, Yield: 73%).

[0555] calcd. C<sub>28</sub>H<sub>17</sub>BrN<sub>2</sub>O: C, 70.45; H, 3.59; Br, 16.74; N, 5.87; O, 3.35. found: C, 70.41; H, 3.59; Br, 16.70; N, 5.85; O, 3.32.

## Synthesis of Compound e-15

[0556] 7.0 g (14.7 mmol) of the intermediate e-16-2, 5.4 g (11.0 mmol) of the intermediate e-16-3, 5.1 g (36.7 mmol) of potassium carbonate, and 0.8 g (0.7 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 50 mL of 1,4-dioxane and 25 mL of water, in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 200 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound e-15 (6.6 g, Yield: 70%).

[0557] calcd. C<sub>46</sub>H<sub>29</sub>N<sub>3</sub>O: C, 86.36; H, 4.57; N, 6.57; O, 2.50. found: C, 86.31; H, 4.53; N, 6.54; O, 2.50.



## Synthesis of Intermediate e-26-2

**[0559]** 15.0 g (62.8 mmol) of the intermediate E-4, 27.9 g (62.8 mmol) of intermediate e-26-1 (=intermediate C-29-2), 21.7 g (156.9 mmol) of potassium carbonate, and 3.6 g (3.1 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 200 mL of 1,4-dioxane and 100 mL of water in a 500 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 24 hours. The obtained mixture was added to 600 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate e-26-2 (24.2 g, Yield: 74%).

**[0560]** calcd. C<sub>34</sub>H<sub>20</sub>ClN<sub>3</sub>O: C, 78.23; H, 3.86; Cl, 6.79; N, 8.05; O, 3.07. found: C, 78.23; H, 3.84; Cl, 6.72; N, 8.03; O, 3.05.

## Synthesis of Compound e-23

**[0561]** 15.0 g (28.7 mmol) of the intermediate e-26-2, 3.5 g (28.7 mmol) of phenylboronic acid, 9.9 g (71.8 mmol) of

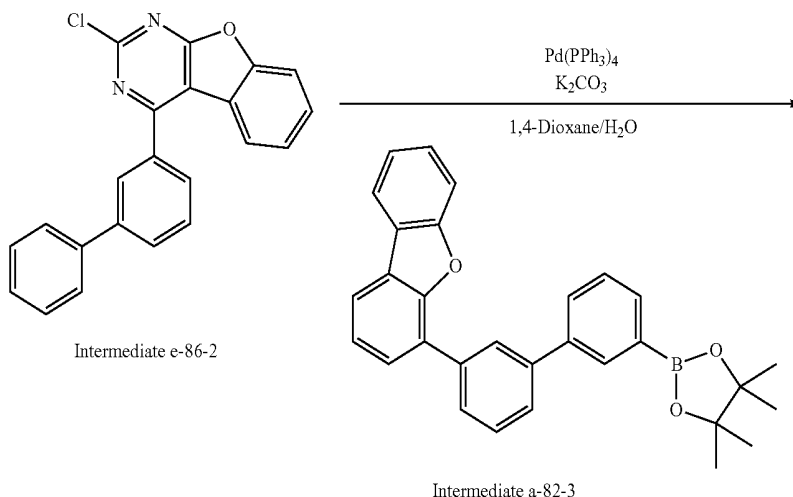
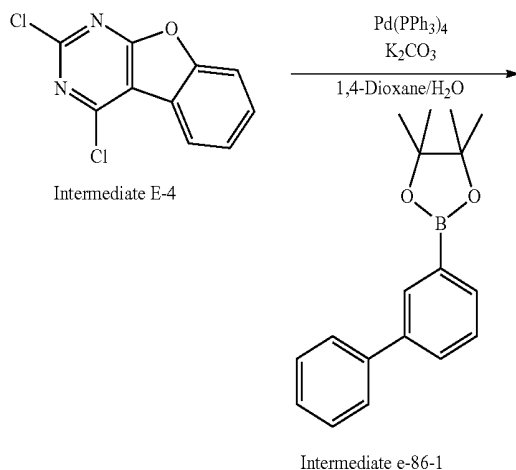
potassium carbonate, and 1.7 g (1.4 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 100 mL of 1,4-dioxane and 50 mL of water in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 300 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound e-23 (11.0 g, Yield: 68%).

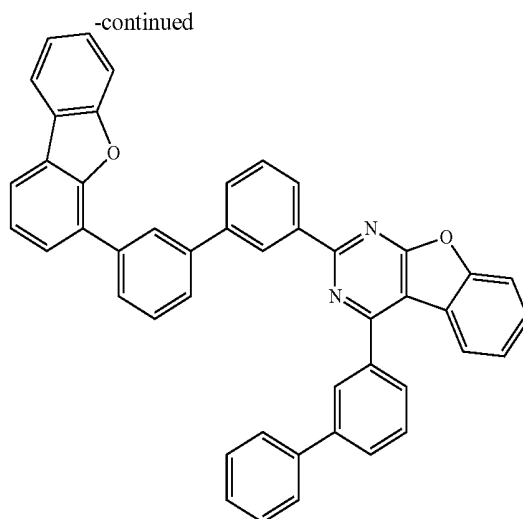
**[0562]** calcd. C<sub>40</sub>H<sub>25</sub>N<sub>3</sub>O: C, 85.24; H, 4.47; N, 7.46; O, 2.84. found: C, 85.23; H, 4.47; N, 7.45; O, 2.80.

## Synthesis Example ad-31

## Synthesis of Compound e-73

**[0563]**





#### Synthesis of Intermediate e-86-2

**[0564]** 15.0 g (62.8 mmol) of the intermediate E-4, 17.6 g (62.8 mmol) of the intermediate e-86-1, 21.7 g (156.9 mmol) of potassium carbonate, and 3.6 g (3.1 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 200 mL of 1,4-dioxane and 100 mL of water in a 500 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 24 hours. The obtained mixture was added to 600 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate e-86-2 (15.7 g, Yield: 70%).

**[0565]** calcd. C<sub>22</sub>H<sub>13</sub>ClN<sub>2</sub>O: C, 74.06; H, 3.67; Cl, 9.94; N, 7.85; O, 4.48. found: C, 74.00; H, 3.64; Cl, 9.92; N, 7.84; O, 4.46.

#### Synthesis of Compound e-73

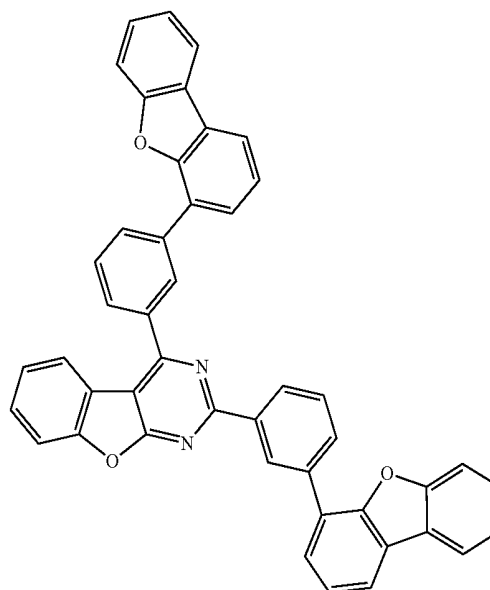
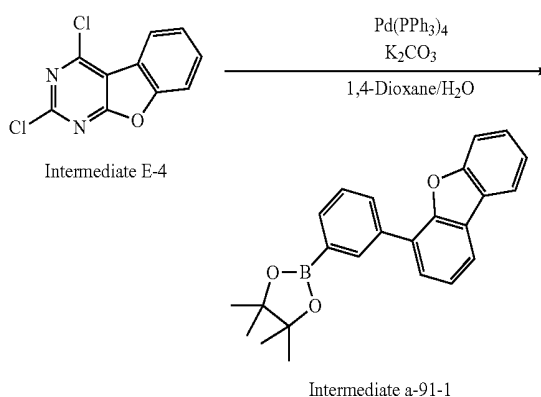
**[0566]** 15.0 g (42.0 mmol) of the intermediate e-86-2, 18.8 g (42.0 mmol) of intermediate a-82-3, 14.5 g (105.1 mmol) of potassium carbonate, and 2.4 g (2.1 mmol) of tetrakis (triphenylphosphine)palladium(0) were added to 140 mL of 1,4-dioxane and 70 mL of water in a 500 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 12 hours. The obtained mixture was added to 450 mL of methanol, and a solid crystallized therein was filtered, dissolved in monochlorobenzene, and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the compound e-73 (19.7 g, Yield: 73%).

**[0567]** calcd. C<sub>46</sub>H<sub>28</sub>N<sub>2</sub>O<sub>2</sub>: C, 86.23; H, 4.40; N, 4.37; O, 4.99. found: C, 86.21; H, 4.37; N, 4.36; O, 4.94.

#### Synthesis Example ad-32

#### Synthesis of Compound e-84

**[0568]**



## Synthesis of Compound e-84

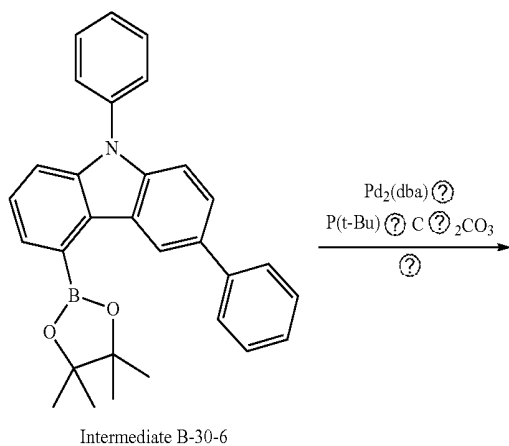
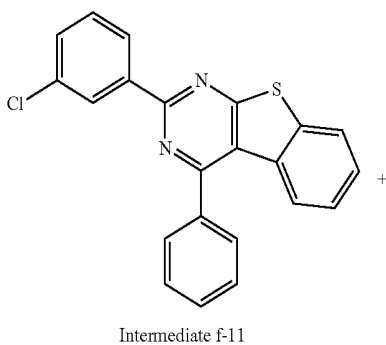
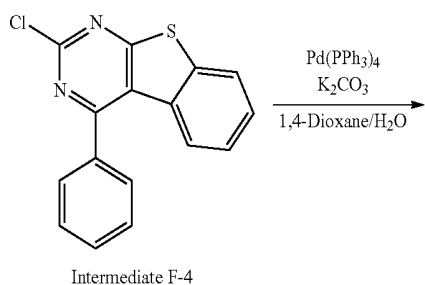
[0569] The compound e-84 (7.9 g, Yield: 73%) was synthesized in the same manner as in the synthesis of the compound a-84 in Synthesis Example ad-21, except that the intermediate E-4, instead of the intermediate A, were used.

[0570] calcd. C<sub>46</sub>H<sub>26</sub>N<sub>2</sub>O<sub>3</sub>: C, 84.39; H, 4.00; N, 4.28; O, 7.33. found: C, 84.36; H, 3.99; N, 4.27; O, 7.33.

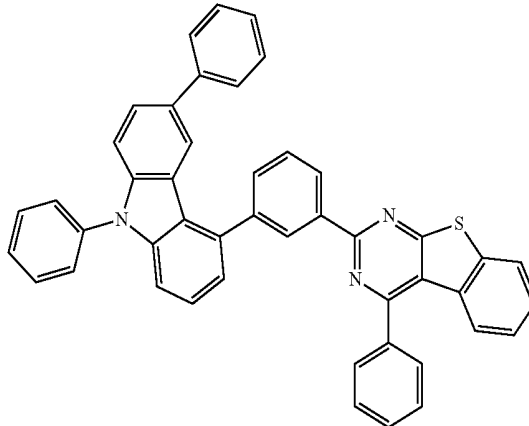
## Synthesis Example ad-33

## Synthesis of Compound f-10

[0571]



-continued



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## Synthesis of Intermediate f-11

[0572] The intermediate f-11 (10.2 g, Yield: 65%) was synthesized in the same manner as in the synthesis of the intermediate e-11 in Synthesis Example ad-28, except that the intermediate F-4, instead of the intermediate E-5, were used.

[0573] calcd. C<sub>22</sub>H<sub>13</sub>ClN<sub>2</sub>S: C, 70.87; H, 3.51; Cl, 9.51; N, 7.51; S, 8.60. found: C, 70.84; H, 3.46; Cl, 9.49; N, 7.50; S, 8.58.

## Synthesis of Compound f-10

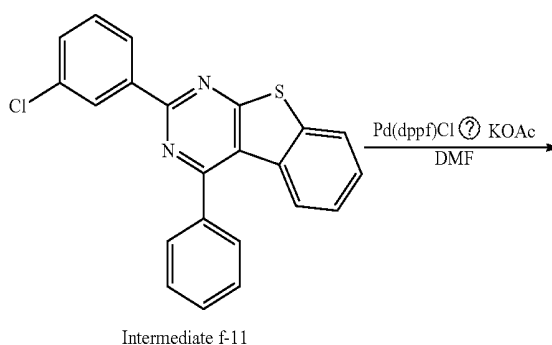
[0574] The compound f-10 (7.1 g, Yield: 63%) was synthesized in the same manner as in the synthesis of the intermediate e-10 in Synthesis Example ad-28, except that the intermediate f-11, instead of the intermediate e-11, were used.

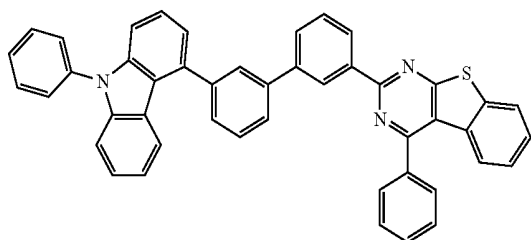
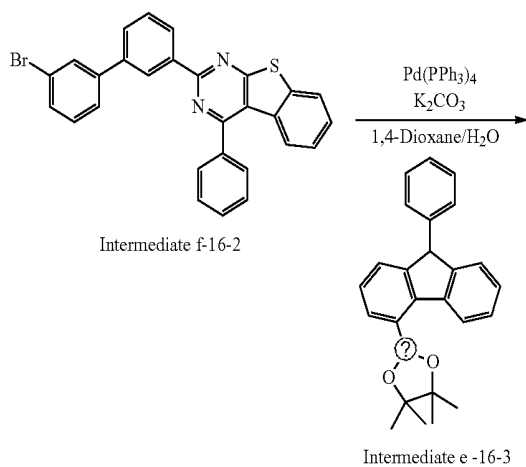
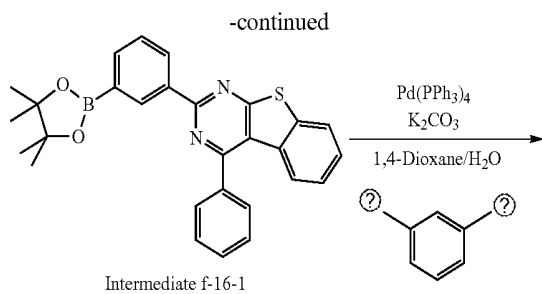
[0575] calcd. C<sub>46</sub>H<sub>29</sub>N<sub>3</sub>S: C, 84.25; H, 4.46; N, 6.41; S, 4.89. found: C, 84.21; H, 4.42; N, 6.40; S, 4.85.

## Synthesis Example ad-34

## Synthesis of Compound f-15

[0576]





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#### Synthesis of Intermediate f-16-1

**[0577]** The intermediate f-16-1 (13.1 g Yield: 68%) was synthesized in the same manner as in the synthesis of the intermediate e-16-1 in Synthesis Example ad-29, except that the intermediate f-11, instead of the intermediate e-11, was used.

**[0578]** calcd. C<sub>28</sub>H<sub>25</sub>BN<sub>2</sub>O<sub>2</sub>S: C, 72.42; H, 5.43; B, 2.33; N, 6.03; O, 6.89; S, 6.90. found: C, 72.39; H, 5.41; B, 2.30; N, 6.01; O, 6.88; S, 6.85.

#### Synthesis of Intermediate f-16-2

**[0579]** The intermediate f-16-2 (11.0 g, Yield: 62%) was synthesized in the same manner as in the synthesis of the intermediate e-16-2 in Synthesis Example ad-29, except that the intermediate f-16-1, instead of the intermediate e-16-1, was used.

**[0580]** calcd. C<sub>28</sub>H<sub>17</sub>BrN<sub>2</sub>S: C, 68.16; H, 3.47; Br, 16.19; N, 5.68; S, 6.50. found: C, 68.13; H, 3.44; Br, 16.16; N, 5.61; S, 6.49.

#### Synthesis of Compound f-15

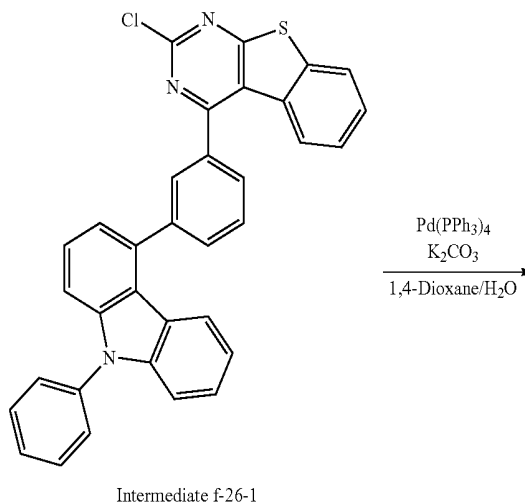
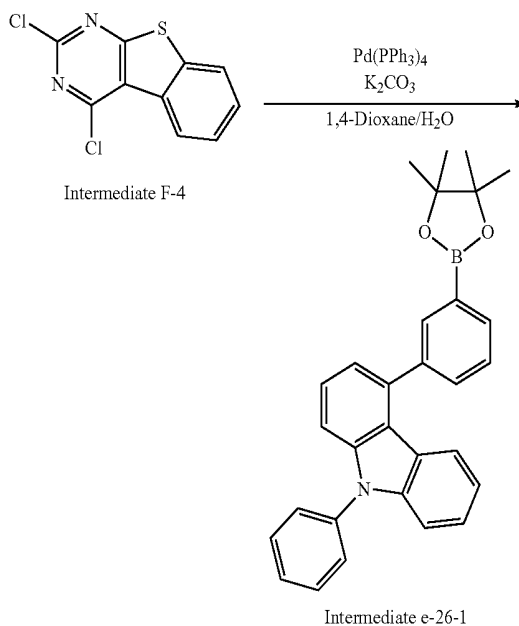
**[0581]** The compound f-15 (8.8 g, Yield: 73%) was synthesized in the same manner as in the synthesis of the compound e-15 in Synthesis Example ad-29, except that the intermediate f-16-2, instead of the intermediate e-16-2, was used.

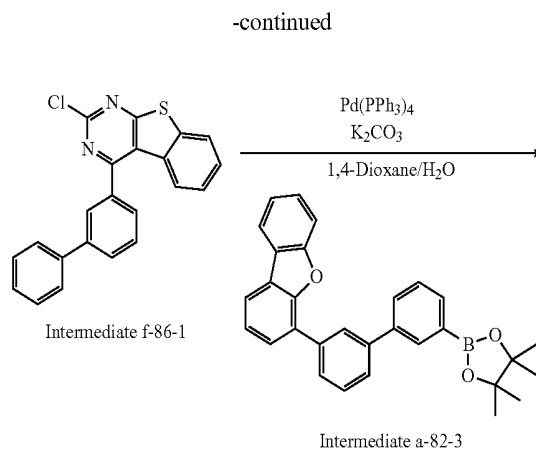
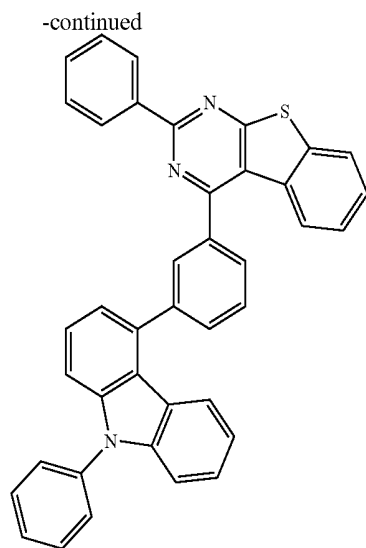
**[0582]** calcd. C<sub>46</sub>H<sub>29</sub>N<sub>3</sub>S: C, 84.25; H, 4.46; N, 6.41; S, 4.89. found: C, 84.23; H, 4.44; N, 6.40; S, 4.88.

#### Synthesis Example ad-35

#### Synthesis of Compound f-23

**[0583]**





#### Synthesis of Intermediate f-26-1

**[0584]** The intermediate f-26-1 (13.9 g, Yield: 68%) was synthesized in the same manner as in the synthesis of the compound e-26-2 in Synthesis Example ad-30, except that the intermediate F-4, instead of the intermediate E-4, was used.

**[0585]** calcd. C<sub>34</sub>H<sub>20</sub>ClN<sub>3</sub>S: C, 75.90; H, 3.75; Cl, 6.59; N, 7.81; S, 5.96. found: C, 75.89; H, 3.74; Cl, 6.59; N, 7.77; S, 5.91.

#### Synthesis of Compound f-23

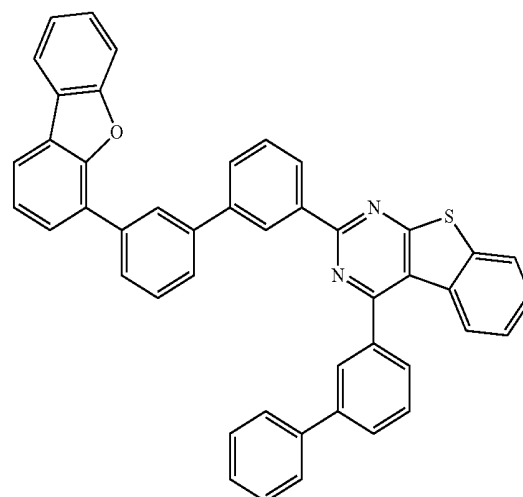
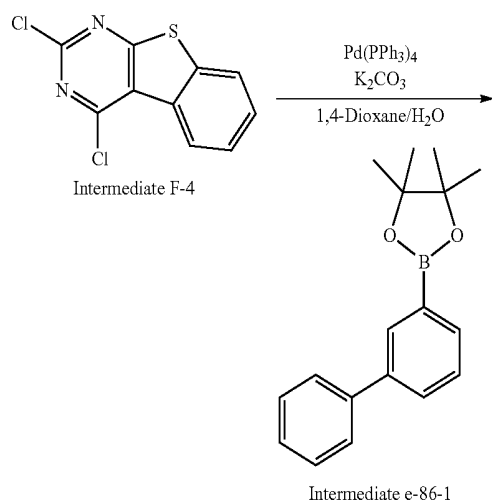
**[0586]** The compound f-23 (6.0 g, Yield: 64%) was synthesized in the same manner as in the synthesis of the compound e-23 in Synthesis Example ad-30, except that the intermediate f-26-1, instead of the intermediate e-26-2, was used.

**[0587]** calcd. C<sub>40</sub>H<sub>25</sub>N<sub>3</sub>S: C, 82.87; H, 4.35; N, 7.25; S, 5.53. found: C, 82.84; H, 4.31; N, 7.23; S, 5.50.

#### Synthesis Example ad-36

#### Synthesis of Compound f-73

**[0588]**



#### Synthesis of Intermediate f-86-1

**[0589]** The intermediate f-86-1 (11.1 g, Yield: 71%) was synthesized in the same manner as in the synthesis of the intermediate e-86-2 in Synthesis Example ad-31, except that the intermediate F-4, instead of the intermediate E-4, was used.

**[0590]** calcd. C<sub>22</sub>H<sub>13</sub>ClN<sub>2</sub>S: C, 70.87; H, 3.51; Cl, 9.51; N, 7.51; S, 8.60. found: C, 70.85; H, 3.46; Cl, 9.47; N, 7.45; S, 8.60.

#### Synthesis of Compound f-73

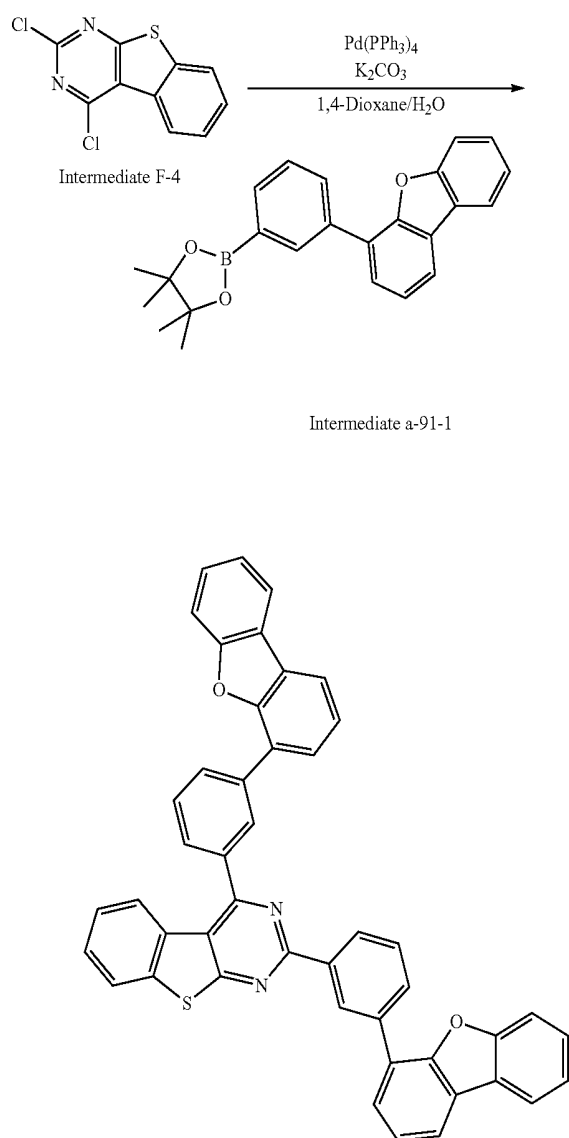
**[0591]** The compound f-73 (8.7 g, Yield: 69%) was synthesized in the same manner as in the synthesis of the compound e-73 in Synthesis Example ad-31, except that the intermediate f-86-1, instead of the intermediate e-86-2, was used.

[0592] calcd. C<sub>46</sub>H<sub>28</sub>N<sub>2</sub>O<sub>2</sub>S: C, 84.12; H, 4.30; N, 4.27; O, 2.44; S, 4.88. found: C, 84.11; H, 4.26; N, 4.27; O, 2.43; S, 4.87.

## Synthesis Example ad-37

## Synthesis of Compound f-84

[0593]



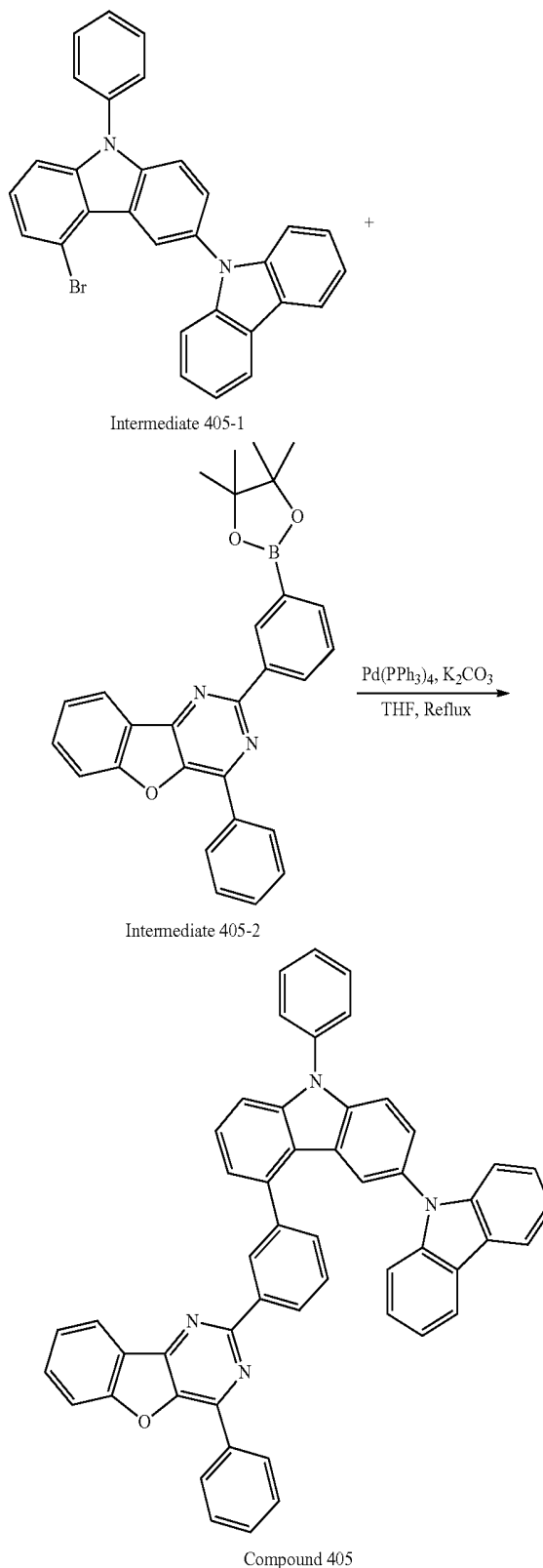
## Synthesis of Compound f-84

[0594] The compound f-84 (8.2 g, Yield: 68%) was synthesized in the same manner as in the synthesis of the compound e-84 in Synthesis Example ad-32, except that the intermediate F-4, instead of the intermediate E-4, was used.

[0595] calcd. C<sub>46</sub>H<sub>26</sub>N<sub>2</sub>O<sub>2</sub>S: C, 82.37; H, 3.91; N, 4.18; O, 4.77; S, 4.78. found: C, 82.35; H, 3.90; N, 4.16; O, 4.77; S, 4.76.

Synthesis Example ad-38  
Synthesis of Compound 405

[0596]



## Synthesis of Compound 405

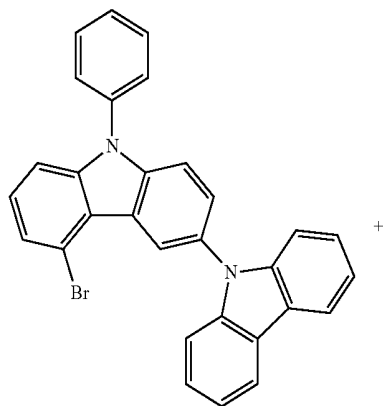
[0597] The compound 405 (11.1 g, Yield: 73%) was synthesized in the same manner as in the synthesis of the compound f-84 in Synthesis Example ad-37, except that the intermediate 405-1 and the intermediate 405-2, instead of the intermediate F-4 and the intermediate a-91-1, were used.

[0598] calcd. C<sub>52</sub>H<sub>32</sub>N<sub>4</sub>O: C, 85.69; H, 4.43; N, 7.69; O, 2.20. found: C, 85.66; H, 4.42; N, 7.67; O, 2.18.

## Synthesis Example ad-39

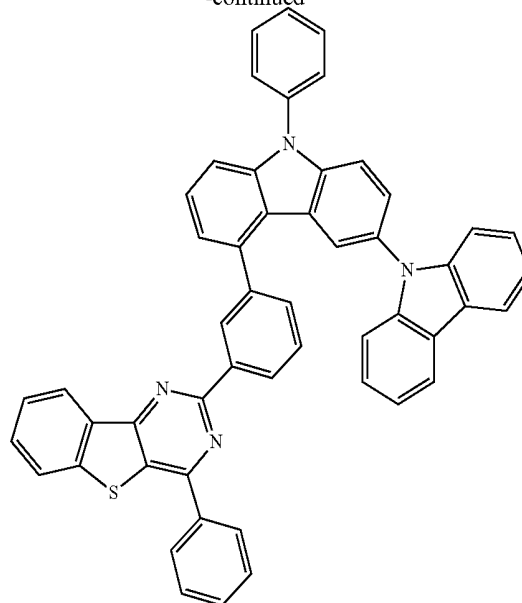
## Synthesis of Compound 406

[0599]



Intermediate 405-1

-continued



Compound 406

## Synthesis of Compound 406

[0600] The compound 406 (14.8 g, Yield: 76%) was synthesized in the same manner as in the synthesis of the compound 405 in Synthesis Example ad-38, except that the intermediate A-5-2, instead of the intermediate A-5-2, was used.

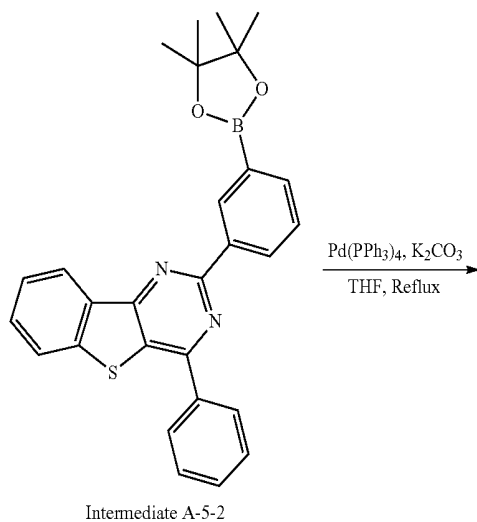
[0601] calcd. C<sub>52</sub>H<sub>32</sub>N<sub>4</sub>S: C, 83.84; H, 4.33; N, 7.52; S, 4.30. found: C, 83.83; H, 4.32; N, 7.49; S, 4.27.

## Synthesis of Second Host Compound

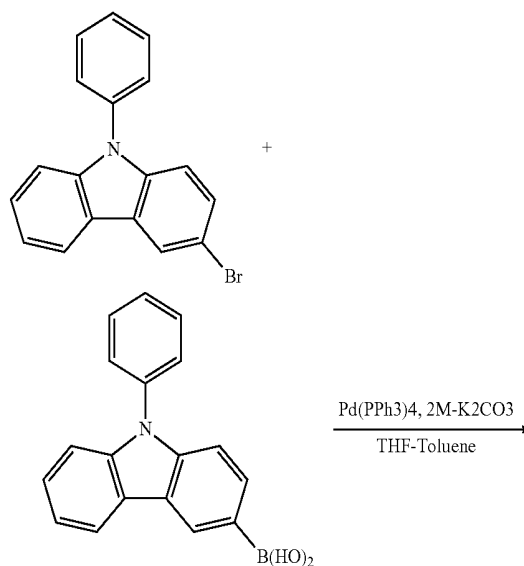
## Synthesis Example 14

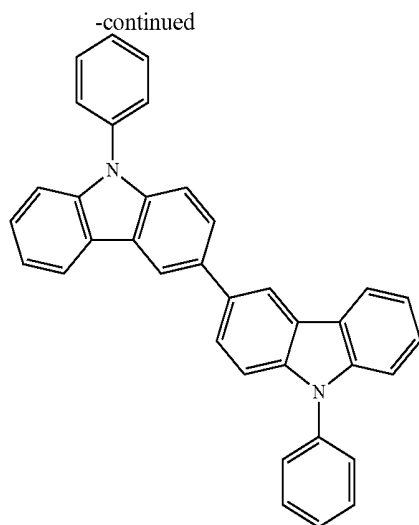
## Synthesis of Compound A1

[0602]



Intermediate A-5-2





화합물 A1

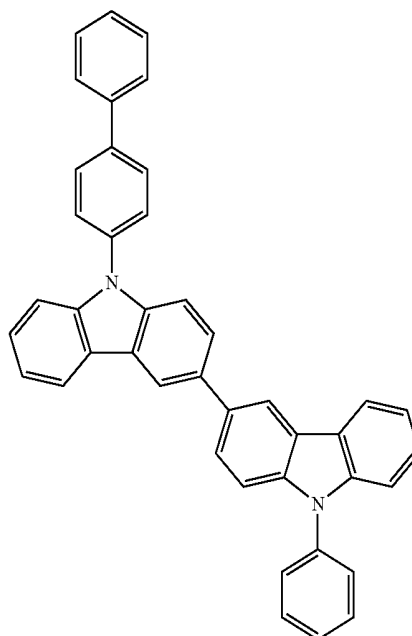
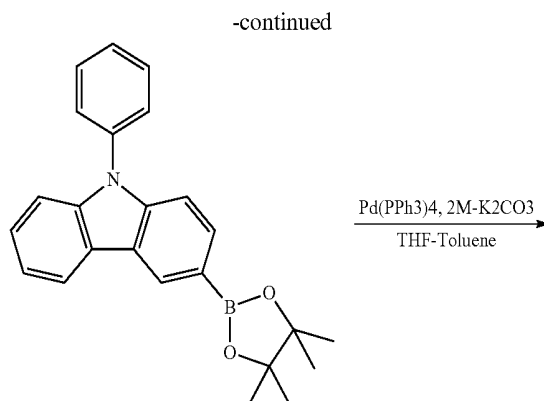
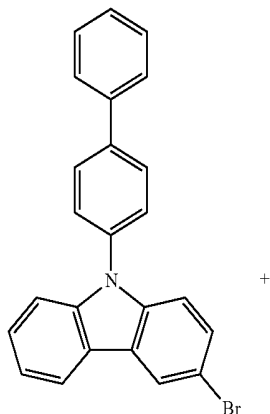
**[0603]** 16.62 g (51.59 mmol) of 3-bromo-N-phenylcarbazole, 17.77 g (61.91 mmol) of N-phenylcarbazole-3-ylboronic acid, and 200 mL of a mixture of tetrahydrofuran (THF) and toluene (1:1), and 100 mL of an aqueous solution of 2M potassium carbonate were mixed in a 500 mL round-bottom flask equipped with a stirrer in a nitrogen atmosphere, and 2.98 g (2.58 mmol) of tetrakis(triphenylphosphine)palladium(0) was added thereto, and heated under reflux in a nitrogen atmosphere for 12 hours. After completion of the reaction, the reaction product was added to methanol to obtain a solid by filtering. This solid was sufficiently washed with water and methanol, and then dried. The resulting product was dissolved in 1 L of chlorobenzene by heating, followed by filtration using silica gel and removing the solvent. The resulting product was dissolved in 500 mL of toluene by heating, followed by recrystallization to obtain Compound A1 (16.05 g, Yield: 64%).

**[0604]** calcd.  $C_{36}H_{24}N_2$ : C, 89.23; H, 4.99; N, 5.78. found: C, 89.45; H, 4.89; N, 5.65.

## Synthesis Example 15

## Synthesis of Compound A2

**[0605]**



화합물 A2

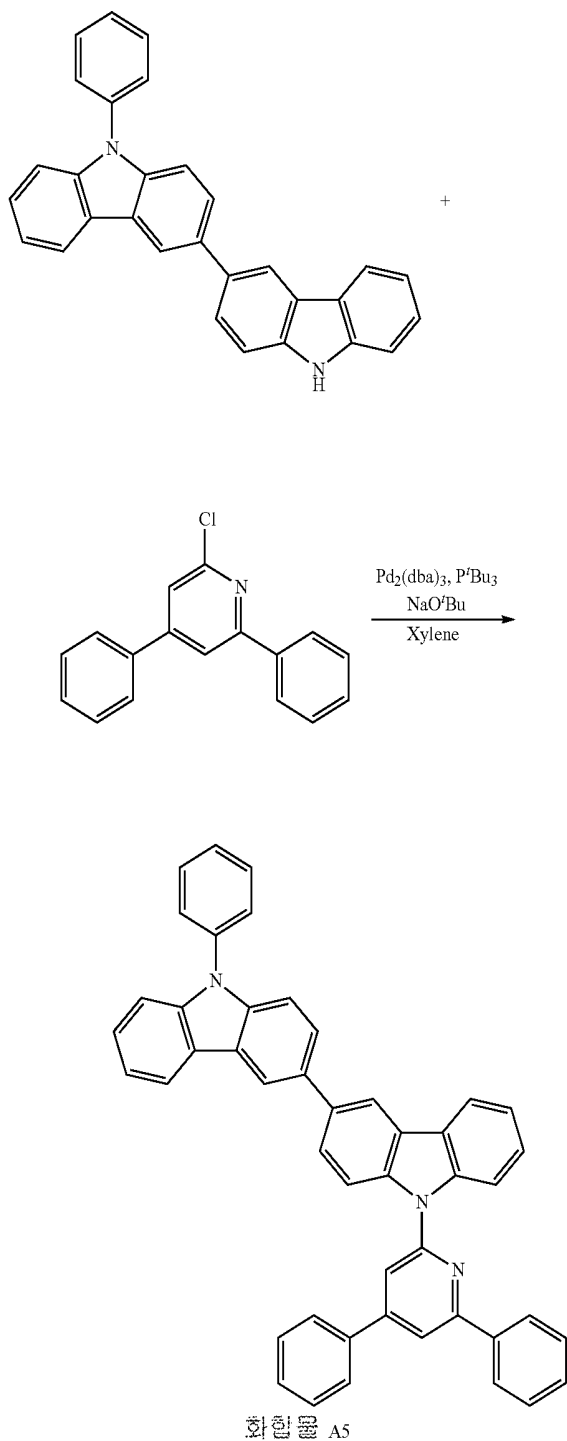
**[0606]** 20.00 g (50.21 mmol) of 3-bromo-N-biphenylcarbazole, 18.54 g (50.21 mmol) of N-phenylcarbazole-3-boronic ester, and 175 mL of a mixture of tetrahydrofuran (THF) and toluene (1:1), and 75 mL of an aqueous solution of 2M potassium carbonate were mixed in a 500 mL round-bottom flask equipped with a stirrer in a nitrogen atmosphere, and 2.90 g (2.51 mmol) of tetrakis(triphenylphosphine)palladium(0) was added thereto, and heated under reflux in a nitrogen atmosphere for 12 hours. After completion of the reaction, the reaction product was added to methanol to obtain a solid by filtering. This solid was sufficiently washed with water and methanol, and then dried. The resulting product was dissolved in 700 mL of chlorobenzene by heating, followed by filtration using silica gel and removing the solvent. The resulting product was dissolved in 400 mL of chlorobenzene by heating, followed by recrystallization to obtain Compound A2 (19.15 g, Yield: 68%).

[0607] calcd.  $C_{42}H_{28}N_2$ : C, 89.97; H, 5.03; N, 5.00. found: C, 89.53; H, 4.92; N, 4.89.

## Synthesis Example 16

## Synthesis of Compound A5

[0608]



[0609] 12.81 g (31.36 mmol) of N-phenyl-3,3-bicarbazole, 8.33 g (31.36 mmol) of 2-chloro-di-4,6-phenylpyri-

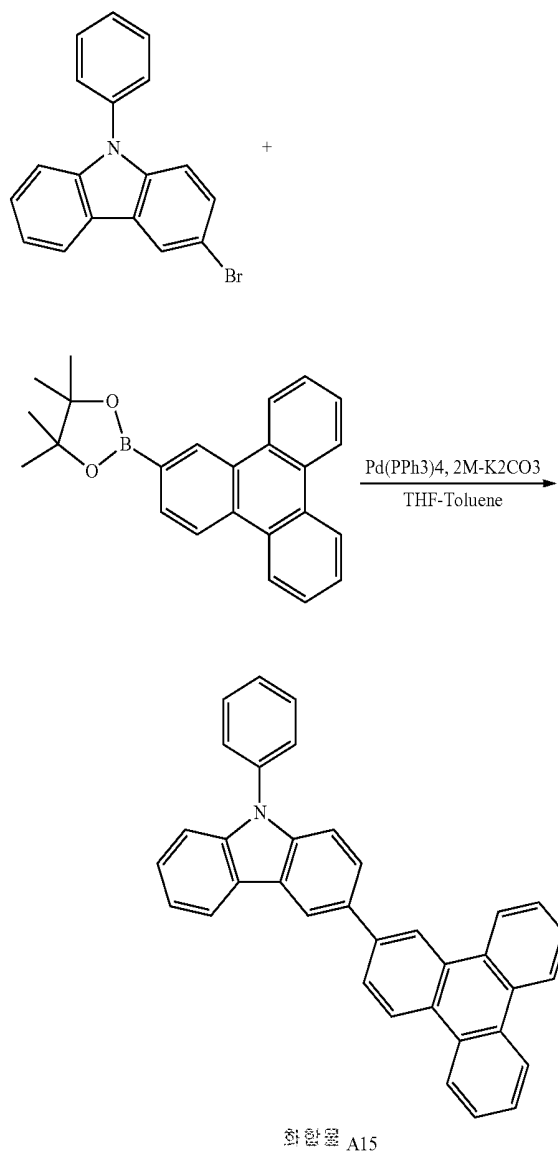
dine, 6.03 g (62.72 mmol) of sodium t-butoxide, 1.80 g (3.14 mmol) of tris(dibenzylideneacetone)dipalladium, and 2.6 mL of tri-t-butylphosphine (50% in toluene) were added to 200 mL of xylene in a 500 mL round-bottom flask, and heated under reflux in a nitrogen atmosphere for 15 hours. The resulting mixture was added to 600 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in dichlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain Compound A5 (13.5 g, Yield: 68%).

[0610] calcd.  $C_{47}H_{31}N_3$ : C, 88.51; H, 4.90; N, 6.59. found: C, 88.39; H, 4.64; N, 6.43.

## Synthesis Example 17

## Synthesis of Compound A15

[0611]



[0612] 10.00 g (31.04 mmol) of 3-bromo-N-phenylcarbazole, 10.99 g (31.04 mmol) of 2-triphenylene boronic ester,

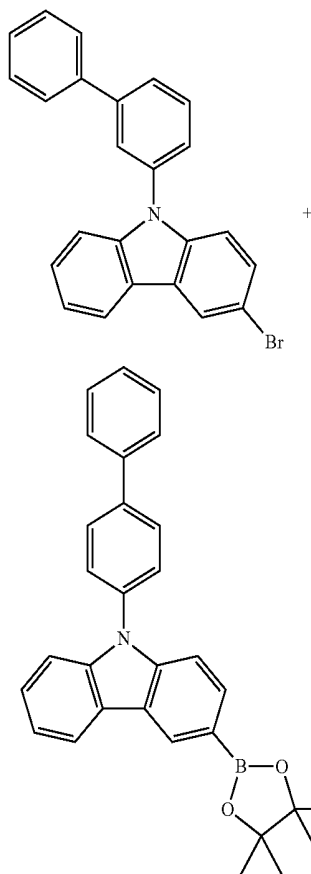
150 mL of a mixture of tetrahydrofuran (THF) and toluene (1:1), and 75 mL of an aqueous solution of 2M potassium carbonate were mixed in a 500 mL round-bottom flask equipped with a stirrer in a nitrogen atmosphere, and 1.79 g (1.55 mmol) of tetrakis(triphenylphosphine)palladium (0) was added thereto, and heated under reflux in a nitrogen atmosphere for 12 hours. After completion of the reaction, the reaction product was added to methanol to obtain a solid by filtering. This solid was sufficiently washed with water and methanol, and then dried. The resulting product was dissolved in 400 mL of chlorobenzene by heating, followed by filtration using silica gel and removing the solvent. The resulting product was dissolved in 300 mL of toluene by heating, followed by recrystallization to obtain Compound A15 (8.74 g, Yield: 60%).

[0613] calcd.  $C_{36}H_{23}N$ : C, 92.08; H, 4.94; N, 2.98. found: C, 92.43; H, 4.63; N, 2.84.

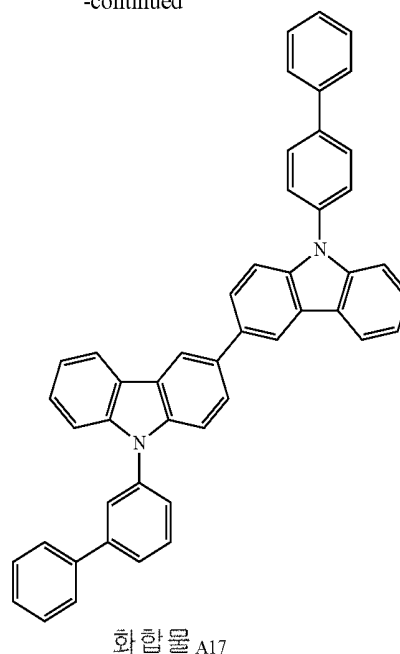
#### Synthesis Example 18

#### Synthesis of Compound A17

[0614]



-continued



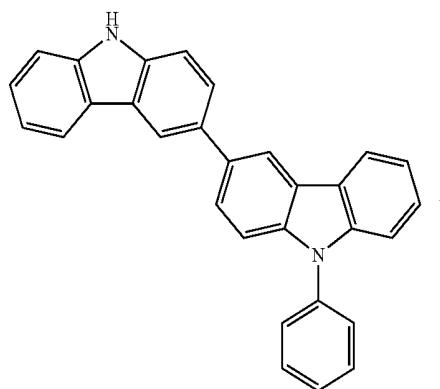
[0615] 15.00 g (37.66 mmol) of 3-bromo-N-methylbiphenylcarbazole, 16.77 g (37.66 mmol) of 3-boronic ester-N-biphenyl carbazole, 200 mL of a mixture of tetrahydrofuran (THF) and toluene (1:1), and 100 mL of an aqueous solution of 2M potassium carbonate were mixed in a 500 mL round-bottom flask equipped with a stirrer in a nitrogen atmosphere, and 2.18 g (1.88 mmol) of tetrakis(triphenylphosphine)palladium (0) was added thereto, and heated under reflux in a nitrogen atmosphere for 12 hours. After completion of the reaction, the reaction product was added to methanol to obtain a solid by filtering. This solid was sufficiently washed with water and methanol, and then dried. The resulting product was dissolved in 500 mL of chlorobenzene by heating, followed by filtration using silica gel and removing the solvent. The resulting product was dissolved in 400 mL of toluene by heating, followed by recrystallization to obtain Compound A17 (16.07 g, Yield: 67%).

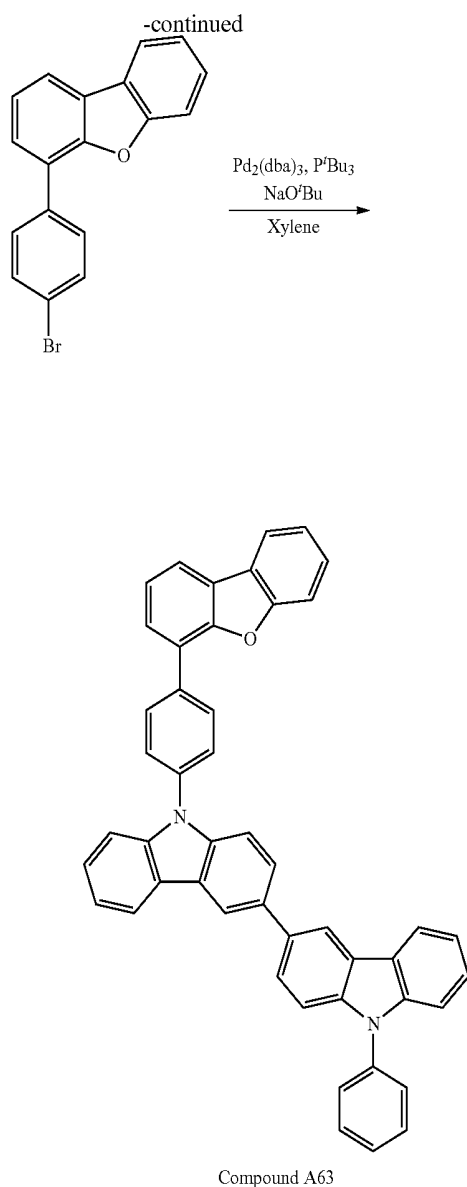
[0616] calcd.  $C_{48}H_{32}N_2$ : C, 90.54; H, 5.07; N, 4.40. found: C, 90.71; H, 5.01; N, 4.27.

#### Synthesis Example ad-38

#### Synthesis of Compound A63

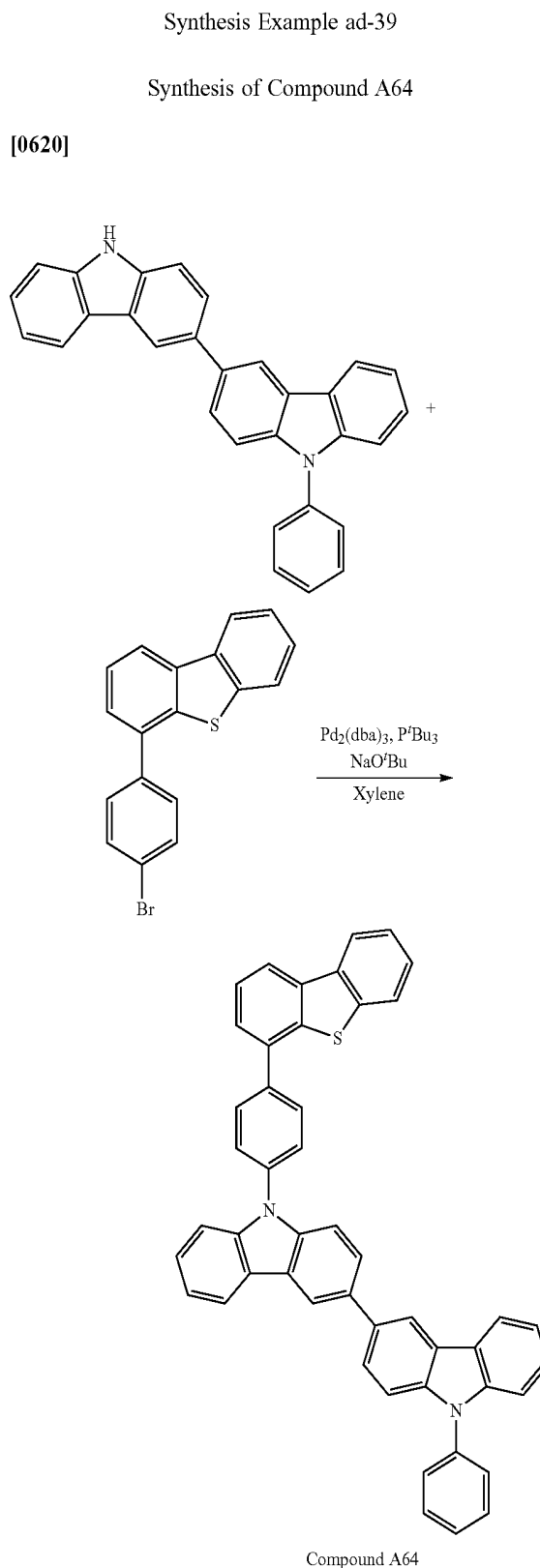
[0617]





**[0618]** 6.3 g (15.4 mmol) of N-phenyl-3,3'-bicarbazole, 5.0 g (15.4 mmol) of 4-(4-bromophenyl)dibenzo[b,d]furan, 3.0 g (30.7 mmol) of sodium t-butoxide, 0.9 g (1.5 mmol) of tris(dibenzylideneacetone)dipalladium, and 1.2 mL (50% in toluene) of tri t-butylphosphine were added to 100 mL of xylene in a 250 mL round-bottom flask, and heated under reflux in a nitrogen atmosphere for 15 hours. The resulting mixture was added to 300 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in monochlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate A63 (7.3 g, Yield: 73%).

**[0619]** calcd. C<sub>48</sub>H<sub>30</sub>N<sub>2</sub>O: C, 88.59; H, 4.65; N, 4.30; O, 2.46. found: C, 88.56; H, 4.62; N, 4.20; O, 2.43.



**[0621]** 6.1 g (15.0 mmol) of N-phenyl-3,3'-bicarbazole, 5.1 g (15.0 mmol) of 4-(4-bromophenyl)dibenzo[b,d]thiophene, 2.9 g (30.0 mmol) of sodium t-butoxide, 0.9 g (1.5 mmol) of tris(dibenzylideneacetone)dipalladium, and 1.2 mL (50% in toluene) of tri t-butylphosphine were added to 100 mL of

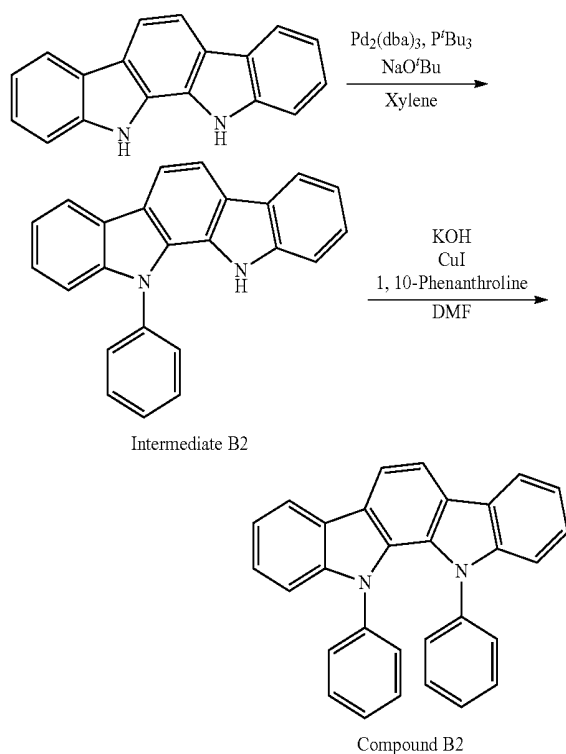
xylene in a 250 mL round-bottom flask, and then heated under reflux in a nitrogen atmosphere for 15 hours. The resulting mixture was added to 300 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in monochlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate A64 (6.7 g, Yield: 67%).

**[0622]** calcd. C<sub>48</sub>H<sub>30</sub>N<sub>2</sub>S: C, 86.46; H, 4.53; N, 4.20; S, 4.81. found: C, 86.41; H, 4.51; N, 4.18; S, 4.80.

### Synthesis Example 19

#### Synthesis of Compound B2

**[0623]**



#### Synthesis of Intermediate B2

**[0624]** 39.99 g (156.01 mmol) of indolocarbazole, 26.94 g (171.61 mmol) of bromobenzene, 22.49 g (234.01 mmol) of sodium t-butoxide, 4.28 g (4.68 mmol) of tris(dibenzylideneacetone)dipalladium, and 2.9 mL of tri-*t*-butylphosphine (50% in toluene) were added to 500 mL of xylene in a 1000 mL round-bottom flask, and mixed and heated under reflux in a nitrogen atmosphere for 15 hours. The resulting mixture was added to 1000 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in dichlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain the intermediate B2 (23.01 g, Yield: 44%). calcd. C<sub>24</sub>H<sub>16</sub>N<sub>2</sub>: C, 86.72; H, 4.85; N, 8.43. found: C, 86.72; H, 4.85; N, 8.43.

#### Synthesis of Compound B2

**[0625]** 22.93 g (69.03 mmol) of the intermediate B2, 11.38 g (72.49 mmol) of bromobenzene, 4.26 g (75.94 mmol) of potassium hydroxide, 13.14 g (69.03 mmol) of copper iodide, and 6.22 g (34.52 mmol) of 1,10-phenanthroline were added to 230 mL of dimethylformamide (DMF) in a 500 mL round-bottom flask, and heated under reflux in a nitrogen atmosphere for 15 hours. The resulting mixture was added to 1000 mL of methanol to obtain crystalline solid powder by filtering. The resulting product was dissolved in dichlorobenzene and filtered using silica gel/Celite, followed by removing an appropriate amount of the organic solvent and recrystallization with methanol to obtain Compound B2 (12.04 g, Yield: 43%). calcd. C<sub>30</sub>H<sub>20</sub>N<sub>2</sub>: C, 88.21; H, 4.93; N, 6.86. found: C, 88.21; H, 4.93; N, 6.86.

#### Evaluation Example 1

##### Evaluation of HOMO, LUMO, and Triplet (T1) Energy Levels of Synthesized Compounds

**[0626]** The highest occupied molecular orbital (HOMO) energy levels, lowest unoccupied molecular orbital (LUMO) energy levels, and T1 energy levels of the synthesized compounds were evaluated according to the methods described in Table 2 below. The results are shown in Table 1.

TABLE 2

HOMO energy level evaluation method	Each of the compounds was diluted in CHCl <sub>3</sub> to a concentration of $1 \times 10^{-5}$ M, and then UV absorption spectra thereof were measured at room temperature using a spectrometer (Shimadzu UV-350 Spectrometer). A HOMO energy level of the compound was calculated based on the optical band gap (E <sub>g</sub> ) of the absorption spectrum edge.
LUMO energy level evaluation method	A potential (V)-current (A) plot of each of the compounds was obtained using cyclic voltammetry (CV) (Electrolyte: 0.1M Bu <sub>4</sub> NClO <sub>4</sub> /Solvent: CH <sub>2</sub> Cl <sub>2</sub> / Electrode: 3-electrode system (working electrode: GC, reference electrode: Ag/AgCl, auxiliary electrode: Pt)), and a LUMO energy of the compound was calculated based on the reduction onset potential in the potential-current plot.
T1 energy level evaluation method	A mixture of each of the compounds and toluene (prepared by dissolving 1 mg of the compound in 3 cc of toluene) was put in a quartz cell, which was then placed in liquid nitrogen (77K) for photoluminescence spectroscopy. Photoluminescence spectra of the compounds were measured using a photoluminescence spectrometer, and then compared with those at room temperature to analyze only peaks appearing at low temperature. A T1 energy level of each of the compounds was calculated based on the low-temperature peaks.

#### Evaluation Example 2

##### Thermal Characteristics Evaluation of Compounds

**[0627]** Thermal analysis of each of the synthesized compounds was performed using thermo gravimetric analysis (TGA) and differential scanning calorimetry (DSC) (N<sub>2</sub> atmosphere, temperature range: room temperature to 800° C. (10° C./min)-TGA, room temperature to 400° C.-DSC, Pan Type: Pt Pan in disposable Al Pan (TGA), disposable Al

pan (DSC)). The results are shown in Table 3. Referring to Table 3, the synthesized compounds were found to have good thermal stabilities.

TABLE 3

Compound No.	T <sub>g</sub>	T <sub>c</sub>	T <sub>m</sub>
5	105	179	238
16	121	211	260
9	130	214	278
37	102	174	232
40	110	176	234
21	119	204	257
12	123	215	265
13	124	219	260
18	129	224	267
11	90	153	221
45	117	209	256
48	114	201	248

### Manufacture of Organic Light-Emitting Device

#### Emission Layer Device 1

##### Single Host

##### Example 1

**[0628]** An glass substrate with an ITO electrode was cut to a size of 50 mm×50 mm×0.5 mm, washed by sonication in acetone isopropyl alcohol and then in pure water each for 15 minutes, and washed with UV ozone for 30 minutes. m-MT-DATA was vacuum-deposited on the ITO electrode on the glass substrate at a deposition rate of 1 Å/sec to form an HIL having a thickness of 600 Å, and then α-NPB was vacuum-deposited on the HIL at a deposition rate of 1 Å/sec to form a HTL having a thickness of 300 Å. Subsequently, Ir(ppy)<sub>3</sub> (dopant) and Compound 9 (host) were co-deposited on the HTL at a deposition rate of 0.1 Å/sec and 1 Å/sec, respectively, to form an EML having a thickness of 400 Å. BA1q was vacuum-deposited on the EML at a deposition rate of 1 Å/sec to form an hole blocking layer (HBL) having a thickness of 50 Å, and then Alq<sub>3</sub> was vacuum-deposited on the HBL to form a HTL having a thickness of 300 Å. LiF and Al were sequentially vacuum-deposited on the ETL to form an EIL having a thickness of 10 Å and a cathode having a thickness of 2000 Å, respectively, thereby manufacturing an organic light-emitting device.

##### Example 2

**[0629]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 16, instead of Compound 9, was used as a host to form the EML.

##### Example 3

**[0630]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 48, instead of Compound 9, was used as a host to form the EML.

##### Example ad-1

**[0631]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 37, instead of Compound 9, was used as a host to form the EML.

##### Example ad-2

**[0632]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 40, instead of Compound 9, was used as a host to form the EML.

##### Example ad-3

**[0633]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 45, instead of Compound 9, was used as a host to form the EML.

##### Example ad-4

**[0634]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 5, instead of Compound 9, was used as a host to form the EML.

##### Example ad-5

**[0635]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 8, instead of Compound 9, was used as a host to form the EML.

##### Example ad-6

**[0636]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 11, instead of Compound 9, was used as a host to form the EML.

##### Example ad-7

**[0637]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 12, instead of Compound 9, was used as a host to form the EML.

##### Example ad-8

**[0638]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 13, instead of Compound 9, was used as a host to form the EML.

##### Example ad-9

**[0639]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 16, instead of Compound 9, was used as a host to form the EML.

##### Example ad-10

**[0640]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 18, instead of Compound 9, was used as a host to form the EML.

##### Example ad-11

**[0641]** An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 21, instead of Compound 9, was used as a host to form the EML.



## Example ad-32

[0662] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound a-84, instead of Compound 9, was used as a host to form the EML.

## Example ad-33

[0663] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound a-85, instead of Compound 9, was used as a host to form the EML.

## Example ad-34

[0664] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound a-87, instead of Compound 9, was used as a host to form the EML.

## Example ad-35

[0665] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound a-91, instead of Compound 9, was used as a host to form the EML.

## Example ad-36

[0666] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound a-95, instead of Compound 9, was used as a host to form the EML.

## Example ad-37

[0667] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound b-77, instead of Compound 9, was used as a host to form the EML.

## Example ad-38

[0668] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound b-84, instead of Compound 9, was used as a host to form the EML.

## Example ad-39

[0669] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound e-10, instead of Compound 9, was used as a host to form the EML.

## Example ad-40

[0670] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound e-15, instead of Compound 9, was used as a host to form the EML.

## Example ad-41

[0671] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound e-23, instead of Compound 9, was used as a host to form the EML.

## Example ad-42

[0672] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound e-73, instead of Compound 9, was used as a host to form the EML.

## Example ad-43

[0673] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound e-84, instead of Compound 9, was used as a host to form the EML.

## Example ad-44

[0674] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound f-10, instead of Compound 9, was used as a host to form the EML.

## Example ad-45

[0675] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound f-15, instead of Compound 9, was used as a host to form the EML.

## Example ad-46

[0676] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound f-23, instead of Compound 9, was used as a host to form the EML.

## Example ad-47

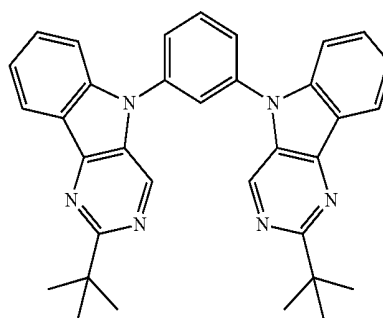
[0677] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound f-73, instead of Compound 9, was used as a host to form the EML.

## Example ad-48

[0678] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound f-84, instead of Compound 9, was used as a host to form the EML.

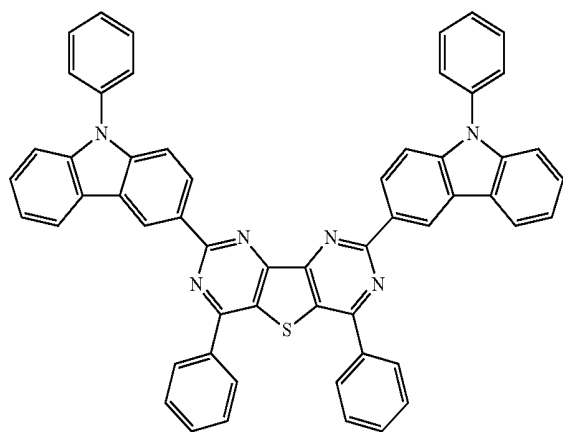
## Comparative Example 1

[0679] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound A, instead of Compound 9, was used as a host to form the EML. <Compound A>



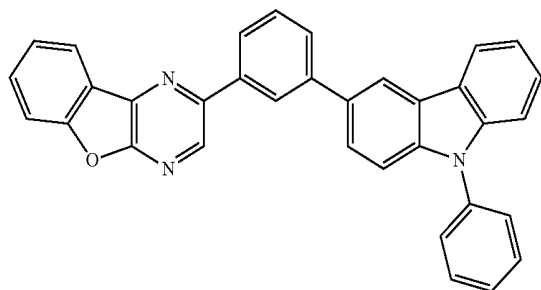
## Comparative Example 2

[0680] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound B, instead of Compound 9, was used as a host to form the EML. <Compound B>



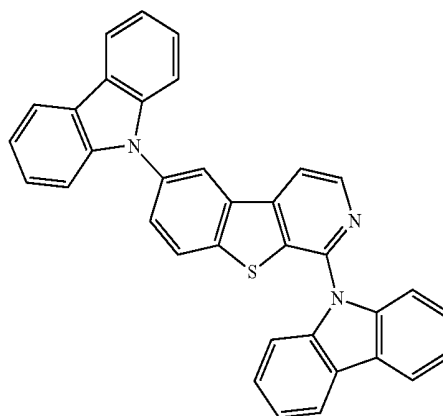
## Comparative Example 3

[0681] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound C, instead of Compound 9, was used as a host to form the EML. <Compound C>



## Comparative Example 4

[0682] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound D, instead of Compound 9, was used as a host to form the EML. <Compound D>



## Evaluation Example 3

## Characteristics Evaluation of Organic Light-Emitting Devices (I)

[0683] Driving voltages, current efficiencies, and luminances of the organic light-emitting devices of Examples 1 to 3, ad-1, ad-3 to ad-22, ad-25 to ad-48, and Comparative Examples 1 to 4 were measured using a PR650 (Spectroscan) Source Measurement Unit (available from Photo Research, Inc.) while supplying power using a Keithley Source-Measure Unit (SMU 236). The results are shown in Table 4 below.

[0684] (1) Measurement of Current Density Change Depending on Voltage Change

[0685] Current of each organic light-emitting device was measured by increasing a voltage from 0 V to 10 V by using a current-voltage meter (Keithley 2400), and the measured current value was divided by an area to provide the results.

[0686] (2) Measurement of Luminance Change Depending on Voltage Change

[0687] Luminance of each organic light-emitting device was measured by increasing a voltage from 0 V to 10 V by using a luminance meter (Minolta Cs-1000A).

[0688] (3) Measurement of Luminous Efficiency

[0689] The luminance and current density obtained from the above (1) and (2) and a voltage were used to calculate current efficiency (cd/A) at the same current density (10 mA/cm<sup>2</sup>).

TABLE 4

	Host	Dopant	Driving voltage (V)	Current efficiency (cd/A)	Luminance (cd/m <sup>2</sup> )
Example 1	compound 9	Ir(ppy) <sub>3</sub>	4.3	46	6000
Example 2	compound 16	Ir(ppy) <sub>3</sub>	4.5	51	6000
Example 3	compound 29	Ir(ppy) <sub>3</sub>	4.3	35	6000
Example ad-1	compound 37	Ir(ppy) <sub>3</sub>	4.9	38	6000
Example ad-3	compound 45	Ir(ppy) <sub>3</sub>	4.7	40	6000
Example ad-4	compound 5	Ir(ppy) <sub>3</sub>	4.9	40	6000
Example ad-5	compound 8	Ir(ppy) <sub>3</sub>	5.0	41	6000
Example ad-6	compound 11	Ir(ppy) <sub>3</sub>	4.7	42	6000
Example ad-7	compound 12	Ir(ppy) <sub>3</sub>	4.8	43	6000
Example ad-8	compound 13	Ir(ppy) <sub>3</sub>	4.5	43	6000
Example ad-9	compound 16	Ir(ppy) <sub>3</sub>	4.4	47	6000
Example ad-10	compound 18	Ir(ppy) <sub>3</sub>	4.6	44	6000
Example ad-11	compound 21	Ir(ppy) <sub>3</sub>	4.2	53	6000

TABLE 4-continued

	Host	Dopant	Driving voltage (V)	Current efficiency (cd/A)	Luminescence (cd/m <sup>2</sup> )
Example ad-12	compound a-9	Ir(ppy) <sub>3</sub>	4.2	52	6000
Example ad-13	compound a-10	Ir(ppy) <sub>3</sub>	4.4	45	6000
Example ad-14	compound a-12	Ir(ppy) <sub>3</sub>	4.4	46	6000
Example ad-15	compound a-13	Ir(ppy) <sub>3</sub>	4.5	48	6000
Example ad-16	compound a-31	Ir(ppy) <sub>3</sub>	4.6	47	6000
Example ad-17	compound a-32	Ir(ppy) <sub>3</sub>	4.5	43	6000
Example ad-18	compound a-41	Ir(ppy) <sub>3</sub>	4.5	47	6000
Example ad-19	compound a-45	Ir(ppy) <sub>3</sub>	4.7	43	6000
Example ad-20	compound a-47	Ir(ppy) <sub>3</sub>	4.9	44	6000
Example ad-21	compound a-49	Ir(ppy) <sub>3</sub>	4.8	42	6000
Example ad-22	compound c-9	Ir(ppy) <sub>3</sub>	4.6	39	6000
Example ad-25	compound e-9	Ir(ppy) <sub>3</sub>	4.5	43	6000
Example ad-26	compound f-9	Ir(ppy) <sub>3</sub>	4.4	45	6000
Example ad-27	compound a-73	Ir(ppy) <sub>3</sub>	4.0	53	6000
Example ad-28	compound a-74	Ir(ppy) <sub>3</sub>	4.1	52	6000
Example ad-29	compound a-75	Ir(ppy) <sub>3</sub>	4.3	48	6000
Example ad-30	compound a-79	Ir(ppy) <sub>3</sub>	4.2	49	6000
Example ad-31	compound a-82	Ir(ppy) <sub>3</sub>	4.2	49	6000
Example ad-32	compound a-84	Ir(ppy) <sub>3</sub>	4.0	51	6000
Example ad-33	compound a-85	Ir(ppy) <sub>3</sub>	4.2	47	6000
Example ad-34	compound a-87	Ir(ppy) <sub>3</sub>	4.2	48	6000
Example ad-35	compound a-91	Ir(ppy) <sub>3</sub>	4.4	47	6000
Example ad-36	compound a-95	Ir(ppy) <sub>3</sub>	4.1	52	6000
Example ad-37	compound b-77	Ir(ppy) <sub>3</sub>	4.2	50	6000
Example ad-38	compound b-84	Ir(ppy) <sub>3</sub>	4.3	51	6000
Example ad-39	compound e-10	Ir(ppy) <sub>3</sub>	4.5	45	6000
Example ad-40	compound e-15	Ir(ppy) <sub>3</sub>	4.2	49	6000
Example ad-41	compound e-23	Ir(ppy) <sub>3</sub>	4.4	49	6000
Example ad-42	compound e-73	Ir(ppy) <sub>3</sub>	4.2	50	6000
Example ad-43	compound e-84	Ir(ppy) <sub>3</sub>	4.1	50	6000
Example ad-44	compound f-10	Ir(ppy) <sub>3</sub>	4.4	46	6000
Example ad-45	compound f-15	Ir(ppy) <sub>3</sub>	4.2	51	6000
Example ad-46	compound f-23	Ir(ppy) <sub>3</sub>	4.3	48	6000
Example ad-47	compound f-73	Ir(ppy) <sub>3</sub>	4.1	51	6000
Example ad-48	compound f-84	Ir(ppy) <sub>3</sub>	4.0	51	6000
Comparative Example 1	compound A	Ir(ppy) <sub>3</sub>	5.0	38	6000
Comparative Example 2	compound B	Ir(ppy) <sub>3</sub>	5.1	29	6000
Comparative Example 3	compound C	Ir(ppy) <sub>3</sub>	4.8	34	6000
Comparative Example 4	compound D	Ir(ppy) <sub>3</sub>	4.8	31	6000

[0690] From the Table 4, the organic light-emitting devices according to Examples 1 to 3, ad-1, ad-3 to ad-22, and ad-25 to ad-48 showed a low driving voltage and high

efficiency compared with the organic light-emitting devices according to Comparative Examples 1 to 4.

[0691] They have excellent charge transport characteristics as a phosphorescent host material, may overlap with the spectrum of a dopant well, improves performance such as efficiency increase and decrease of a driving voltage, and maximizes its performance as an OLED material.

#### Manufacture of Organic Light-Emitting Device (Emission Layer of Device-Mixed Host)

##### Example 4

[0692] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Ir(ppy)<sub>3</sub> (dopant), Compound 16 (first host), and Compound A1 (second host) were co-deposited in a weight ratio of 10:45:45 on the HTL to form the EML having a thickness of 400 Å.

##### Example 5

[0693] An organic light-emitting device was manufactured in the same manner as in Example 4, except that Compound A2, instead of Compound A1, was used to form the EML.

##### Example 6

[0694] An organic light-emitting device was manufactured in the same manner as in Example 4, except that Compound A5, instead of Compound A1, was used to form the EML.

##### Example 7

[0695] An organic light-emitting device was manufactured in the same manner as in Example 4, except that Compound A15, instead of Compound A1, was used to form the EML.

##### Example 8

[0696] An organic light-emitting device was manufactured in the same manner as in Example 4, except that Compound A17, instead of Compound A1, was used to form the EML.

##### Example 9

[0697] An organic light-emitting device was manufactured in the same manner as in Example 4, except that Compound B2, instead of Compound A1, was used to form the EML.

##### Example 10

[0698] An organic light-emitting device was manufactured in the same manner as in Example 4, except that Compound 48, instead of Compound 16, was used to form the EML.

##### Example ad-49

[0699] An organic light-emitting device was manufactured in the same manner as in Example 10, except that Compound A17, instead of Compound A1, was used to form the EML.

## Example ad-50

[0700] An organic light-emitting device was manufactured in the same manner as in Example 4, except that Compound a-9, instead of Compound 16, was used to form the EML.

## Example ad-51

[0701] An organic light-emitting device was manufactured in the same manner as in Example ad-50, except that Compound A2, instead of Compound A1, was used to form the EML.

## Example ad-52

[0702] An organic light-emitting device was manufactured in the same manner as in Example ad-50, except that Compound A5, instead of Compound A1, was used to form the EML.

## Example ad-53

[0703] An organic light-emitting device was manufactured in the same manner as in Example ad-50, except that Compound A15, instead of Compound A1, was used to form the EML.

## Example ad-54

[0704] An organic light-emitting device was manufactured in the same manner as in Example ad-50, except that Compound A17, instead of Compound A1, was used to form the EML.

## Example ad-55

[0705] An organic light-emitting device was manufactured in the same manner as in Example ad-50, except that Compound B2, instead of Compound A1, was used to form the EML.

## Example ad-56

[0706] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound 18, instead of Compound 16, was used to form the EML.

## Example ad-57

[0707] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound a-10, instead of Compound 16, was used to form the EML.

## Example ad-58

[0708] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound a-31, instead of Compound 16, was used to form the EML.

## Example ad-59

[0709] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound a-32, instead of Compound 16, was used to form the EML.

## Example ad-60

[0710] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound a-73, instead of Compound 16, was used to form the EML.

## Example ad-61

[0711] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound a-84, instead of Compound 16, was used to form the EML.

## Example ad-62

[0712] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound b-77, instead of Compound 16, was used to form the EML.

## Example ad-63

[0713] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound b-84, instead of Compound 16, was used to form the EML.

## Example ad-64

[0714] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound e-15, instead of Compound 16, was used to form the EML.

## Example ad-65

[0715] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound e-73, instead of Compound 16, was used to form the EML.

## Example ad-66

[0716] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound e-84, instead of Compound 16, was used to form the EML.

## Example ad-67

[0717] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound f-15, instead of Compound 16, was used to form the EML.

## Example ad-68

[0718] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound f-73, instead of Compound 16, was used to form the EML.

## Example ad-69

[0719] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound f-84, instead of Compound 16, was used to form the EML.

## Example ad-70

[0720] An organic light-emitting device was manufactured in the same manner as in Example 4, except that Ir(ppy)<sub>3</sub> (dopant), Compound a-73 (first host), and Compound A64 (second host) were co-deposited in a weight ratio of 10:45:45 on the HTL to form the EML having a thickness of 400 Å.

## Example ad-71

[0721] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound a-84, instead of Compound a-73, was used to form the EML.

## Example ad-72

[0722] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound b-77, instead of Compound a-73, was used to form the EML.

## Example ad-73

[0723] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound b-84, instead of Compound a-73, was used to form the EML.

## Example ad-74

[0724] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound e-15, instead of Compound a-73, was used to form the EML.

## Example ad-75

[0725] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound e-73, instead of Compound a-73, was used to form the EML.

## Example ad-76

[0726] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound e-84, instead of Compound a-73, was used to form the EML.

## Example ad-77

[0727] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound f-15, instead of Compound a-73, was used to form the EML.

## Example ad-78

[0728] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound f-73, instead of Compound a-73, was used to form the EML.

## Example ad-79

[0729] An organic light-emitting device was manufactured in the same manner as in Example 8, except that Compound f-84, instead of Compound a-73, was used to form the EML.

## Evaluation Example 4

## Characteristics Evaluation of Organic Light-Emitting Devices (II)

[0730] The driving voltages, efficiency, and luminance of the organic light-emitting devices according to Examples 4 to 10, Examples ad-49 to ad-79, and Comparative Examples 1 to 4 were evaluated using the same method as in the Evaluation Example 3, and the results are shown in the following Table 5.

[0731] T<sub>95</sub> indicates the time taken until an initial luminosity (assumed as 100%) is reduced to 95%.

TABLE 5

	First host	Second host	Dopant	Driving voltage (V)	Current efficiency (cd/A)	Luminance (cd/m <sup>2</sup> )	T <sub>95</sub> Life-span (hr)
Example 4	compound 16	compound A1	Ir(ppy) <sub>3</sub>	4.0	54	6000	70
Example 5	compound 16	compound A2	Ir(ppy) <sub>3</sub>	4.2	50	6000	65
Example 6	compound 16	compound A5	Ir(ppy) <sub>3</sub>	4.3	48	6000	71
Example 7	compound 16	compound A15	Ir(ppy) <sub>3</sub>	4.4	48	6000	85
Example 8	compound 16	compound A17	Ir(ppy) <sub>3</sub>	4.3	49	6000	67
Example 9	compound 16	compound B2	Ir(ppy) <sub>3</sub>	4.5	47	6000	61
Example 10	compound 48	compound A1	Ir(ppy) <sub>3</sub>	4.2	55	6000	50
Example ad-49	compound 48	compound A17	Ir(ppy) <sub>3</sub>	4.5	50	6000	73
Example ad-50	compound a-9	compound A1	Ir(ppy) <sub>3</sub>	4.1	54	6000	82
Example ad-51	compound a-9	compound A2	Ir(ppy) <sub>3</sub>	4.2	52	6000	80
Example ad-52	compound a-9	compound A5	Ir(ppy) <sub>3</sub>	4.3	53	6000	75

TABLE 5-continued

	First host	Second host	Dopant	Driving voltage (V)	Current efficiency (cd/A)	Luminance (cd/m <sup>2</sup> )	T <sub>95</sub> Life-span (hr)
Example ad-53	compound a-9	compound A15	Ir(ppy) <sub>3</sub>	4.4	51	6000	73
Example ad-54	compound a-9	compound A17	Ir(ppy) <sub>3</sub>	4.1	56	6000	85
Example ad-55	compound a-9	compound B2	Ir(ppy) <sub>3</sub>	4.4	52	6000	80
Example ad-56	compound 18	compound A17	Ir(ppy) <sub>3</sub>	4.4	51	6000	80
Example ad-57	compound a-10	compound A17	Ir(ppy) <sub>3</sub>	4.2	54	6000	84
Example ad-58	compound a-31	compound A17	Ir(ppy) <sub>3</sub>	4.4	51	6000	79
Example ad-59	compound a-32	compound A17	Ir(ppy) <sub>3</sub>	4.5	52	6000	76
Example ad-60	compound a-73	compound A17	Ir(ppy) <sub>3</sub>	4.1	55	6000	87
Example ad-61	compound a-84	compound A17	Ir(ppy) <sub>3</sub>	4.2	53	6000	86
Example ad-62	compound b-77	compound A17	Ir(ppy) <sub>3</sub>	4.3	52	6000	84
Example ad-63	compound b-84	compound A17	Ir(ppy) <sub>3</sub>	4.3	51	6000	83
Example ad-64	compound e-15	compound A17	Ir(ppy) <sub>3</sub>	4.3	49	6000	82
Example ad-65	compound e-73	compound A17	Ir(ppy) <sub>3</sub>	4.2	51	6000	80
Example ad-66	compound e-84	compound A17	Ir(ppy) <sub>3</sub>	4.1	53	6000	84
Example ad-67	compound f-15	compound A17	Ir(ppy) <sub>3</sub>	4.2	52	6000	84
Example ad-68	compound f-73	compound A17	Ir(ppy) <sub>3</sub>	4.0	53	6000	86
Example ad-69	compound f-84	compound A17	Ir(ppy) <sub>3</sub>	4.1	52	6000	85
Example ad-70	compound a-73	compound A64	Ir(ppy) <sub>3</sub>	4.0	56	6000	89
Example ad-71	compound a-84	compound A64	Ir(ppy) <sub>3</sub>	4.1	54	6000	86
Example ad-72	compound b-77	compound A64	Ir(ppy) <sub>3</sub>	4.2	53	6000	85
Example ad-73	compound b-84	compound A64	Ir(ppy) <sub>3</sub>	4.3	51	6000	83
Example ad-74	compound e-15	compound A64	Ir(ppy) <sub>3</sub>	4.2	52	6000	82
Example ad-75	compound e-73	compound A64	Ir(ppy) <sub>3</sub>	4.1	53	6000	84
Example ad-76	compound e-84	compound A64	Ir(ppy) <sub>3</sub>	4.1	54	6000	86
Example ad-77	compound f-15	compound A64	Ir(ppy) <sub>3</sub>	4.0	55	6000	86
Example ad-78	compound f-73	compound A64	Ir(ppy) <sub>3</sub>	3.9	55	6000	89
Example ad-79	compound f-84	compound A64	Ir(ppy) <sub>3</sub>	4.1	53	6000	87
Comparative Example 1		compound A	Ir(ppy) <sub>3</sub>	5.0	38	6000	—
Comparative Example 2		compound B	Ir(ppy) <sub>3</sub>	5.1	29	6000	—
Comparative Example 3		compound C	Ir(ppy) <sub>3</sub>	4.8	34	6000	—
Comparative Example 4		compound D	Ir(ppy) <sub>3</sub>	4.8	31	6000	—

[0732] From the Table 5, the organic light-emitting devices according to Examples 4 to 10, and ad-49 to ad-79 showed a lower driving voltage, high efficiency, and long life-span.

#### Manufacture of Organic Light-Emitting Device

##### Emission Layer Device 2

##### Single Host

##### Example ad-80

[0733] An organic light-emitting device was manufactured by using a-49 according to Synthesis Example ad-10 as a host and  $(\text{piq})_2\text{Ir}(\text{acac})$  as a dopant.

[0734] As for an anode, a 1000 Å-thick ITO was used, and as for a cathode, a 1000 Å-thick aluminum (Al) was used. Specifically, a method of manufacturing the organic light-emitting device used an anode obtained by cutting an ITO glass substrate having sheet resistance of  $15 \Omega/\text{cm}^2$  into a size of  $50 \text{ mm} \square 50 \text{ mm} \square 0.7 \text{ mm}$ , ultrasonic wave-cleaning it with acetone, isopropyl alcohol and pure water for 15 minutes respectively and UV ozone-cleaning it for 30 minutes.

[0735] On the substrate, a 800 Å-thick hole transport layer (HTL) was formed by depositing N4,N4'-di(naphthalene-1-yl)-N4,N4'-diphenylbiphenyl-4,4'-diamine (NPB) (80 nm) with a vacuum degree of  $650 \square 10^{-7} \text{ Pa}$  at a deposition rate of 0.1 to 0.3 nm/s. Subsequently, a 300 Å-thick emission layer was formed thereon by using B-75 of Synthesis Example 26 under the same deposit condition, and herein,  $(\text{piq})_2\text{Ir}(\text{acac})$  as a phosphorescent dopant was simultaneously deposited therewith.

[0736] Herein, 3 wt % of the phosphorescent dopant based on 100 wt % of the emission layer was deposited by adjusting its deposition rate.

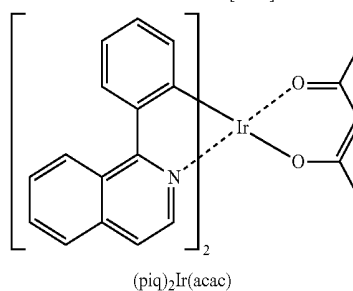
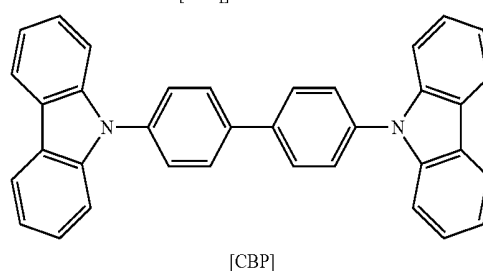
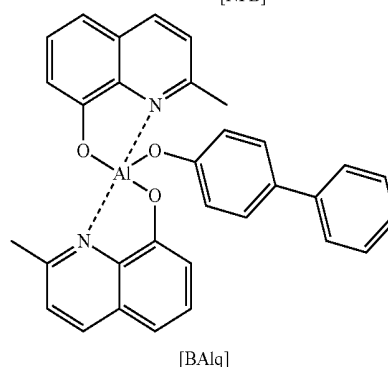
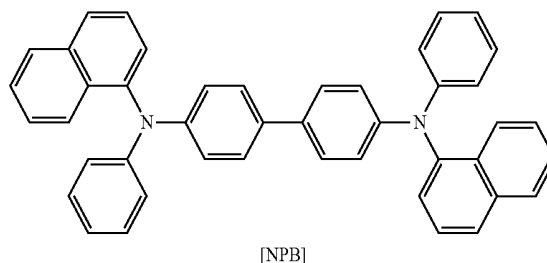
[0737] Then, a 50 Å-thick hole blocking layer was formed by using bis(2-methyl-8-quinolinolate)-4-(phenylphenolato) aluminum (BALq) on the emission layer under the same vacuum deposition condition. Subsequently, a 200 Å-thick electron transport layer was formed thereon by depositing Alq3 under the same vacuum deposition condition. On the electron transport layer (ETL), a cathode was formed by sequentially depositing LiF and Al, manufacturing an organic optoelectronic device.

[0738] The organic optoelectronic device has a structure of ITO/NPB (80 nm)/EML (B-75 (97 중량 %) +  $(\text{piq})_2\text{Ir}(\text{acac})$  (3 wt %), 30 nm)/Balq (5 nm)/Alq3 (20 nm)/LiF (1 nm)/Al (100 nm).

##### Comparative Example ad-1

[0739] An organic light-emitting device was manufactured according to the same method as Example ad-80 except for using CBP having the following structure instead of the compound a-49 of Example ad-80.

[0740] NPB, BALq, CBP and  $(\text{piq})_2\text{Ir}(\text{acac})$  used to manufacture the organic light-emitting device have a structure as follows.



##### Evaluation Example 5

##### Characteristics of Organic Light-Emitting Device (III)

[0741] The driving voltages, efficiency, and luminance of the organic light-emitting devices according to Example ad-80, and Comparative Example ad-1 were evaluated using the same method as in the Evaluation Example 4, and the results are shown in the following Table 6.

[0742]  $T_{90}$  life-span indicates the time taken until current efficiency (cd/A) is reduced to 90% at luminance ( $\text{cd}/\text{m}^2$ ) of  $5000 \text{ cd}/\text{m}^2$ .

TABLE 6

No.	Emission layer	Driving voltage (V)	Color (EL color)	Efficiency (cd/A)	90% life-span (h) at 5000 cd/m <sup>2</sup>
Comparative Example ad-1	CBP	6.4	red	6.0	25
Example ad-80	a-49	5.3	red	12.7	73

[0743] As shown in Table 6, the organic light-emitting device according to Example ad-80 showed an improved driving voltage, luminous efficiency and/or power efficiency compared with the organic light-emitting device according to Comparative Example ad-1.

#### Manufacture of Organic Light-Emitting Device (ETB Device)

##### Example ad-81

[0744] A glass substrate coated with a 1500 Å-thick ITO (Indium tin oxide) thin film was washed with distilled water/ultrasonic wave. The washed glass substrate was ultrasonic wave-washed with a solvent such as isopropyl alcohol, acetone, methanol and the like, dried, delivered to a plasma cleaner, cleaned by using an oxygen plasma therein, cleaned it for 10 minutes, and delivered to a vacuum depositor. This obtained ITO transparent electrode was used as an anode, and a 1400 Å-thick hole injection and transport layer was formed thereon by depositing HT13. Subsequently, on the hole transport layer (HTL), a 200 Å-thick emission layer was formed by doping BH113 and BD370 made by SFC Co. Ltd. as a blue florescent light-emitting host and dopant in an amount of 5 wt %.

[0745] Then, on the emission layer, a 50 Å-thick electron transport auxiliary layer was formed by depositing the compound 48 of Synthesis Example 5. On the electron transport auxiliary layer, a 310 Å-thick electron transport layer (ETL) was formed by vacuum-depositing tris(8-hydroxyquinoline) aluminum (Alq3), and a cathode was formed by sequentially vacuum-depositing 15 Å-thick Liq and 1200 Å-thick Al on the electron transport layer (ETL), manufacturing an organic light-emitting device.

[0746] The organic light-emitting device had a five organic thin film-layered structure, specifically

[0747] ITO/HT13(1400 Å)/EML[BH113:BD370=95:5 wt %](200 Å)/compound 48 (50 Å)/Alq3(310 Å)/Liq(15 Å)/Al (1200 Å).

##### Example ad-82

[0748] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound 16 of Synthesis Example 1 instead of the compound 5 of Example ad-81.

##### Example ad-83

[0749] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound 18 of Synthesis Example 10 instead of the compound 5 of Example ad-81.

##### Example ad-84

[0750] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound a-9 of Synthesis Example ad-2 instead of the compound 5 of Example ad-81.

##### Example ad-85

[0751] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound a-10 of Synthesis Example ad-3 instead of the compound 5 of Example ad-81.

##### Example ad-86

[0752] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound a-31 of Synthesis Example ad-6 instead of the compound 5 of Example ad-81.

##### Example ad-87

[0753] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound a-32 of Synthesis Example ad-7 instead of the compound 5 of Example ad-81.

##### Example ad-88

[0754] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound a-45 of Synthesis Example ad-9 instead of the compound 5 of Example ad-81.

##### Example ad-89

[0755] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound a-47 of Synthesis Example ad-10 instead of the compound 5 of Example ad-81.

##### Example ad-90

[0756] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound a-73 of Synthesis Example ad-17 instead of the compound 5 of Example ad-81.

##### Example ad-91

[0757] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound a-84 of Synthesis Example ad-22 instead of the compound 5 of Example ad-81.

##### Example ad-92

[0758] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound b-77 of Synthesis Example ad-27 instead of the compound 5 of Example ad-81.

##### Example ad-93

[0759] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound b-84 of Synthesis Example ad-28 instead of the compound 5 of Example ad-81.

## Example ad-94

[0760] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound e-15 of Synthesis Example ad-30 instead of the compound 5 of Example ad-81.

## Example ad-95

[0761] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound e-73 of Synthesis Example ad-32 instead of the compound 5 of Example ad-81.

## Example ad-96

[0762] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound e-84 of Synthesis Example ad-33 instead of the compound 5 of Example ad-81.

## Example ad-97

[0763] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound f-15 of Synthesis Example ad-10 instead of the compound 5 of Example ad-81.

## Example ad-98

[0764] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound f-73 of Synthesis Example ad-37 instead of the compound 5 of Example ad-81.

## Example ad-99

[0765] An organic light-emitting device was manufactured according to the same method as Example ad-81 except for using the compound f-84 of Synthesis Example ad-38 instead of the compound 5 of Example ad-81.

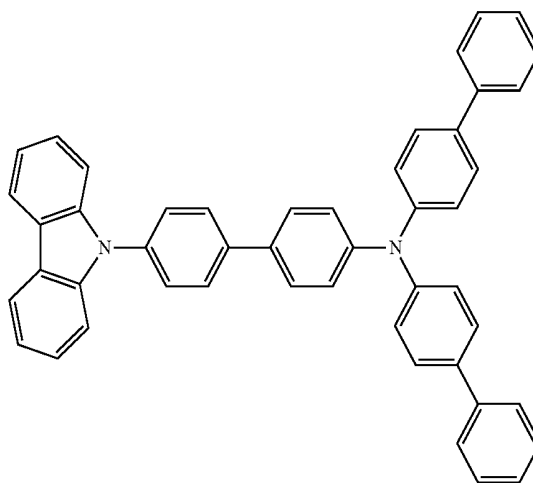
## Example ad-100

[0766] An emission layer was formed by the same method as the method of forming an emission layer of Example ad-81, except that a 1350 Å-thick hole injection and transport layer was formed, and a 50 Å-thick hole transport auxiliary layer on the hole transport layer by vacuum-depositing the compound P-5, instead of forming the 1400 Å-thick hole injection and transport layer. An organic light-emitting device was manufactured according to the same method as Example ad-81 except that an light the compound a-9 of Synthesis Example ad-2 was vacuum-deposited on the emission layer to form a 50 Å-thick electron transport auxiliary layer.

[0767] The organic light-emitting device had a structure of a six-layered organic thin layer, specifically

[0768] ITO/HT13(1350 Å)/P-5(50 Å)/EML[BH113:BD370=95:5 wt %](200 Å)/compound a-9(50 Å)/Alq3(310 Å)/Liq(15 Å)/Al(1200 Å).

[P-5]



## Comparative Example ad-2

[0769] An organic light-emitting device was manufactured according to the same method as Example ad-81 except the electron transport auxiliary layer was not used.

## Evaluation Example 6

## Characteristics Evaluation of Organic Light-Emitting Devices (□)

[0770] The current density and luminance depending on a voltage and luminous efficiency of the organic light-emitting devices according to Examples ad-81 to ad-100, and Comparative Example ad-2 were evaluated using the same method as in the Evaluation Example 4, and the results are shown in the following Tables 7 and Table 8.

[0771]  $T_{97}$  life-spans of the organic light-emitting devices of Example ad-81 to ad-100 and Comparative Example ad-2 were measured as a time when their luminance decreased down to 97% relative to the initial luminance after emitting light with 750 cd/m<sup>2</sup> as the initial luminance (cd/m<sup>2</sup>) and measuring their luminance decrease depending on time with a Polanonix life-span measurement system.

TABLE 7

Devices	Electron transport auxiliary layer	Color coordinate (x, y)	T97 life-span (h) @750nit
Example ad-81	compound 48	(0.133, 0.147)	151
Example ad-82	compound 16	(0.132, 0.148)	161
Example ad-83	compound 18	(0.132, 0.147)	169
Example ad-84	compound a-9	(0.133, 0.147)	197
Example ad-85	compound a-10	(0.133, 0.148)	190
Example ad-86	compound a-31	(0.132, 0.147)	180
Example ad-87	compound a-32	(0.132, 0.148)	185
Example ad-88	compound a-45	(0.133, 0.148)	190
Example ad-89	compound a-47	(0.132, 0.148)	176
Example ad-90	compound a-73	(0.133, 0.148)	194
Example ad-91	compound a-84	(0.133, 0.148)	190
Example ad-92	compound b-77	(0.133, 0.148)	189
Example ad-93	compound b-84	(0.133, 0.148)	190
Example ad-94	compound e-15	(0.133, 0.148)	180
Example ad-95	compound e-73	(0.133, 0.148)	185
Example ad-96	compound e-84	(0.133, 0.148)	184

TABLE 7-continued

Devices	Electron transport auxiliary layer	Color coordinate (x, y)	T97 life-span (h) @750nit
Example ad-97	compound f-15	(0.133, 0.148)	184
Example ad-98	compound f-73	(0.133, 0.148)	190
Example ad-99	compound f-84	(0.133, 0.148)	187
Comparative Example ad-2	None	(0.133, 0.146)	120

[0772] Referring to Table 7, the organic light-emitting devices according to Examples ad-81 to ad-99 showed improved life-span compared with the organic light-emitting device according to Comparative Example ad-2. Accordingly, the electron transport auxiliary layer turned out to improve life-span characteristics of the organic light-emitting device.

TABLE 8

Device	Hole transport auxiliary layer	Electron transport auxiliary layer	Driving voltage	Luminous efficiency	Color coordinate (x, y)	T97 life-span(h) @750nit
Example ad-100	compound P-5	compound a-9	4.23	7.4	(0.136, 0.144)	199
Comparative Example ad-2	—	Not use	5.02	6.8	(0.133, 0.146)	120

[0773] Referring to Table 8, a driving voltage, luminous efficiency and life-span were improved due to a hole transport auxiliary layer.

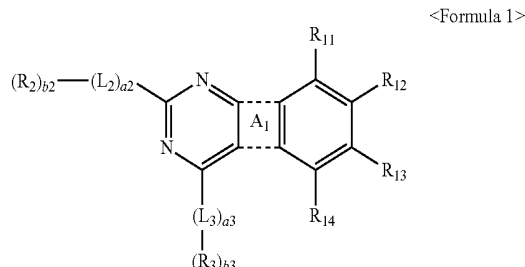
[0774] It should be understood that the exemplary embodiments described therein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

[0775] While one or more embodiments of the present disclosure have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present disclosure as defined by the following claims.

## DESCRIPTION OF SYMBOLS

- [0776] 10: organic photoelectric device  
 [0777] 11: the first electrode  
 [0778] 15: organic layer  
 [0779] 19: the second electrode  
 [0780] 31: hole transport layer (HTL)  
 [0781] 32: emission layer  
 [0782] 33: hole transport auxiliary layer  
 [0783] 34: electron transport layer (ETL)  
 [0784] 35: electron transport auxiliary layer  
 [0785] 36: electron injection layer (EIL)  
 [0786] 37: hole injection layer (HIL)

1. A condensed cyclic compound represented by Formula 1:



wherein, in Formula 1, ring A<sub>1</sub> is represented by Formula 1A,



L<sub>1</sub> to L<sub>3</sub> are each independently selected from a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylene group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroarylene group, and a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, wherein L<sub>2</sub> and L<sub>3</sub> are not a substituted or unsubstituted carbazolyene group, a<sub>1</sub> to a<sub>3</sub> are each independently an integer selected from 0 to 5,

R<sub>1</sub> to R<sub>5</sub> are each independently selected from a hydrogen, a deuterium, a fluoro group (—F), a chloro group (—Cl), a bromo group (—Br), an iodo group (—I), a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> arylthio group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>1</sub>)(Q<sub>2</sub>), —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), and —B(Q<sub>6</sub>)(Q<sub>7</sub>), wherein at least one of R<sub>2</sub> and R<sub>3</sub> is selected from a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

R<sub>11</sub> to R<sub>14</sub> are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a monovalent non-aromatic condensed polycyclic group, and —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>),

wherein R<sub>3</sub> is not a substituted or unsubstituted morpholinyl group;

b1 to b3 are each independently an integer selected from 1 to 3,

at least one of substituents of the substituted C<sub>6</sub>-C<sub>60</sub> arylene group, the substituted C<sub>2</sub>-C<sub>60</sub> heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted C<sub>1</sub>-C<sub>60</sub> alkyl group, the substituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, the substituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, the substituted C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, the substituted C<sub>6</sub>-C<sub>60</sub> aryl group, the substituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, the substituted C<sub>6</sub>-C<sub>60</sub> arylthio group, the substituted C<sub>2</sub>-C<sub>60</sub> heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from

a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group,

a C<sub>1</sub>-C<sub>60</sub> alkyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>11</sub>)(Q<sub>12</sub>), —Si(Q<sub>13</sub>)(Q<sub>14</sub>)(Q<sub>15</sub>), and —B(Q<sub>16</sub>)(Q<sub>17</sub>),

a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group,

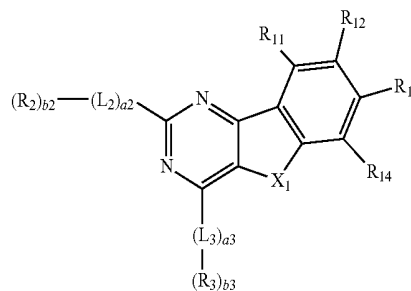
a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>2</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q<sub>21</sub>)(Q<sub>22</sub>), —Si(Q<sub>23</sub>)(Q<sub>24</sub>)(Q<sub>25</sub>), and —B(Q<sub>26</sub>)(Q<sub>27</sub>), and

—N(Q<sub>31</sub>)(Q<sub>32</sub>), —Si(Q<sub>33</sub>)(Q<sub>34</sub>)(Q<sub>35</sub>), and —B(Q<sub>36</sub>)(Q<sub>37</sub>);

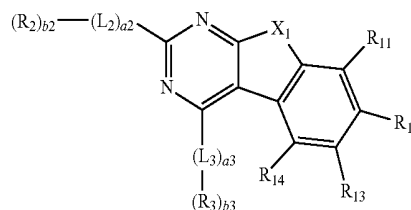
Q<sub>1</sub> to Q<sub>7</sub>, Q<sub>11</sub> to Q<sub>17</sub>, Q<sub>21</sub> to Q<sub>27</sub>, and Q<sub>31</sub> to Q<sub>37</sub> are each independently selected from a hydrogen, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>2</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

2. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound is represented by one of Formulae 1-1 and 1-2:

<Formula 1-1>



<Formula 1-2>

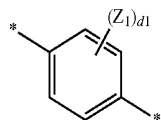


wherein, in Formulae 1-1 to 1-2, X<sub>1</sub>, L<sub>2</sub>, L<sub>3</sub>, a<sub>2</sub>, a<sub>3</sub>, R<sub>2</sub>, R<sub>3</sub>, R<sub>11</sub> to R<sub>14</sub>, b<sub>2</sub> and b<sub>3</sub> are the same as those defined in claim 1.

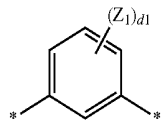
3. The condensed cyclic compound of claim 1, wherein X<sub>1</sub> is S or O.

4. The condensed cyclic compound of claim 1, wherein L<sub>1</sub> to L<sub>3</sub> are each independently represented by one of Formulae 2-1 to 2-11:

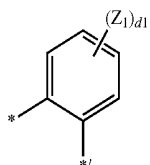
Formula 2-1



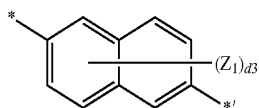
Formula 2-2



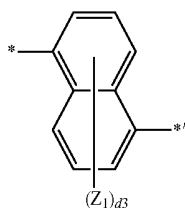
-continued



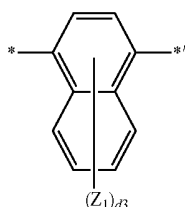
Formula 2-3



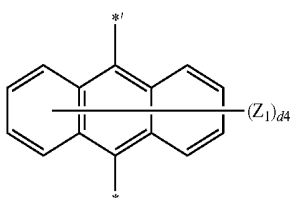
Formula 2-4



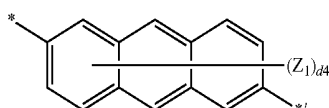
Formula 2-5



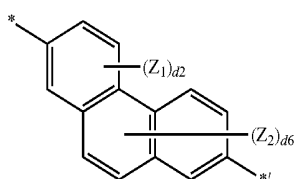
Formula 2-6



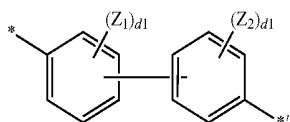
Formula 2-7



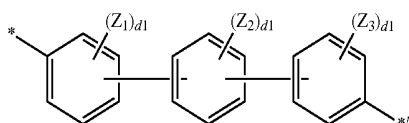
Formula 2-8



Formula 2-9



Formula 2-10



Formula 2-11

C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a triphenylenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazoliny group, a quinoxaliny group, a benzoquinolinyl group, a benzoisoquinolinyl group, a benzoquinazoliny group, a bezoquinoxaliny group, a biphenyl group, and —Si(Q<sub>33</sub>)(Q<sub>34</sub>)(Q<sub>35</sub>), wherein Q<sub>33</sub> to Q<sub>35</sub> are each independently selected from a hydrogen, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazoliny group, a quinoxaliny group, a benzoquinolinyl group, a benzoisoquinolinyl group, a benzoquinazoliny group, and a bezoquinoxaliny group;

d<sub>1</sub> is an integer selected from 1 to 4;

d<sub>2</sub> is an integer selected from 1 to 3;

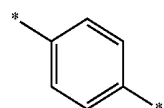
d<sub>3</sub> is an integer selected from 1 to 6;

d<sub>4</sub> is an integer selected from 1 to 8;

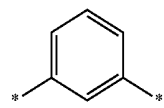
d<sub>6</sub> is an integer selected from 1 to 5; and

\* and \*' are each independently a binding site with an adjacent atom.

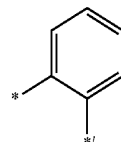
5. The condensed cyclic compound of claim 1, wherein L<sub>1</sub> to L<sub>3</sub> are each independently represented by one of Formulae 3-1 to 3-32:



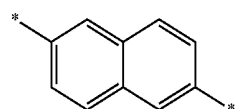
Formula 3-1



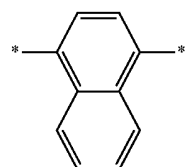
Formula 3-2



Formula 3-3



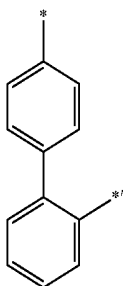
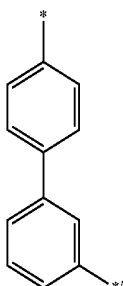
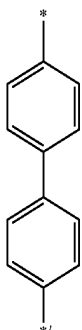
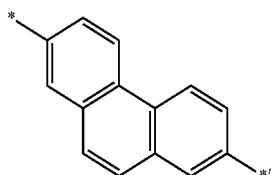
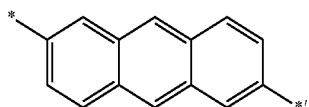
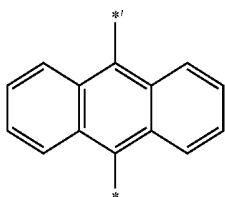
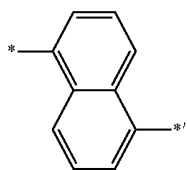
Formula 3-4



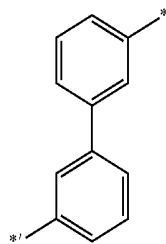
Formula 3-5

wherein, in Formulae 2-1 to 2-11, Z<sub>1</sub> to Z<sub>3</sub> are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino groups, a

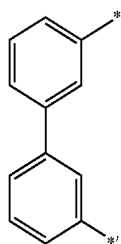
-continued



Formula 3-6



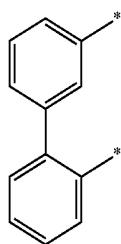
Formula 3-7



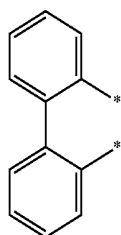
Formula 3-8

Formula 3-9

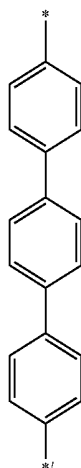
Formula 3-10



Formula 3-11



Formula 3-12



-continued

Formula 3-13

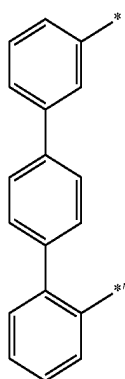
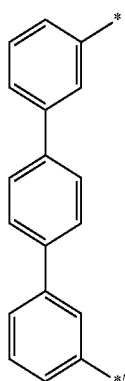
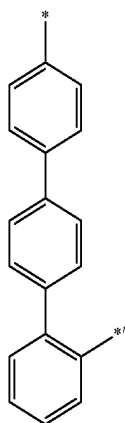
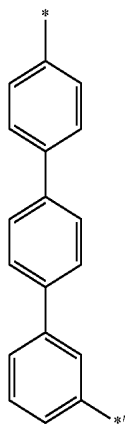
Formula 3-14

Formula 3-15

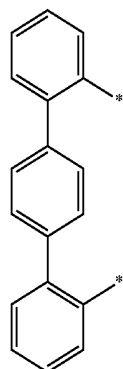
Formula 3-16

Formula 3-17

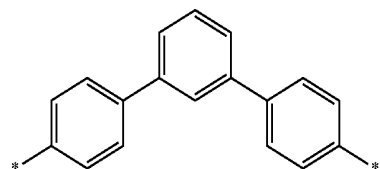
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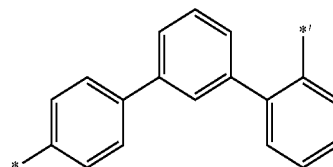
Formula 3-18



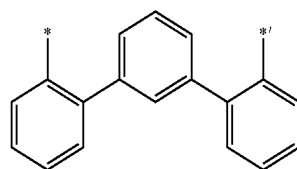
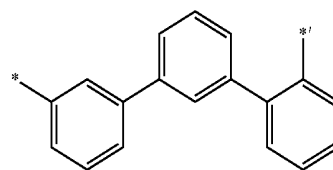
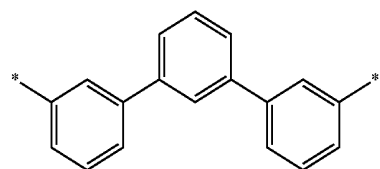
Formula 3-19



Formula 3-20



Formula 3-21



-continued

Formula 3-22

Formula 3-23

Formula 3-24

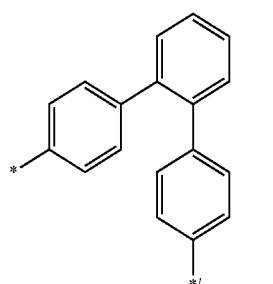
Formula 3-25

Formula 3-26

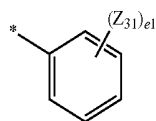
Formula 3-27

Formula 3-28

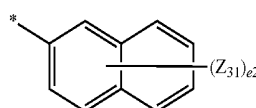
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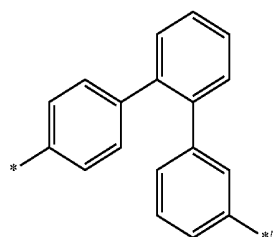
Formula 3-29



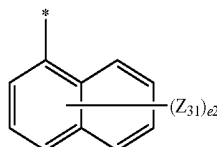
Formula 4-1



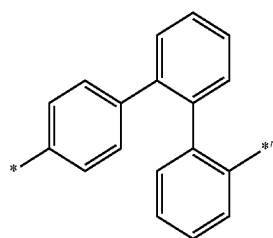
Formula 4-2



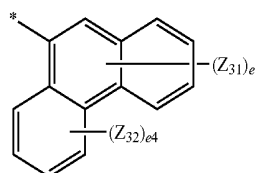
Formula 3-30



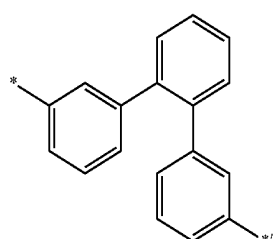
Formula 4-3



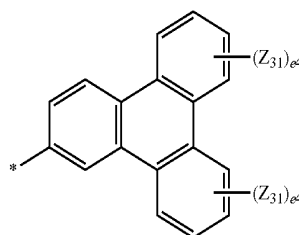
Formula 3-31



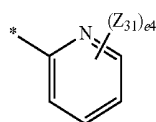
Formula 4-4



Formula 3-32



Formula 4-5



Formula 4-6

wherein, in Formulae 3-1 to 3-33,

\* and \*' are each independently a binding site with an adjacent atom.

6. The condensed cyclic compound of claim 1, wherein  $R_1$  to  $R_5$  are each independently selected from

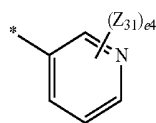
a hydrogen, a deuterium,  $-F$ ,  $-Cl$ ,  $-Br$ ,  $-I$ , a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group,

a  $C_1$ - $C_{20}$  alkyl group and a  $C_1$ - $C_{20}$  alkoxy group, each substituted with at least one of a deuterium atom,  $-F$ ,  $-Cl$ ,  $-Br$ ,  $-I$ , a hydroxyl group, a cyano group, an amino group, and an amidino group,

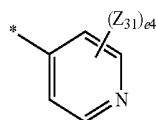
a group represented by one of Formulae 4-1 to 4-34, and  $-\text{Si}(\text{Q}_3)(\text{Q}_4)(\text{Q}_5)$ ,

wherein  $R_4$  and  $R_5$  are not  $-\text{Si}(\text{Q}_3)(\text{Q}_4)(\text{Q}_5)$ ; and

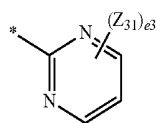
at least one of  $R_2$  and  $R_3$  are each independently selected from a group represented by one of Formulae 4-26 to 4-33:



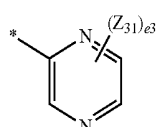
Formula 4-7



Formula 4-8

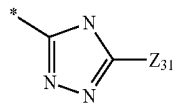
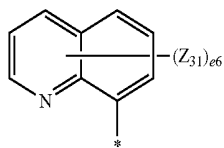
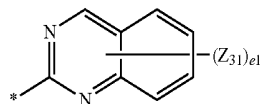
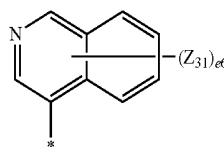
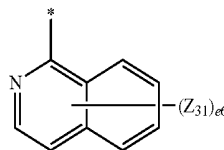
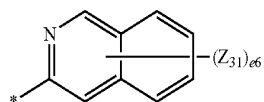
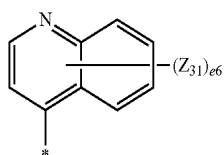
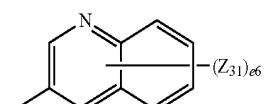
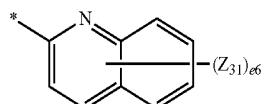
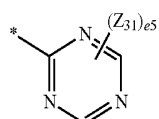
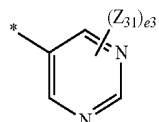
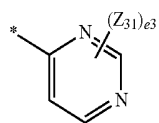


Formula 4-9



Formula 4-10

-continued



Formula 4-11

Formula 4-12

Formula 4-13

Formula 4-14

Formula 4-15

Formula 4-16

Formula 4-17

Formula 4-18

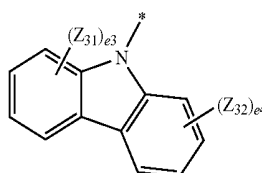
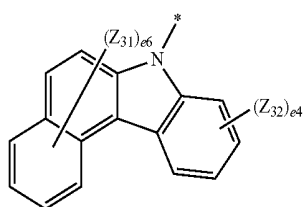
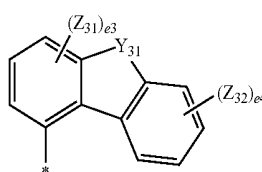
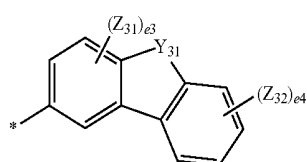
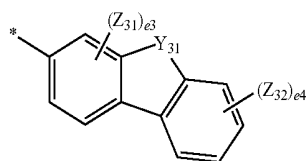
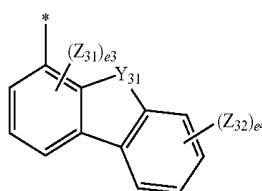
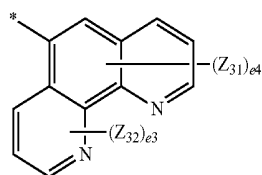
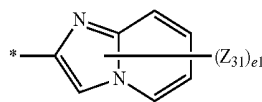
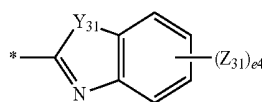
Formula 4-19

Formula 4-20

Formula 4-21

Formula 4-22

-continued



Formula 4-23

Formula 4-24

Formula 4-25

Formula 4-26

Formula 4-27

Formula 4-28

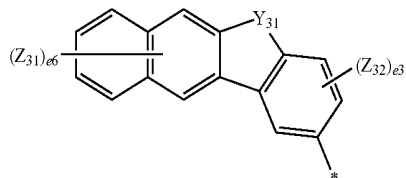
Formula 4-29

Formula 4-30

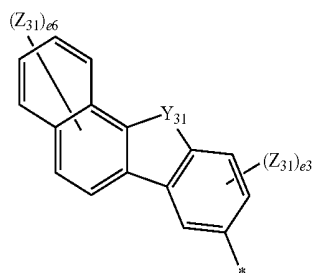
Formula 4-31

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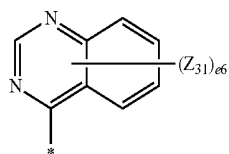
Formula 4-32



Formula 4-33



Formula 4-34



wherein, in Formulae 4-1 to 4-34,

$Y_{31}$  is O, S, or N( $Z_{35}$ ), where  $Y_{31}$  in Formula 4-23 is not NH,

$Z_{31}$ ,  $Z_{32}$ , and  $Z_{33}$  are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a quaterphenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazoliny group, a quinoxaliny group, benzoquinolinyl group, benzoisoquinolinyl group, benzoquinazoliny group, benzoquinoxaliny group, and —Si( $Q_{33}$ )( $Q_{34}$ )( $Q_{35}$ ), wherein  $Q_{33}$  to  $Q_{35}$  are each independently selected from a hydrogen, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazoliny group, benzoquinolinyl group, benzoisoquinolinyl group, benzoquinazoliny group, benzoquinoxaliny group, and a quinoxaliny group,

$e_1$  is an integer selected from 1 to 5,  
 $e_2$  is an integer selected from 1 to 7,  
 $e_3$  is an integer selected from 1 to 3,  
 $e_4$  is an integer selected from 1 to 4,  
 $e_5$  is 1 or 2,  
 $e_6$  is an integer selected from 1 to 6, and  
 \* is a binding site with an adjacent atom.

7. The condensed cyclic compound of claim 1, wherein at least one of  $R_2$  and  $R_3$  is selected from

a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a benzocarbazolyl group,  
 a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and a benzocarbazolyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, —Si( $Q_{33}$ )( $Q_{34}$ )( $Q_{35}$ ), a phenyl group, a naphthyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluo-ranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, a benzoquinolinyl group, a benzoisoquinolinyl group, a benzoquinazoliny group, benzoquinoxaliny group, a carbazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group; and

$Q_{33}$  to  $Q_{35}$  are each independently selected from a hydrogen, a  $C_1$ - $C_{60}$  alkyl group, a  $C_2$ - $C_{60}$  alkenyl group, a  $C_2$ - $C_{60}$  alkynyl group, a  $C_1$ - $C_{60}$  alkoxy group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_2$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

8. The condensed cyclic compound of claim 1, wherein  $R_{11}$  to  $R_{14}$  are each independently selected from

a hydrogen, a deuterium, —F, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group,  
 a  $C_1$ - $C_{20}$  alkyl group and a  $C_1$ - $C_{20}$  alkoxy group, each substituted with at least one of a deuterium atom, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, and an amidino group,  
 a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azuleny group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluo-ranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, and a pentacenyl group.

9. The condensed cyclic compound of claim 1, wherein  $R_1$  to  $R_5$  are each independently selected from

a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group,

a C<sub>1</sub>-C<sub>20</sub> alkyl group and a C<sub>1</sub>-C<sub>20</sub> alkoxy group, each substituted with at least one of a deuterium atom, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, and an amidino group,

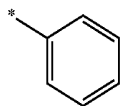
a group represented by one of Formulae 5-1 to 5-141, and —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>),

wherein R<sub>4</sub> and R<sub>5</sub> are not —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>);

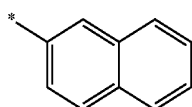
at least one of R<sub>2</sub> and R<sub>3</sub> are each independently a group represented by one of Formulae 5-10 to 5-17, 5-22 to 5-26, and 5-56 to 5-141; and

R<sub>11</sub> to R<sub>14</sub> are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, an amino group, an amidino group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, and a C<sub>1</sub>-C<sub>20</sub> alkoxy group,

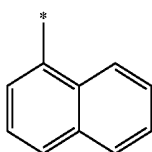
a group represented by one of Formulae 5-1 to 5-9 and —Si(Q<sub>3</sub>)(Q<sub>4</sub>)(Q<sub>5</sub>), wherein Q<sub>3</sub> to Q<sub>5</sub> are each independently selected from a hydrogen, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a naphthyl group, an anthracenyl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, a chrysenyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinazoliny group, a quinoxaliny group, benzoquinolinyl group, and a benzoquinoxaliny group:



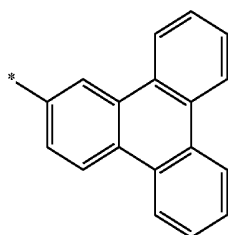
Formula 5-1



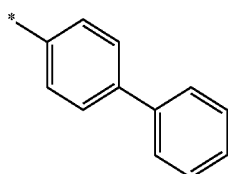
Formula 5-2



Formula 5-3

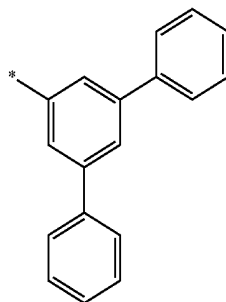


Formula 5-4

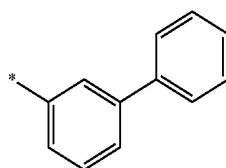


Formula 5-5

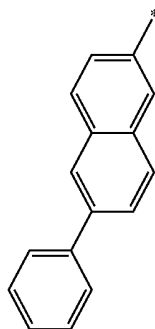
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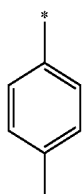
Formula 5-6



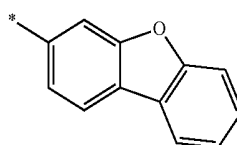
Formula 5-7



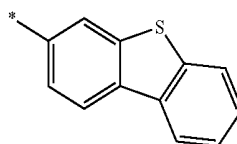
Formula 5-8



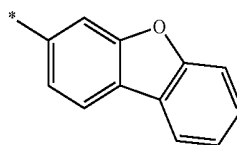
Formula 5-9



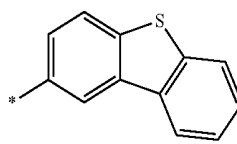
Formula 5-10



Formula 5-11

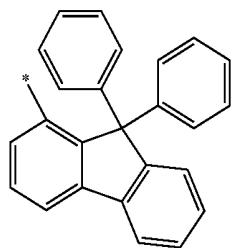
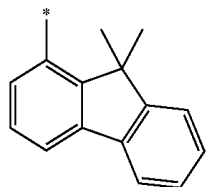
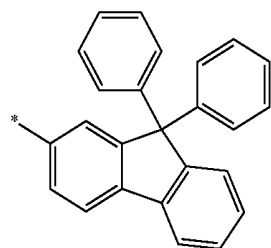
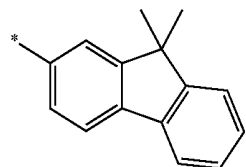
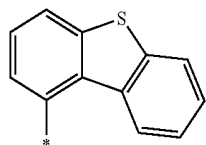
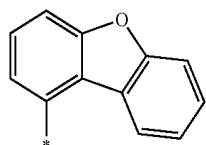
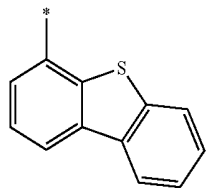
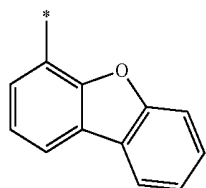


Formula 5-12



Formula 5-13

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Formula 5-14

Formula 5-15

Formula 5-16

Formula 5-17

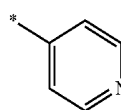
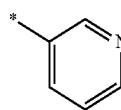
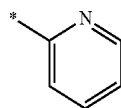
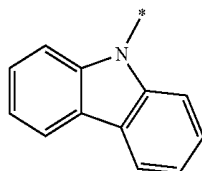
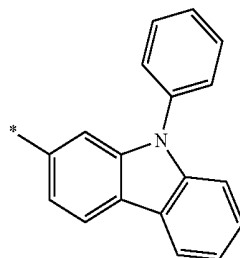
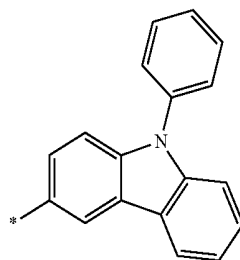
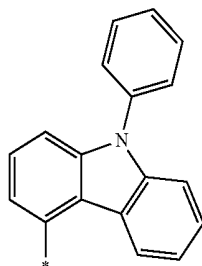
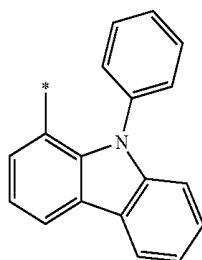
Formula 5-18

Formula 5-19

Formula 5-20

Formula 5-21

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Formula 5-22

Formula 5-23

Formula 5-24

Formula 5-25

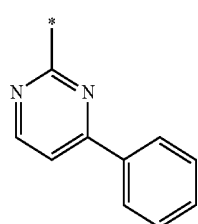
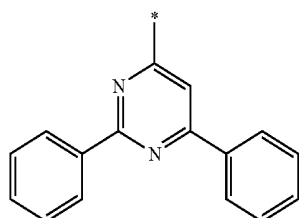
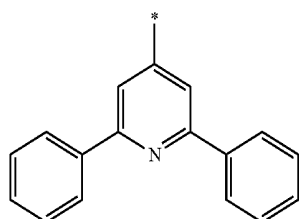
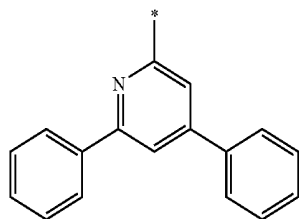
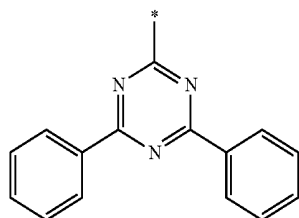
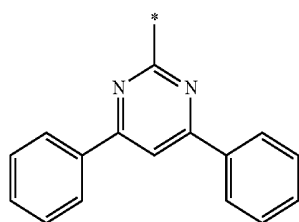
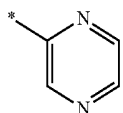
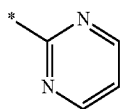
Formula 5-26

Formula 5-27

Formula 5-28

Formula 5-29

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Formula 5-30

Formula 5-31

Formula 5-32

Formula 5-33

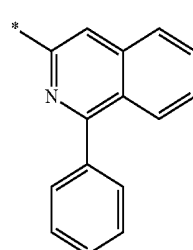
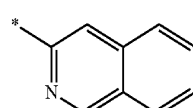
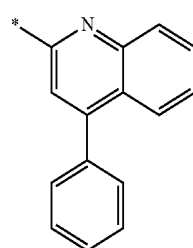
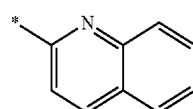
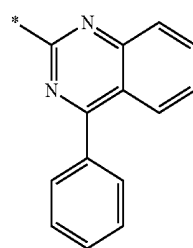
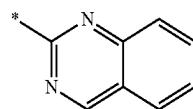
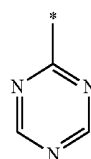
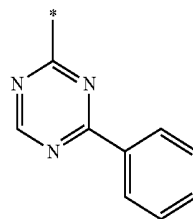
Formula 5-34

Formula 5-35

Formula 5-36

Formula 5-37

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Formula 5-38

Formula 5-39

Formula 5-40

Formula 5-41

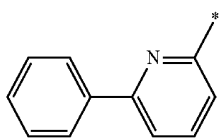
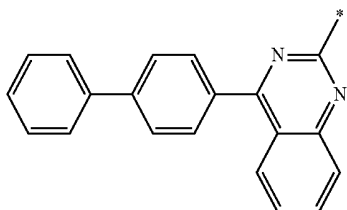
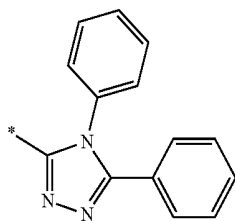
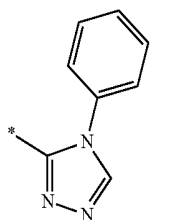
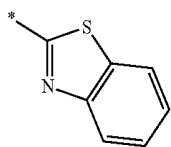
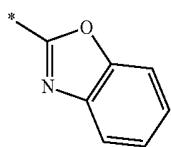
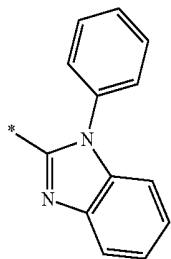
Formula 5-42

Formula 5-43

Formula 5-44

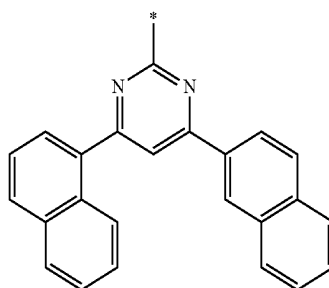
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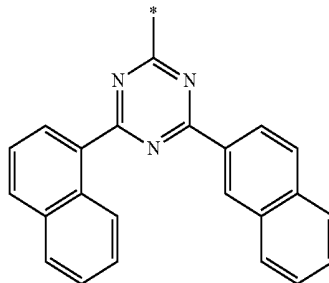
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Formula 5-46



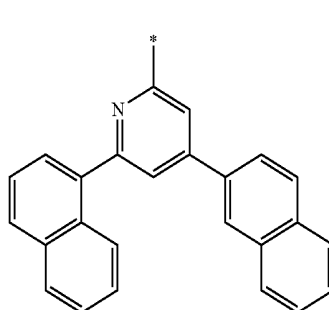
Formula 5-53

Formula 5-47



Formula 5-54

Formula 5-48

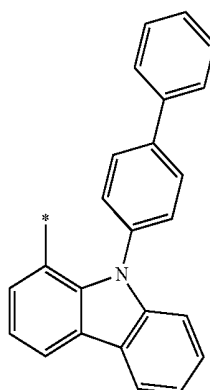


Formula 5-55

Formula 5-49

Formula 5-50

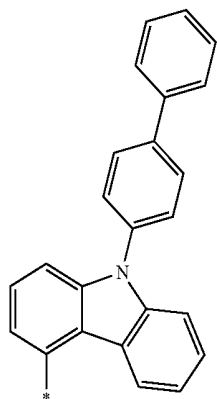
Formula 5-51



Formula 5-56

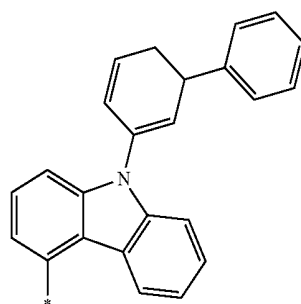
Formula 5-52

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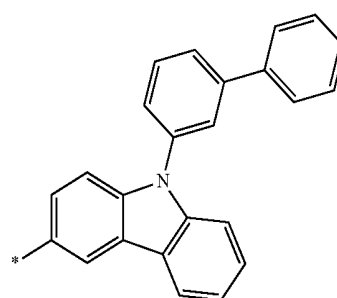
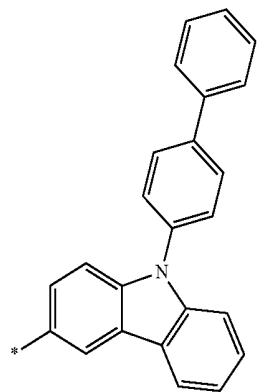
Formula 5-57

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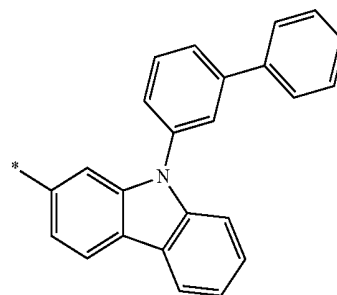
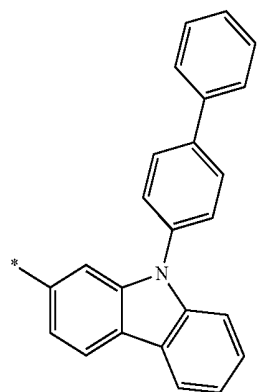
Formula 5-61

Formula 5-58



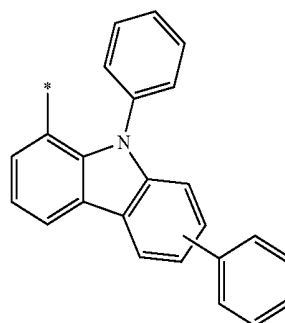
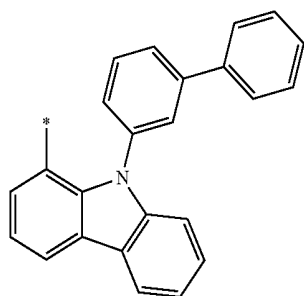
Formula 5-62

Formula 5-59



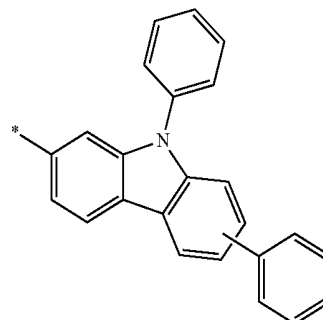
Formula 5-63

Formula 5-60

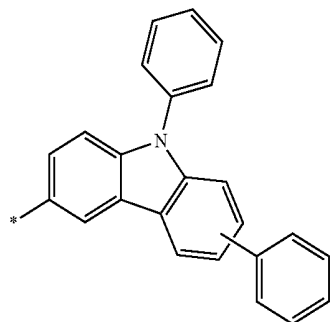


Formula 5-64

Formula 5-65

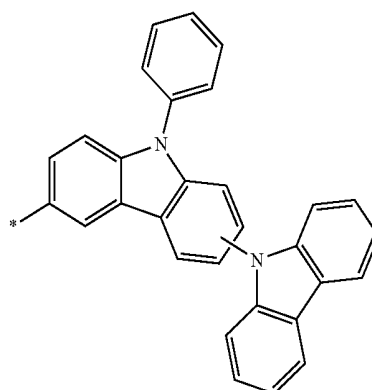


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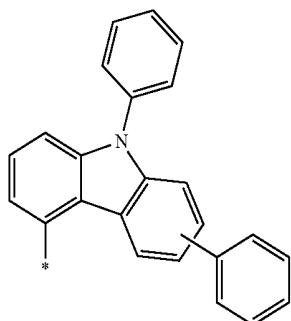


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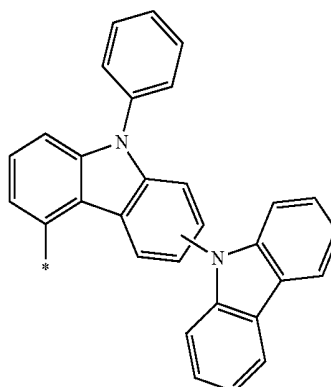
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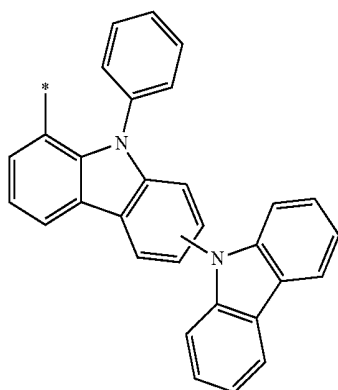
Formula 5-70



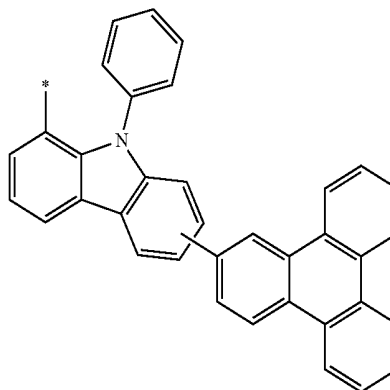
Formula 5-67



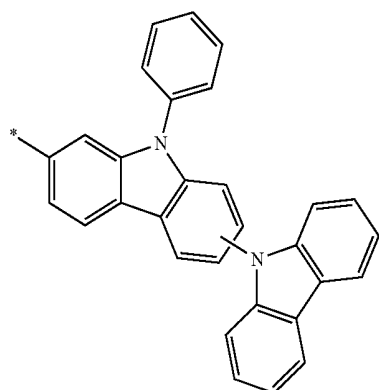
Formula 5-71



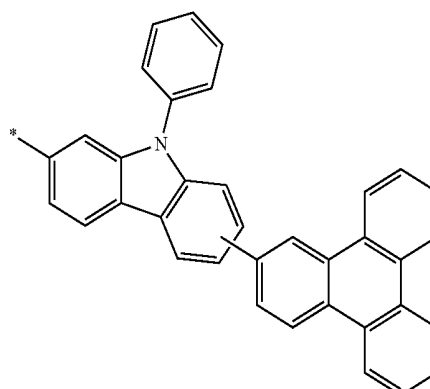
Formula 5-68



Formula 5-72



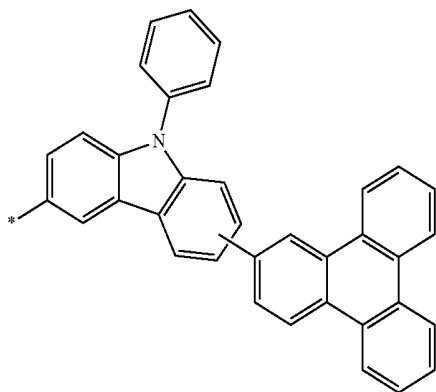
Formula 5-69



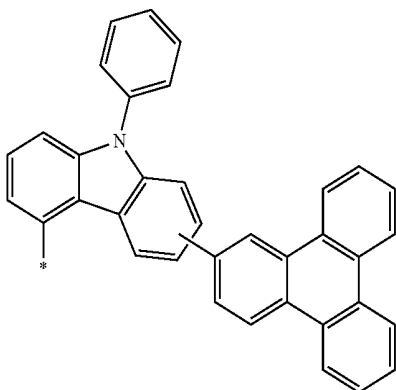
Formula 5-73

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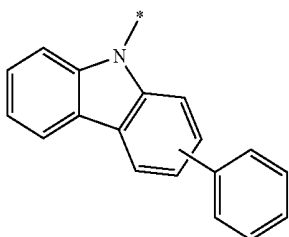
Formula 5-74



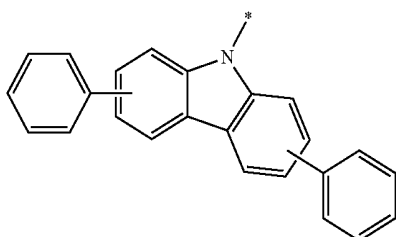
Formula 5-75



Formula 5-76

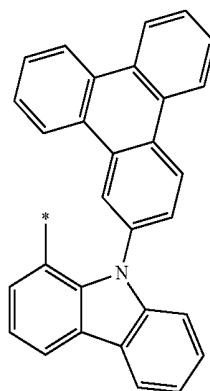


Formula 5-77

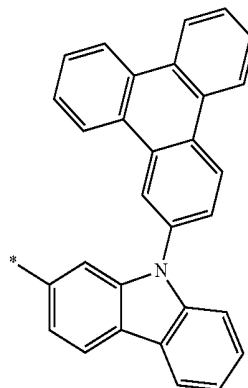


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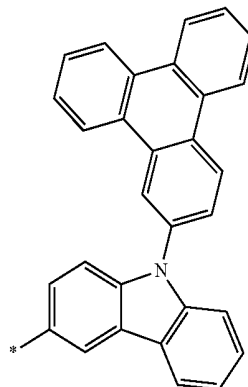
Formula 5-78



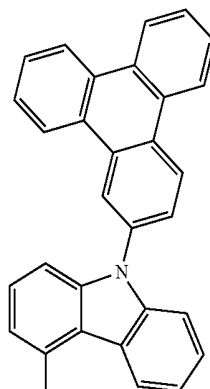
Formula 5-79



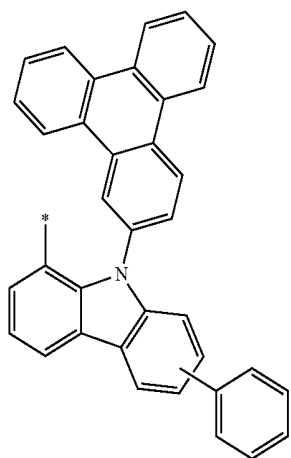
Formula 5-80



Formula 5-81

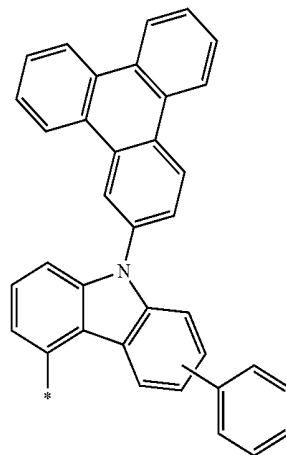


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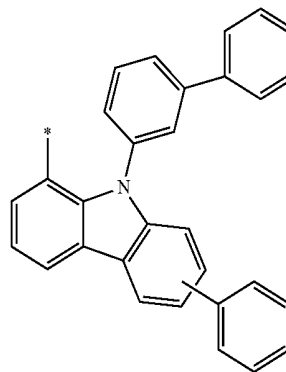
Formula 5-82

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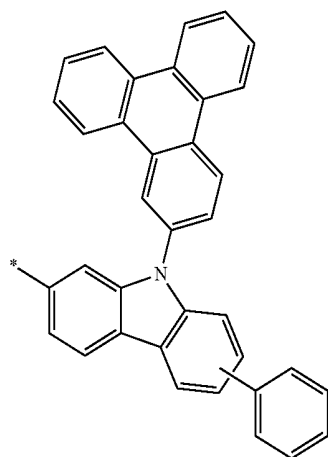


Formula 5-85

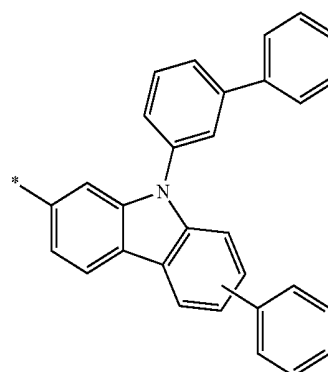
Formula 5-83



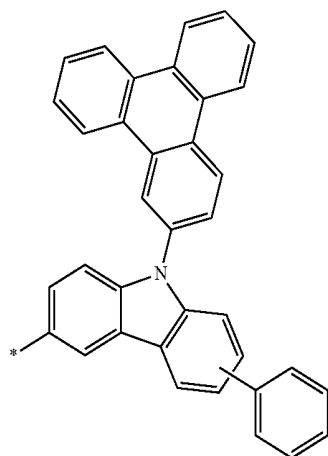
Formula 5-86



Formula 5-84

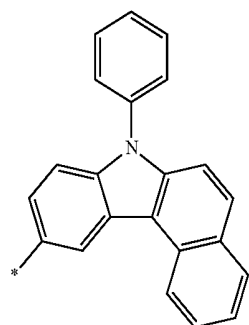
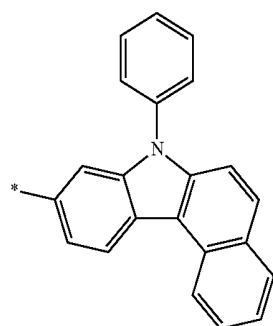
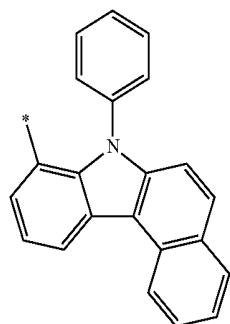
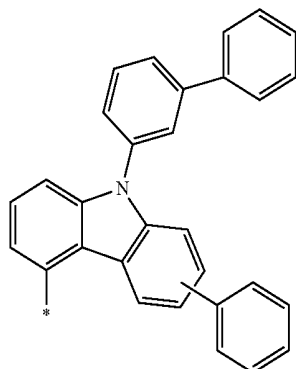


Formula 5-87



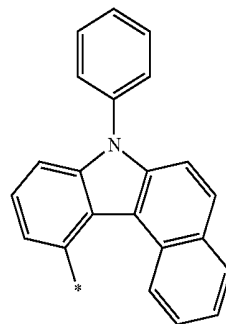
Formula 5-88

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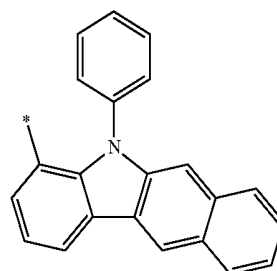
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Formula 5-89



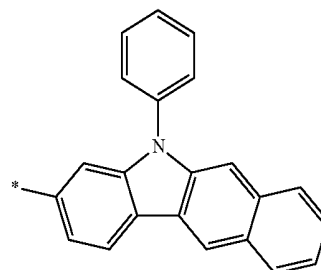
Formula 5-93

Formula 5-90



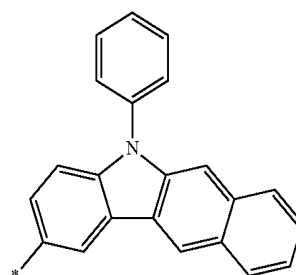
Formula 5-94

Formula 5-91



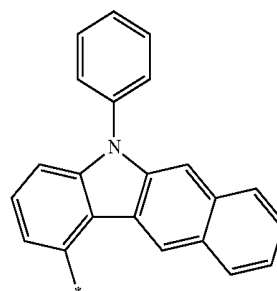
Formula 5-95

Formula 5-92

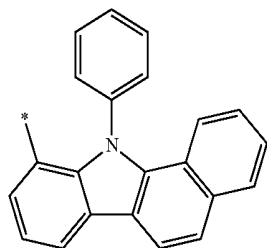


Formula 5-96

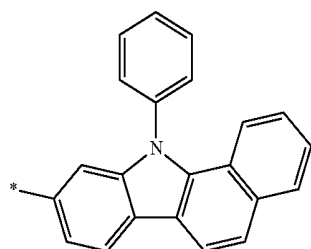
Formula 5-97



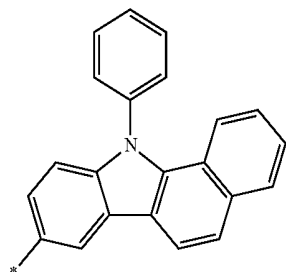
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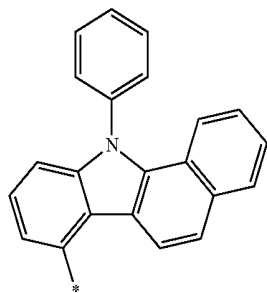
Formula 5-98



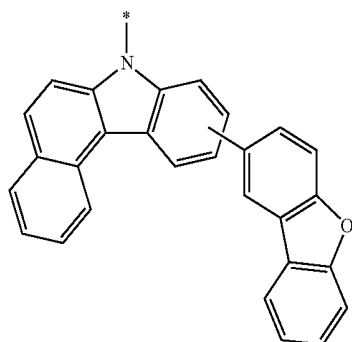
Formula 5-99



Formula 5-100

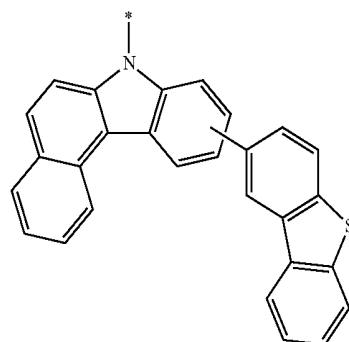


Formula 5-101

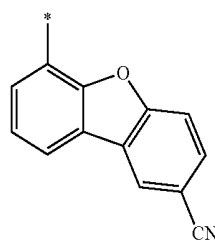


Formula 5-102

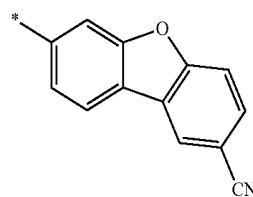
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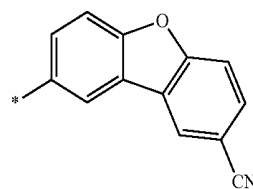
Formula 5-103



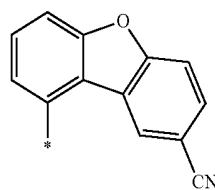
Formula 5-104



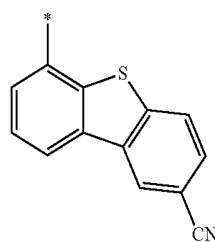
Formula 5-105



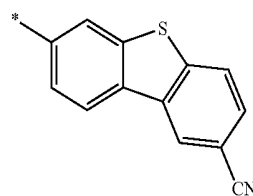
Formula 5-106



Formula 5-107

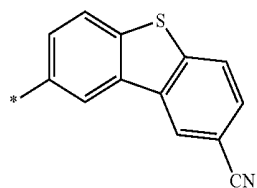


Formula 5-108

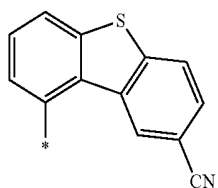


Formula 5-109

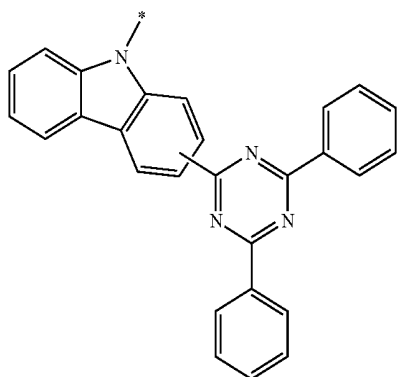
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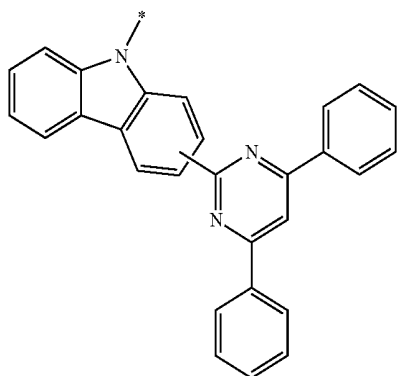
Formula 5-110



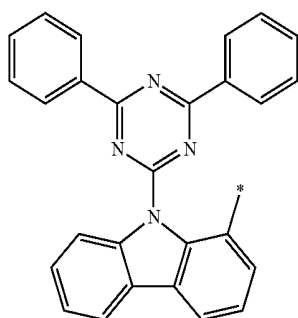
Formula 5-111



Formula 5-112

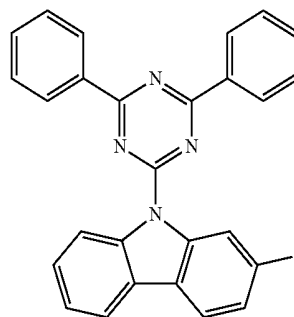


Formula 5-113

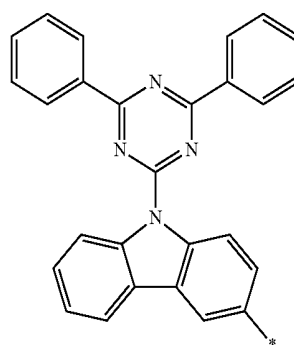


Formula 5-114

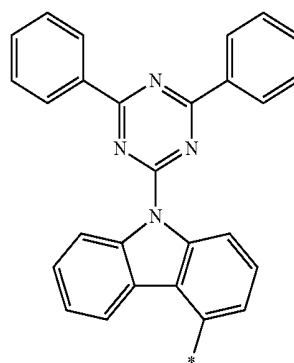
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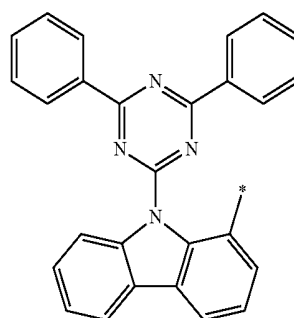
Formula 5-115



Formula 5-116

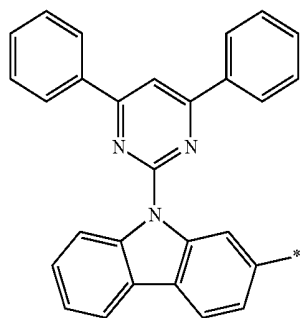


Formula 5-117

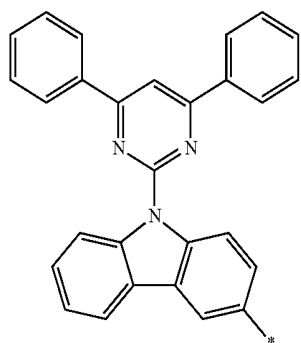


Formula 5-118

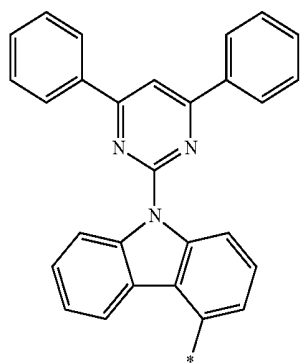
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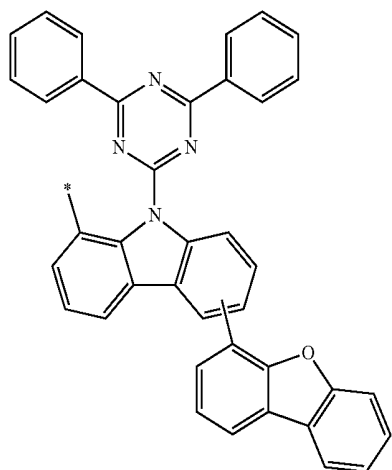
Formula 5-119



Formula 5-120

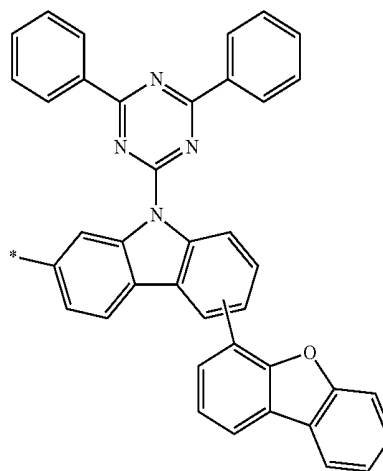


Formula 5-121

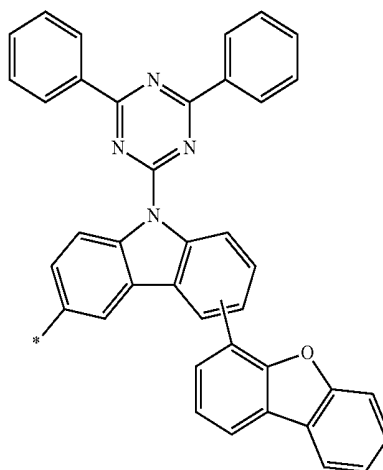


Formula 5-122

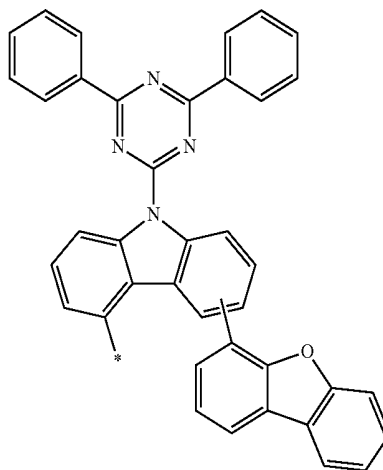
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Formula 5-123

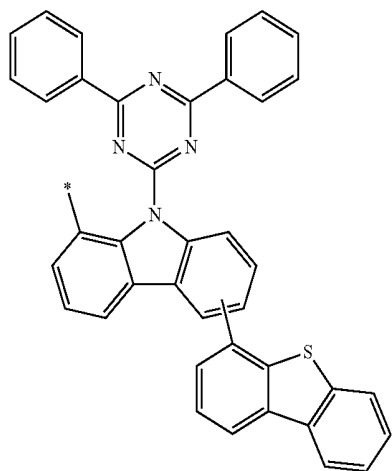


Formula 5-124



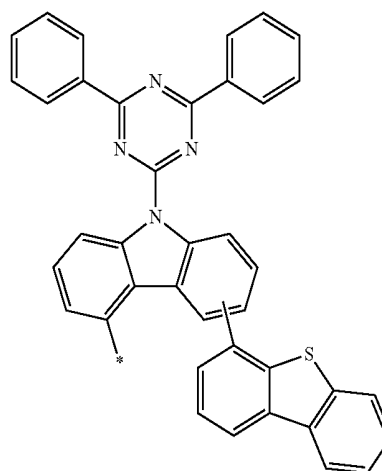
Formula 5-125

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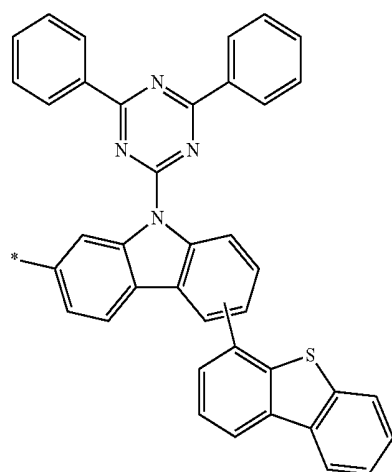


Formula 5-126

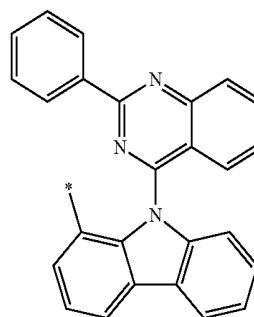
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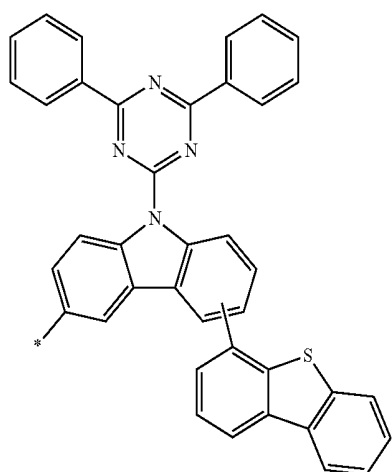
Formula 5-129



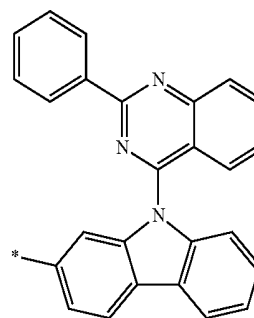
Formula 5-127



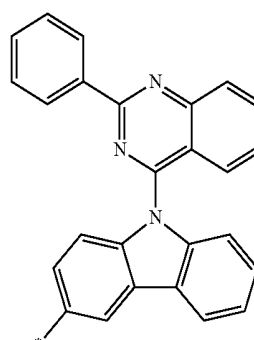
Formula 5-130



Formula 5-128



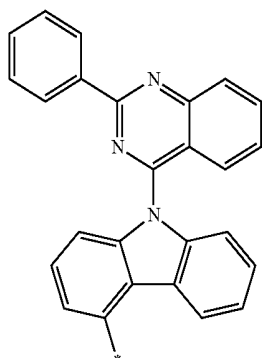
Formula 5-131



Formula 5-132

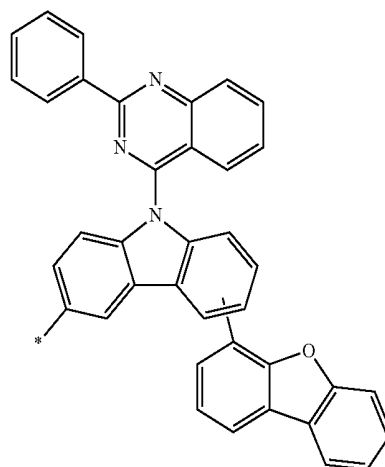
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Formula 5-133

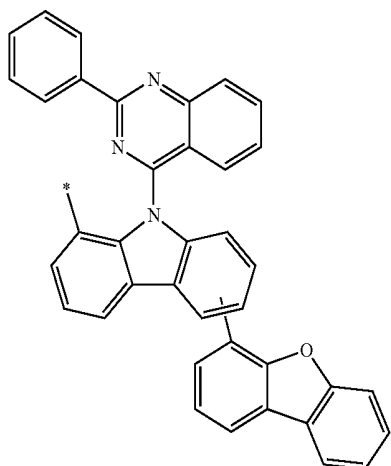


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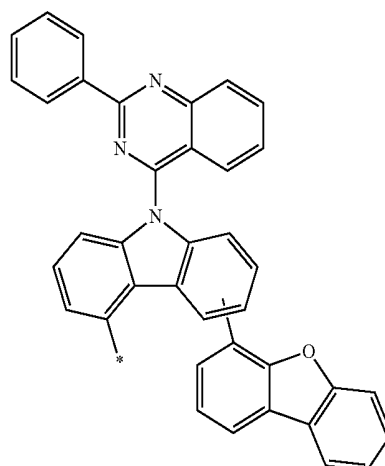
Formula 5-136



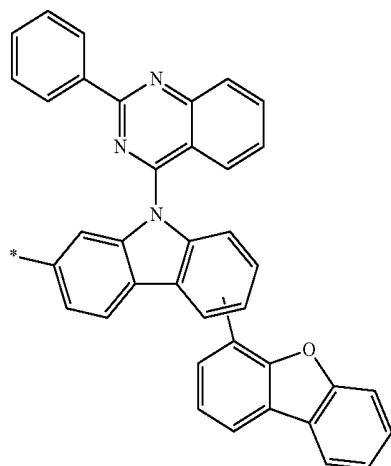
Formula 5-134



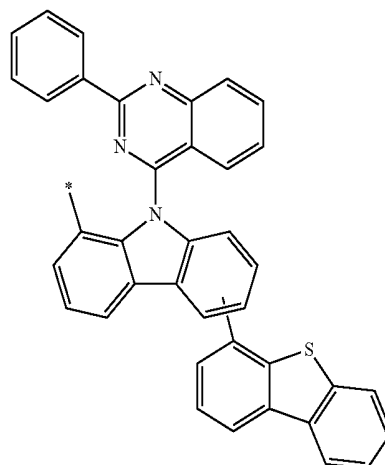
Formula 5-137



Formula 5-135

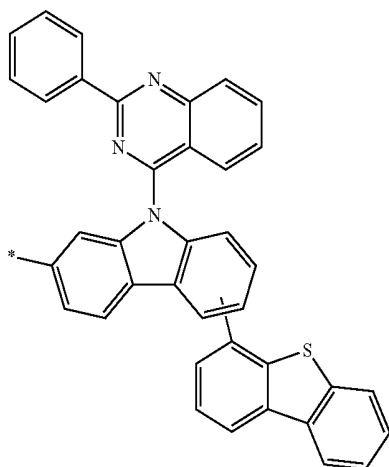


Formula 5-138



-continued

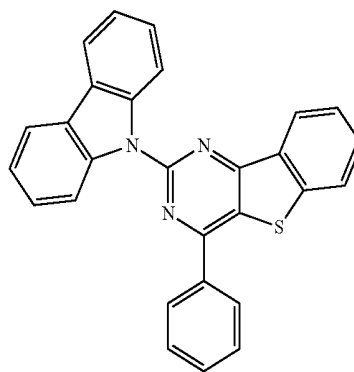
Formula 5-139



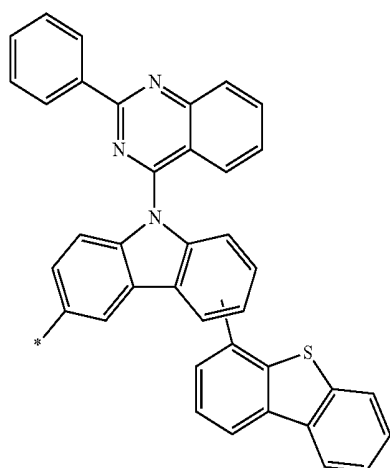
10. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound of Formula 1 is one of Compounds listed in following Group I:

[Group I]

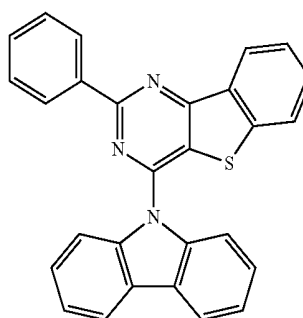
5



Formula 5-140

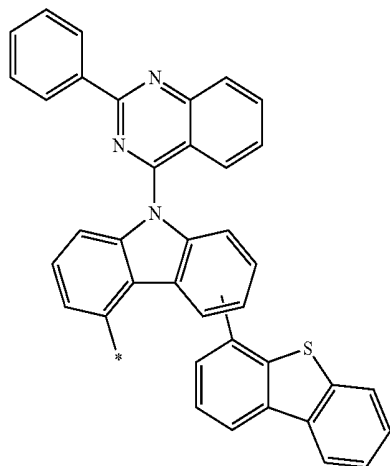


8

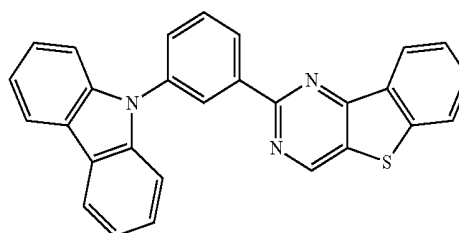


9

Formula 5-141



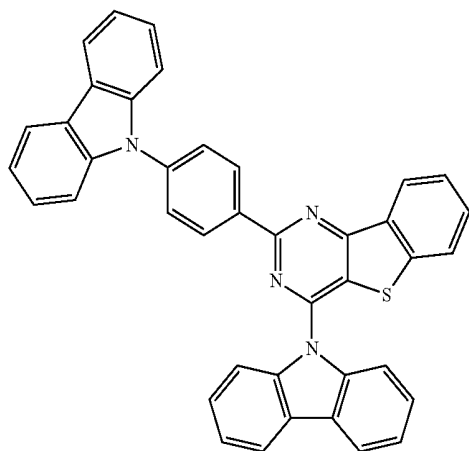
11



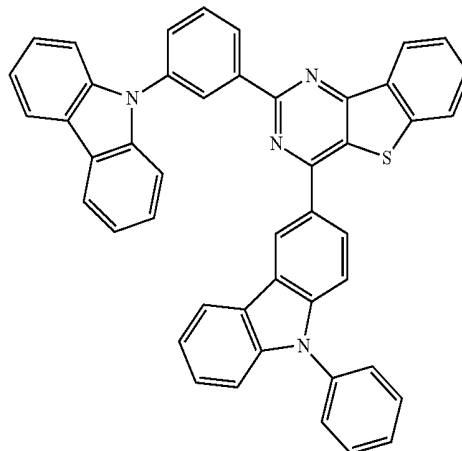
wherein, in Formulae 5-1 to 5-141,

\* is a binding site with an adjacent atom.

-continued



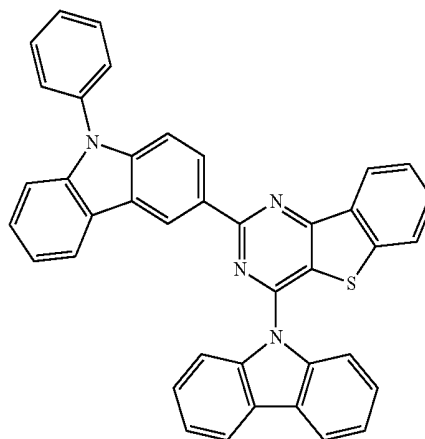
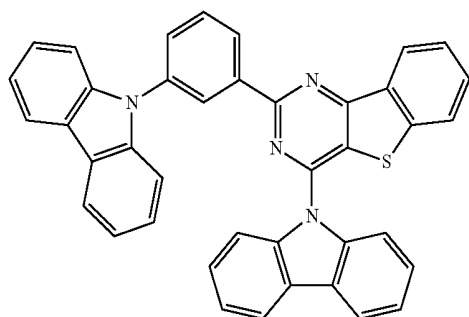
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18

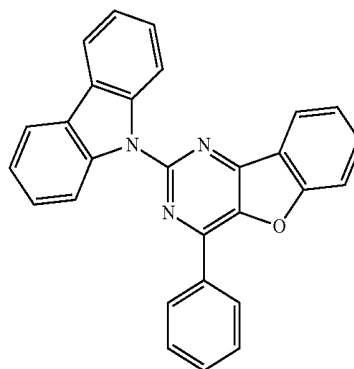
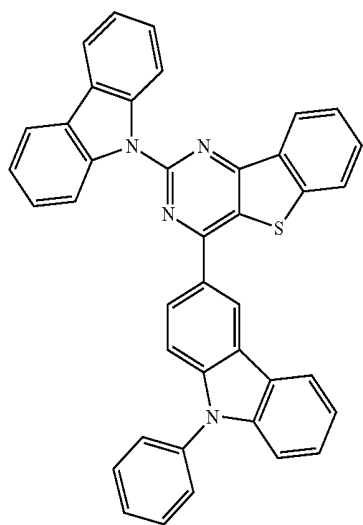
12

21



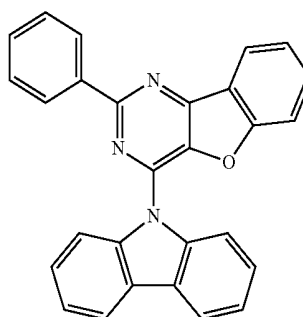
13

37

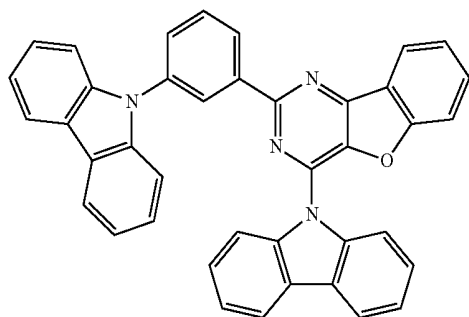


16

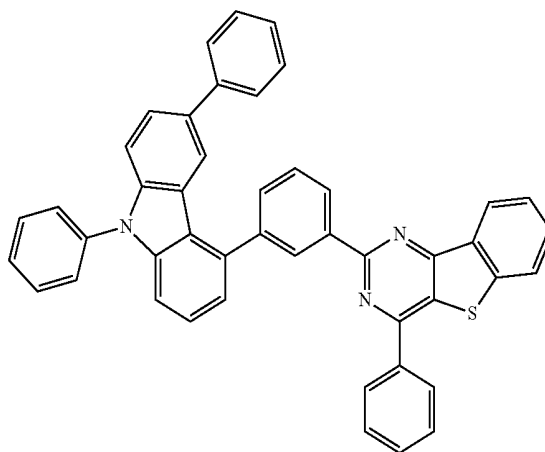
40



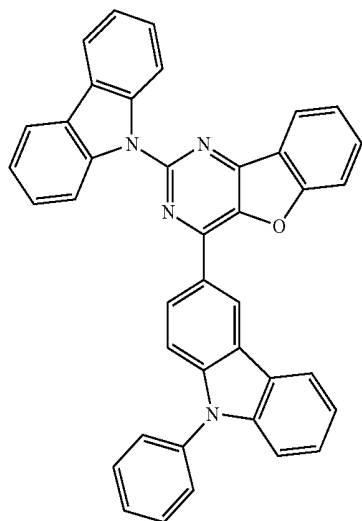
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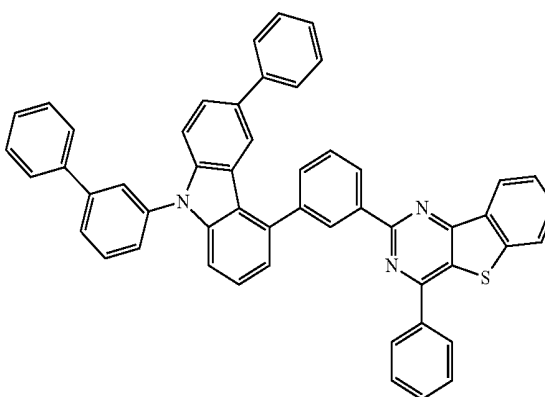
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48

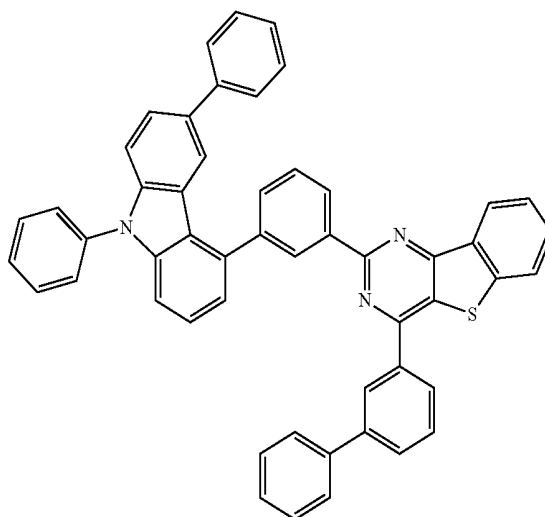
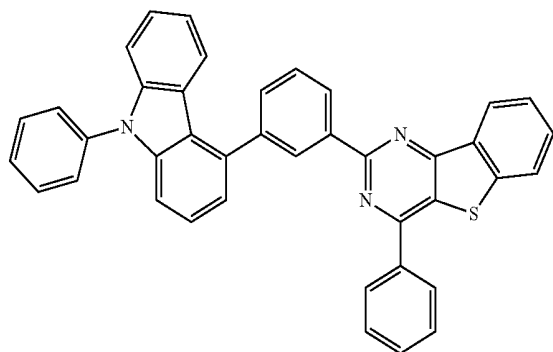


a-12



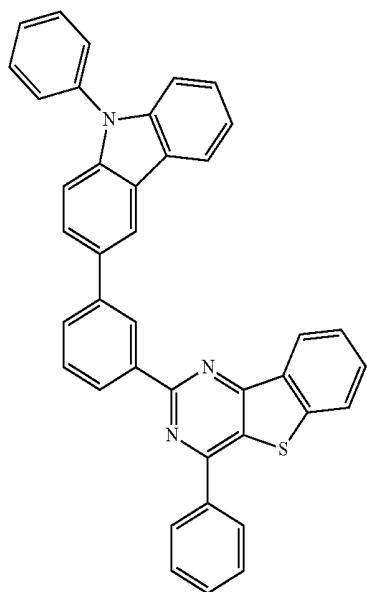
a-13

a-9



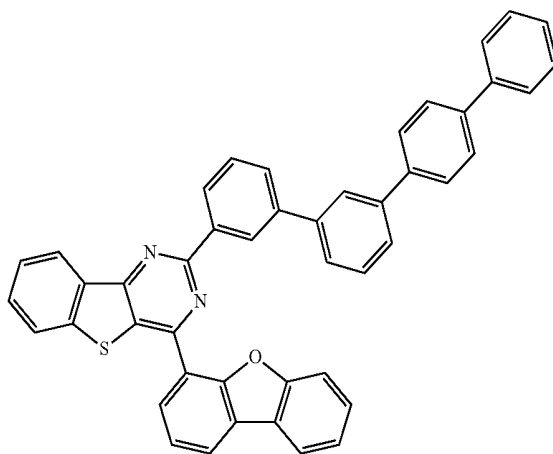
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a-31

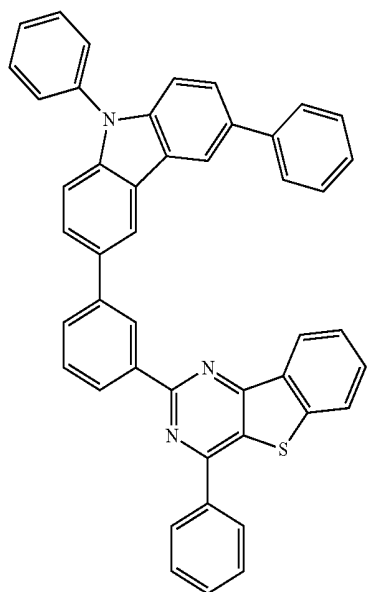


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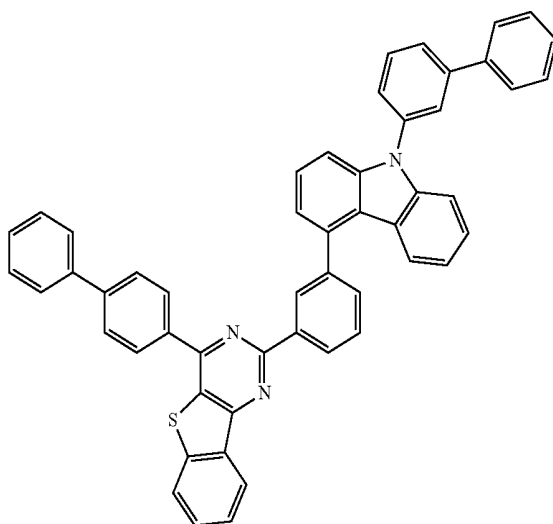
a-45



a-32

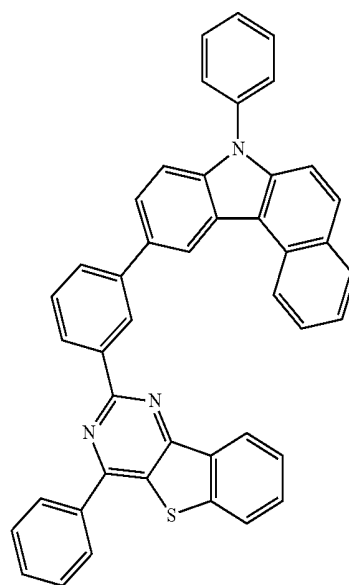
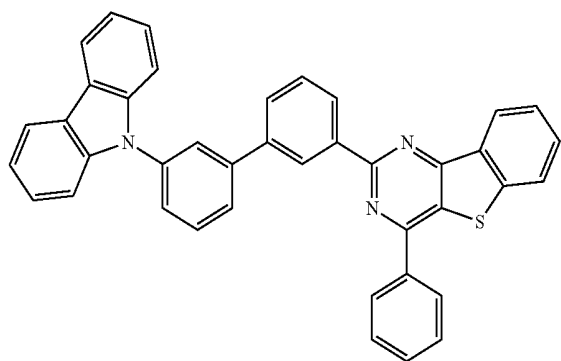


a-47



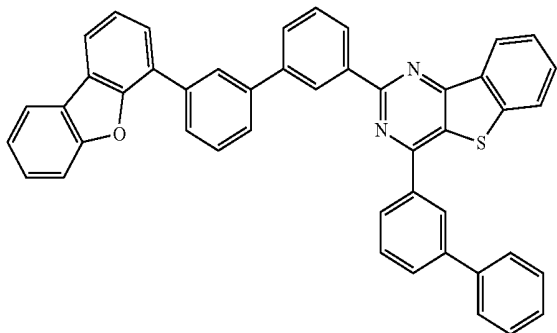
a-49

a-41

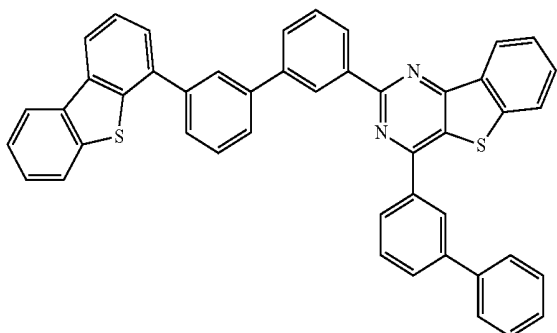


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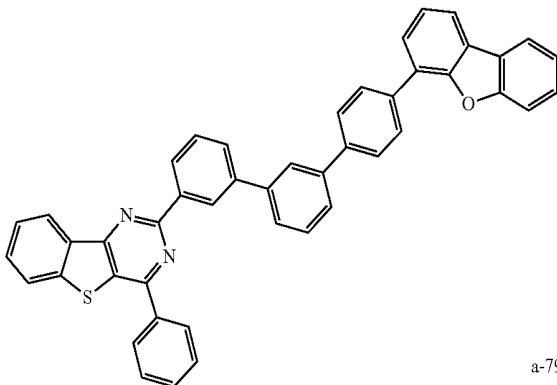
a-73



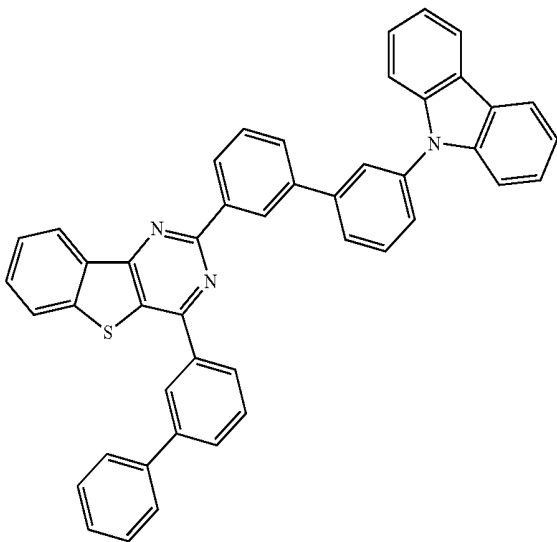
a-74



a-75

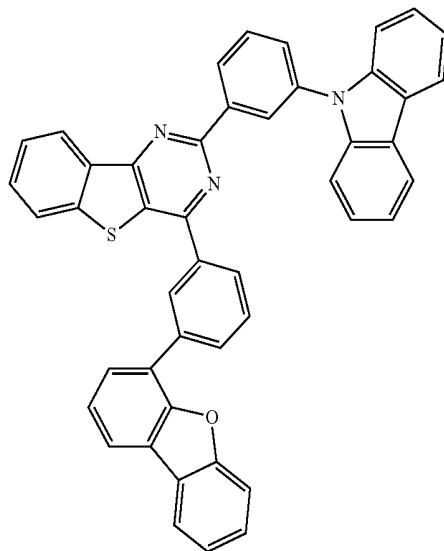


a-79

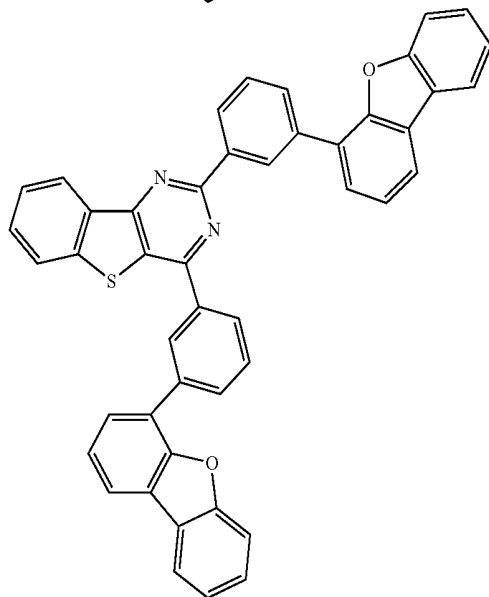


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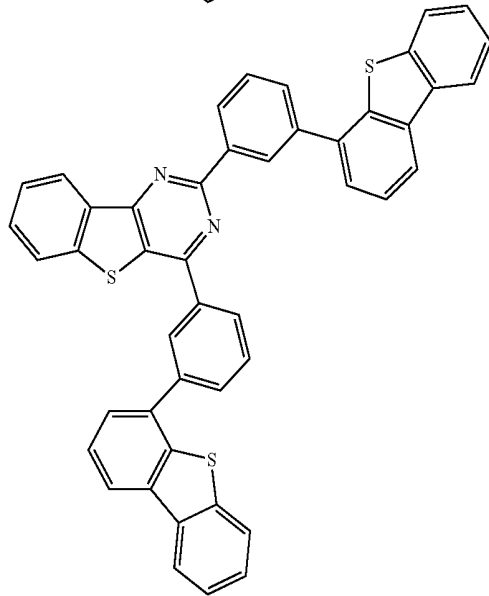
a-82



a-84

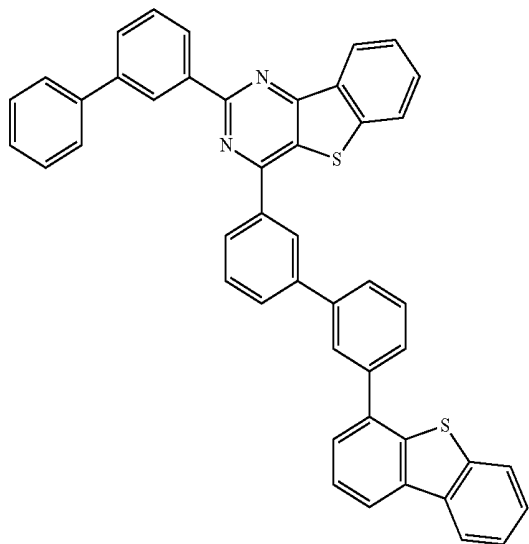


a-85



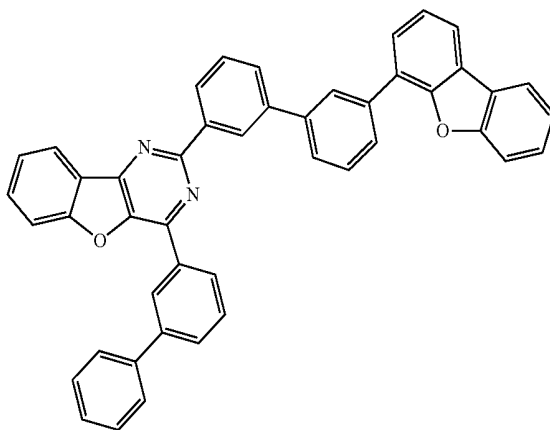
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a-87

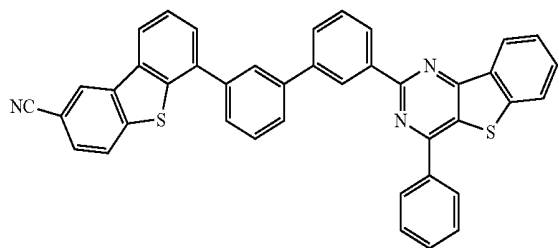


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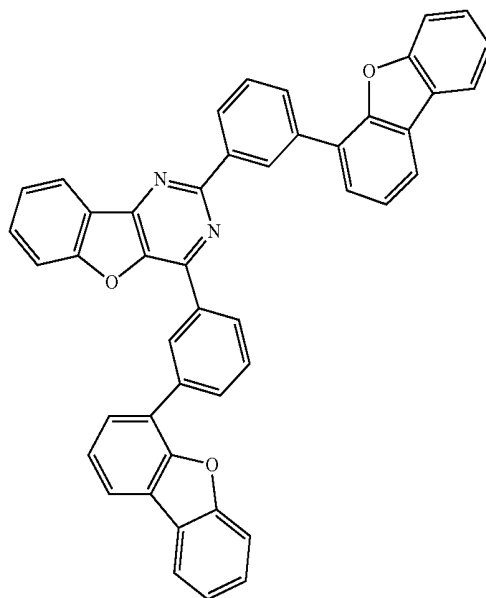
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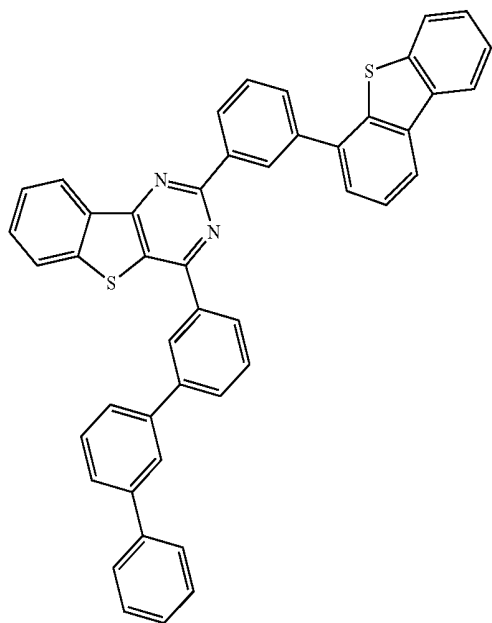
a-91



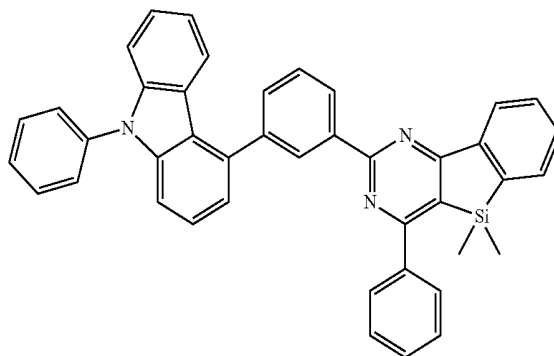
b-84



a-95

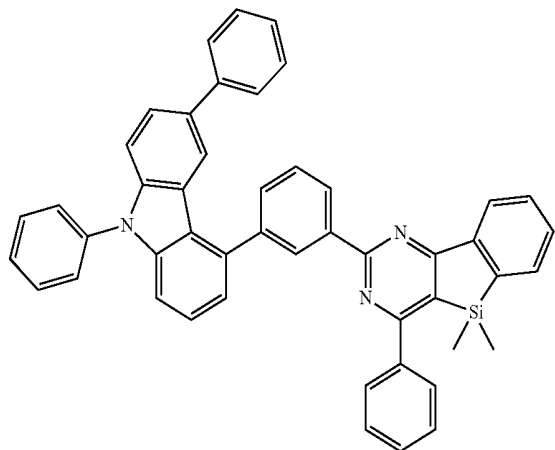


c-9



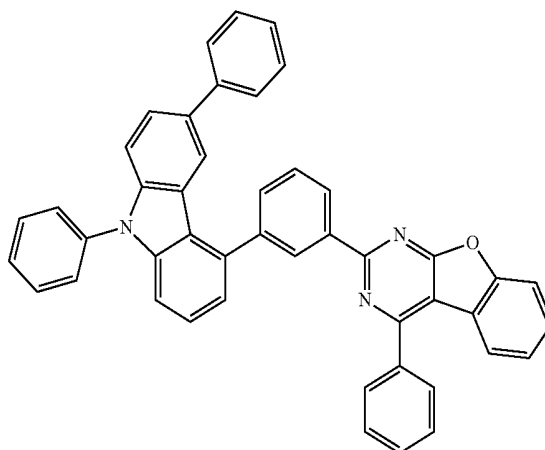
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c-10

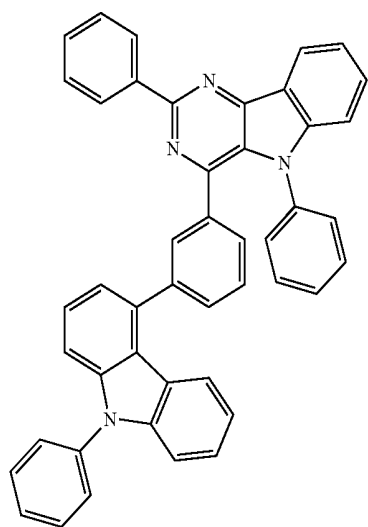


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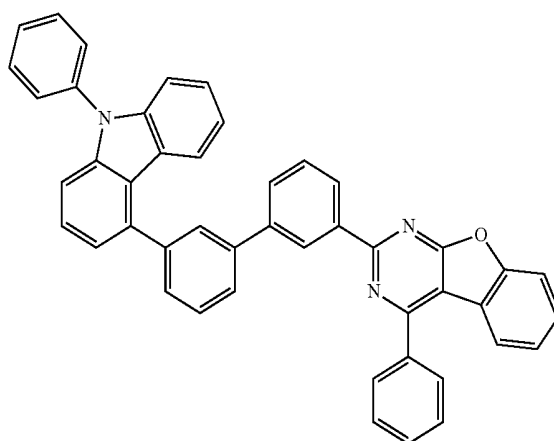
e-10



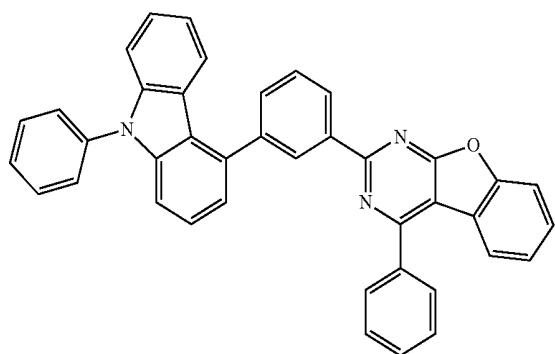
d-23



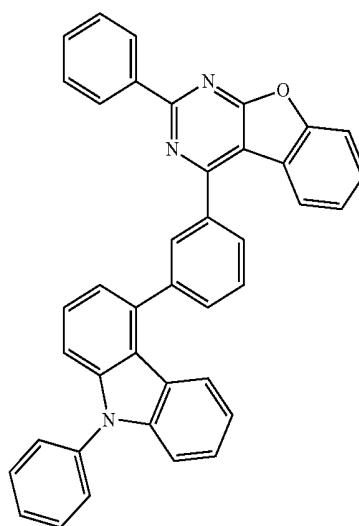
e-15



e-9

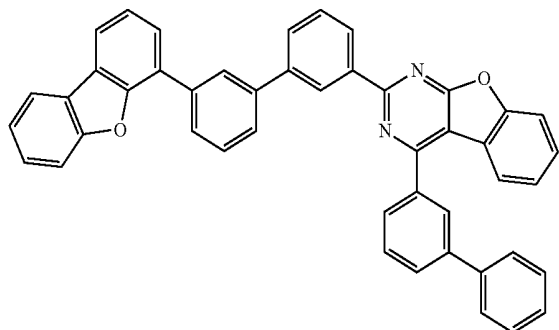


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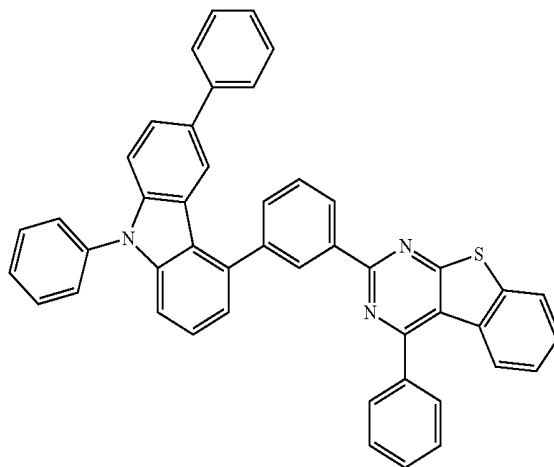
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e-73

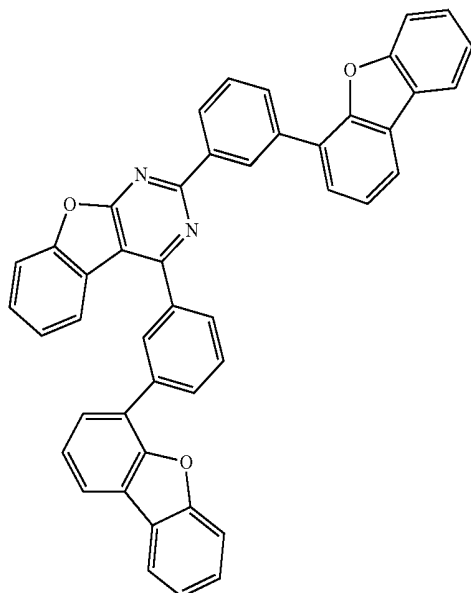


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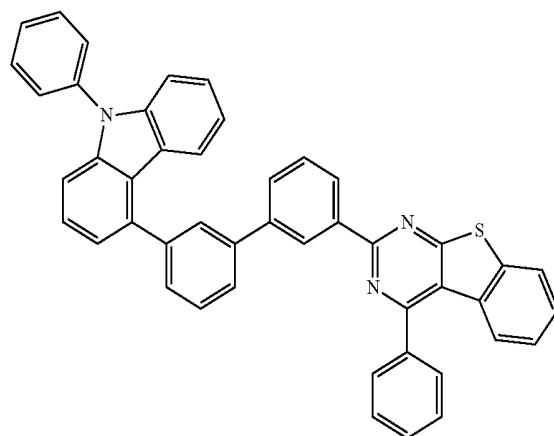
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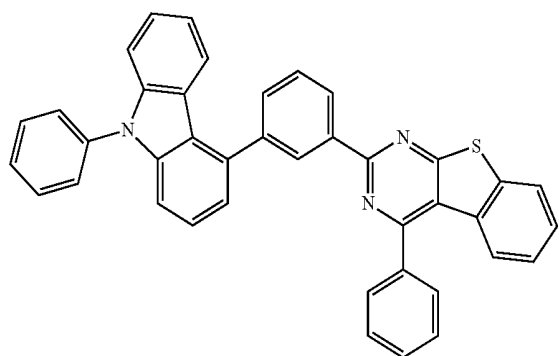
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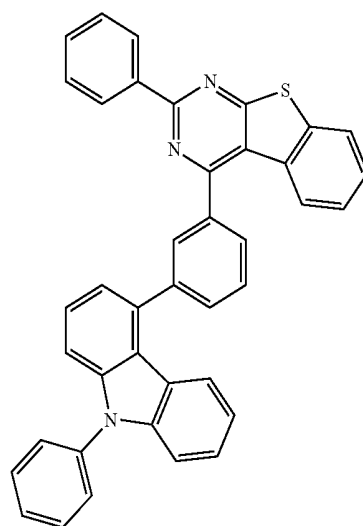
f-15



f-9

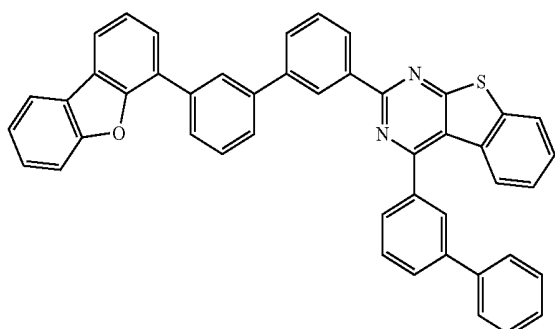


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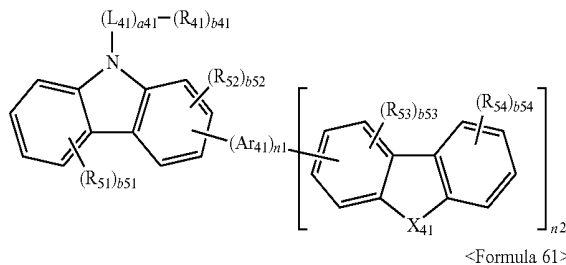


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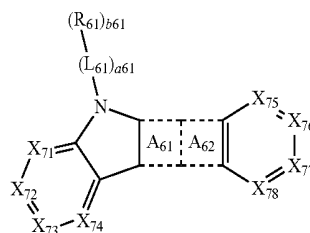
f-73



&lt;Formula 41&gt;

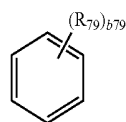
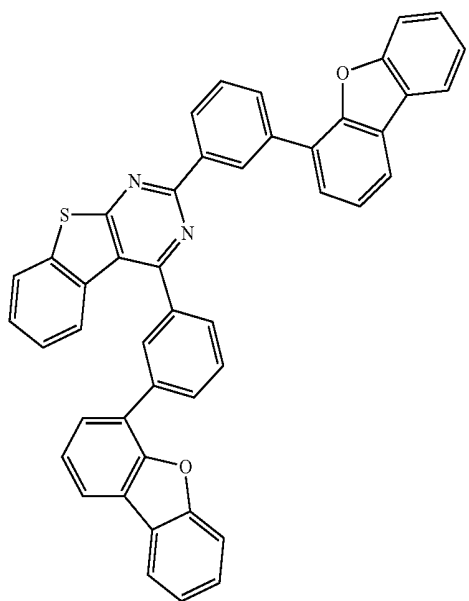


&lt;Formula 61&gt;



&lt;Formula 61A&gt;

f-84



&lt;Formula 61B&gt;



wherein, in Formulae 41 and 61,

$X_{41}$  is N-[( $L_{42}$ ) $a_{42}$ -( $R_{42}$ ) $b_{42}$ ], S, O, S(=O), S(=O) $_2$ , a C(=O), a C( $R_{43}$ )( $R_{44}$ ), Si( $R_{43}$ )( $R_{44}$ ), P( $R_{43}$ ), P(=O)( $R_{43}$ ), or C=N( $R_{43}$ );

Ring  $A_{61}$  in Formula 61 is represented by Formula 61A;

Ring  $A_{62}$  in Formula 61 is represented by Formula 61B;

$X_{61}$  is N-[( $L_{62}$ ) $a_{62}$ -( $R_{62}$ ) $b_{62}$ ], S, O, S(=O), S(=O) $_2$ , a C(=O), a C( $R_{63}$ )( $R_{64}$ ), Si( $R_{63}$ )( $R_{64}$ ), P( $R_{63}$ ), P(=O)( $R_{63}$ ), or C=N( $R_{63}$ );

$X_{71}$  is C( $R_{71}$ ) or N;  $X_{72}$  is C( $R_{72}$ ) or N;  $X_{73}$  is C( $R_{73}$ ) or N;  $X_{74}$  is C( $R_{74}$ ) or N;  $X_{75}$  is C( $R_{75}$ ) or N;  $X_{76}$  is C( $R_{76}$ ) or N;  $X_{77}$  is C( $R_{77}$ ) or N;  $X_{78}$  is C( $R_{78}$ ) or N;

$Ar_{41}$ ,  $L_{41}$ ,  $L_{42}$ ,  $L_{61}$ , and  $L_{62}$  are each independently selected from a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkylene group, a substituted or unsubstituted  $C_2$ - $C_{10}$  heterocycloalkylene group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkenylene group, a substituted or unsubstituted  $C_2$ - $C_{10}$  heterocycloalkenylene group, a substituted or unsubstituted  $C_6$ - $C_{60}$  arylene group, a substituted or unsubstituted  $C_2$ - $C_{60}$  heteroarylene group, a substituted or unsubstituted divalent nonaromatic condensed polycyclic group, and a substituted or unsubstituted divalent nonaromatic condensed heteropolycyclic group;

$n_1$  and  $n_2$  are each independently an integer selected from 0 to 3;

$R_{41}$  to  $R_{44}$ ,  $R_{51}$  to  $R_{54}$ ,  $R_{61}$  to  $R_{64}$ , and  $R_{71}$  to  $R_{79}$  are each independently selected from a hydrogen, a deuterium, a fluoro group (—F), a chloro group (—Cl), a bromo group (—Br), an iodo group (—I), a hydroxyl group, a cyano group, an amino group, an amidino group, a substituted or unsubstituted  $C_1$ - $C_{60}$  alkyl group, a substituted or unsubstituted  $C_2$ - $C_{60}$  alkenyl group, a substituted or unsubstituted  $C_2$ - $C_{60}$  alkynyl group, a sub-

11. An organic light-emitting device comprising  
a first electrode;  
a second electrode; and  
an organic layer interposed between the first electrode and the second electrode,  
wherein the organic layer comprises the condensed cyclic compound of claim 1.

12. The organic light-emitting device of claim 11, wherein, in the organic layer, the condensed cyclic compound is included in an emission layer as a host, or an electron transport auxiliary layer.

13. The organic light-emitting device of claim 12, wherein the condensed cyclic compound is included in the emission layer as a host, and the host further comprises at least one of a first compound represented by Formula 41 and a second compound represented by Formula 61:

stituted or unsubstituted  $C_1$ - $C_{60}$  alkoxy group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkyl group, a substituted or unsubstituted  $C_2$ - $C_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkenyl group, a substituted or unsubstituted  $C_2$ - $C_{10}$  heterocycloalkenyl group, a substituted or unsubstituted  $C_6$ - $C_{60}$  aryl group, a substituted or unsubstituted  $C_6$ - $C_{60}$  aryloxy group, a substituted or unsubstituted  $C_6$ - $C_{60}$  arylthio group, a substituted or unsubstituted  $C_2$ - $C_{60}$  heteroaryl group, a substituted or unsubstituted monovalent nonaromatic condensed polycyclic group, a substituted or unsubstituted monovalent nonaromatic condensed heteropolycyclic group,  $-N(Q_1)(Q_2)$ ,  $-Si(Q_3)(Q_4)(Q_5)$ , and  $-B(Q_6)(Q_7)$ ;

$Q_1$  to  $Q_7$  are each independently selected from a hydrogen, a  $C_1$ - $C_{60}$  alkyl group, a  $C_2$ - $C_{60}$  alkenyl group, a  $C_2$ - $C_{60}$  alkynyl group, a  $C_1$ - $C_{60}$  alkoxy group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_7$ - $C_{60}$  heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

a41, a42, a61, and a62 are each independently an integer selected from 0 to 3; and

b41, b42, b51 to b54, b61, b62, and b79 are each independently an integer selected from 1 to 3.

14. The organic light-emitting device of claim 13, wherein the emission layer comprises a first host, a second host, and a dopant,

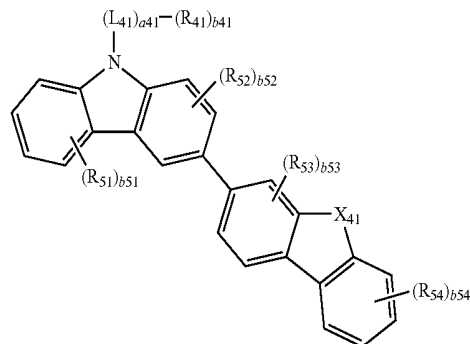
the first host and the second host differ from each other, the first host comprises the condensed cyclic compound, and

the second host comprises at least one of a first compound represented by Formula 41 and a second compound represented by Formula 61.

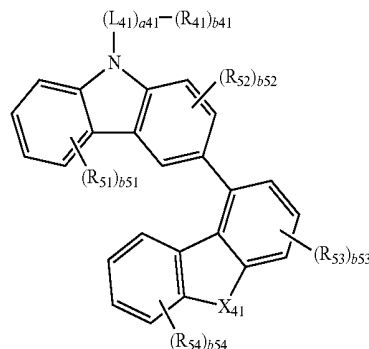
15. The organic light-emitting device of claim 13, wherein the first compound is represented by one of Formulae 41-1 to 41-12, and the second compound is represented by one of Formulae 61-1 to 61-6:

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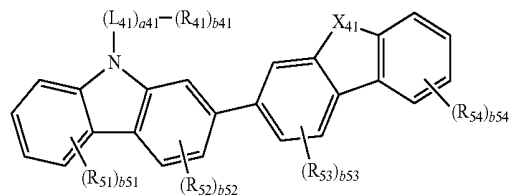
Formula 41-3



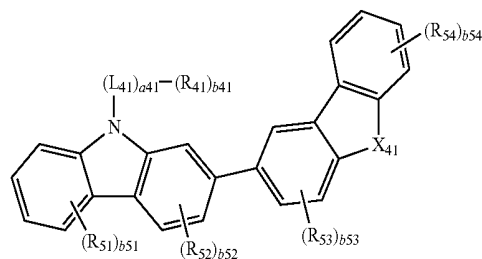
Formula 41-4



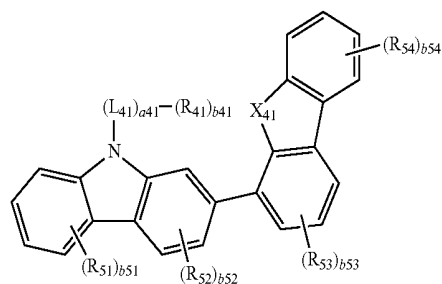
Formula 41-5



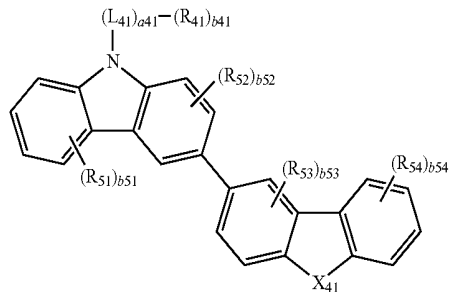
Formula 41-6



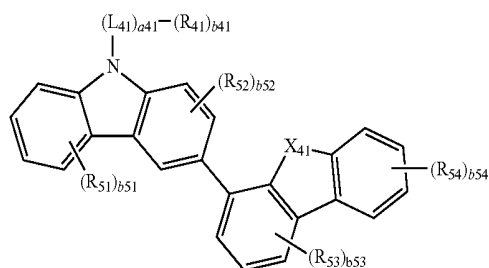
Formula 41-7



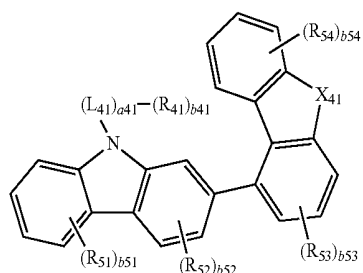
Formula 41-1



Formula 41-2

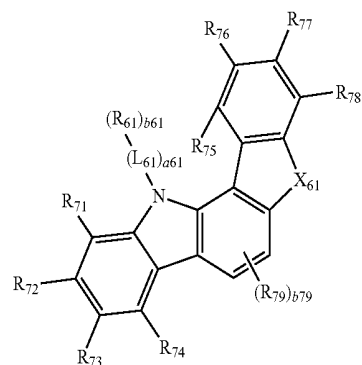


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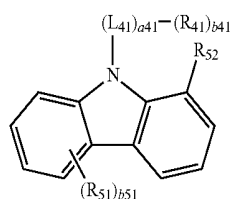


Formula 41-8

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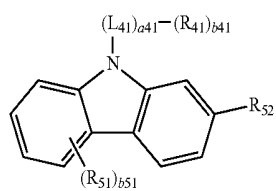


Formula 61-2

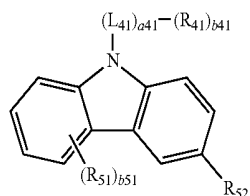
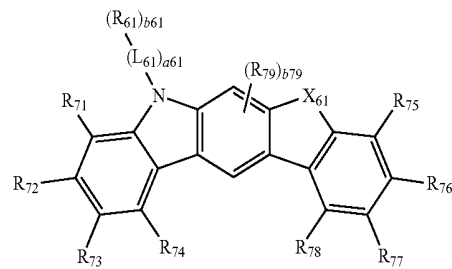


Formula 41-9

Formula 61-3

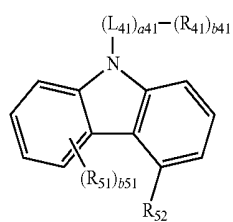


Formula 41-10

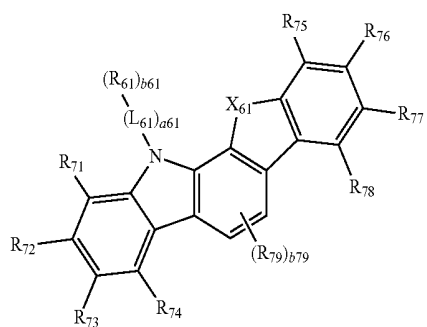
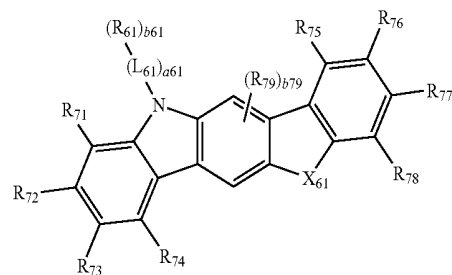


Formula 41-11

Formula 61-4

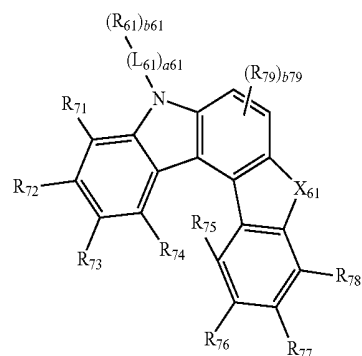


Formula 41-12



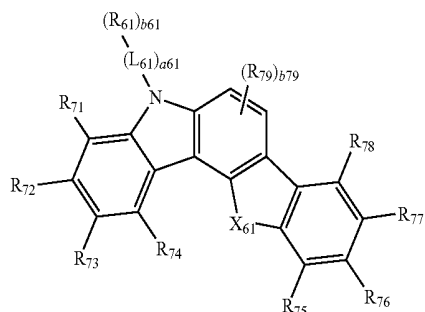
Formula 61-1

Formula 61-5



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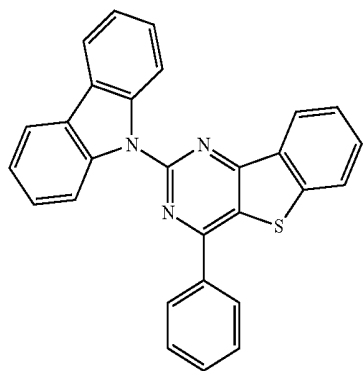
Formula 61-6



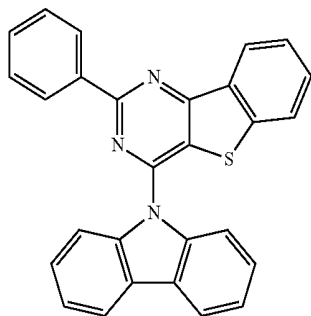
wherein, in Formulae 41-1 to 41-12 and Formulae 61-1 to 61-6,  $X_{41}$ ,  $X_{61}$ ,  $L_{41}$ ,  $a_{41}$ ,  $L_{61}$ ,  $a_{61}$ ,  $R_{41}$ ,  $b_{41}$ ,  $b_{42}$ ,  $R_{51}$  to  $R_{54}$ ,  $R_{61}$ ,  $b_{51}$  to  $b_{54}$ ,  $b_{61}$ ,  $R_{71}$  to  $R_{79}$  and  $b_{79}$  are the same as those defined in claim 13.

16. The organic light-emitting device of claim 13, wherein the condensed cyclic compound comprises one of Compounds listed in following Group I, and the first compound and the second compound comprises one of Compounds listed in following Group II:

[Group I]



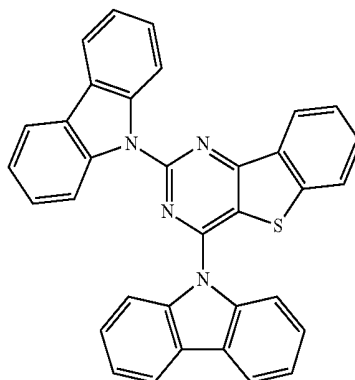
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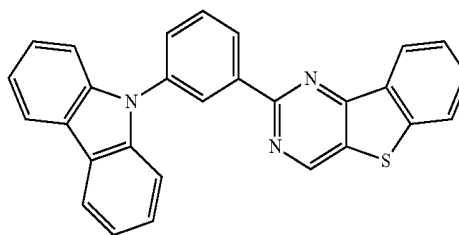
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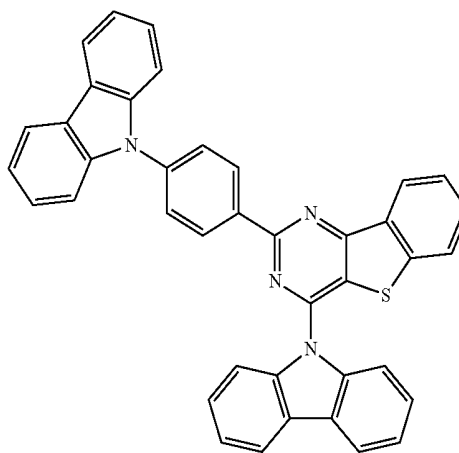
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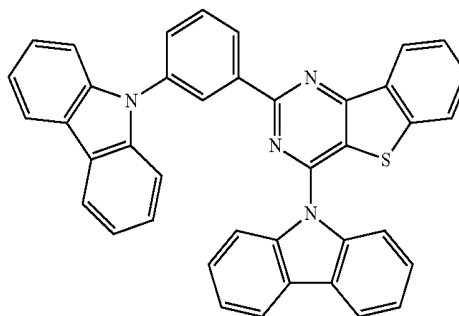
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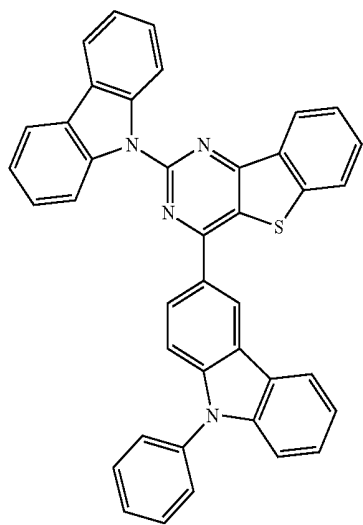
12



13

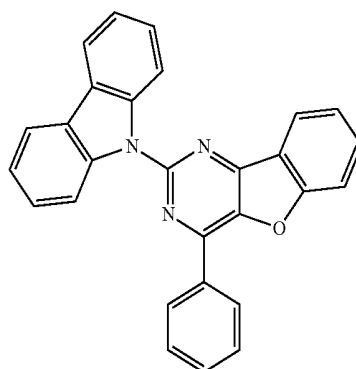


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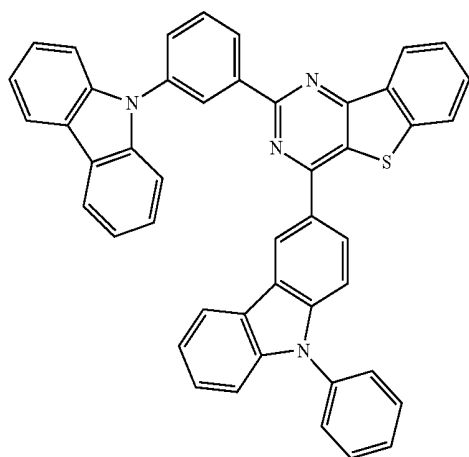


16

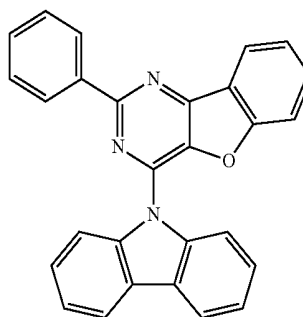
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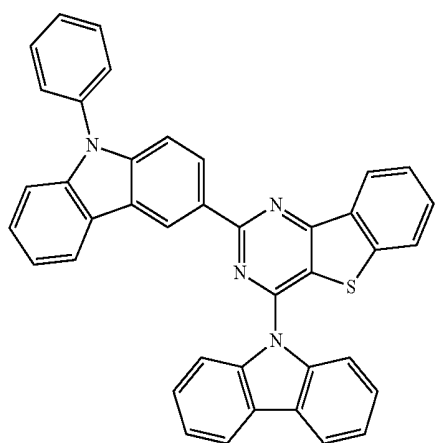
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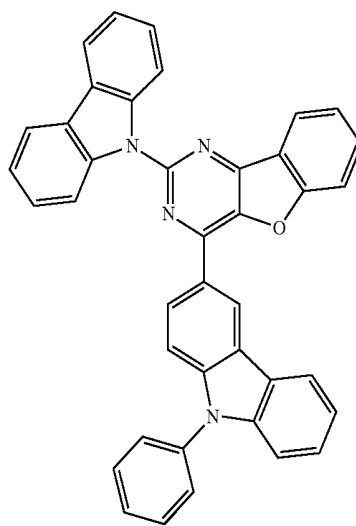
18



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21

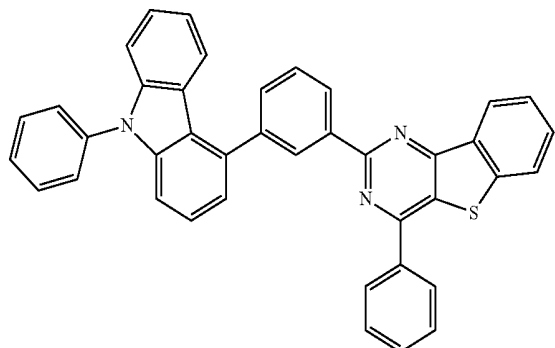


45

48

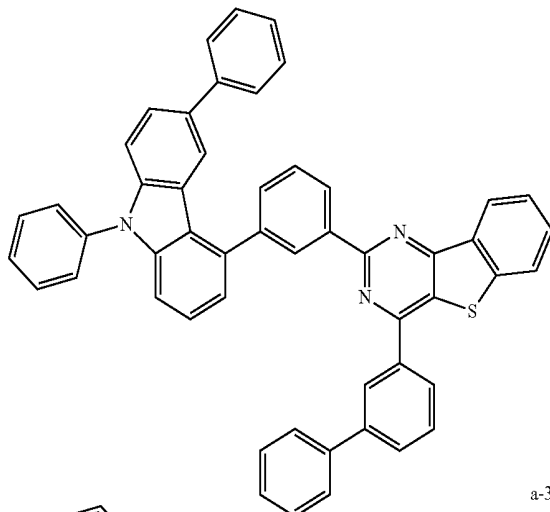
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a-9

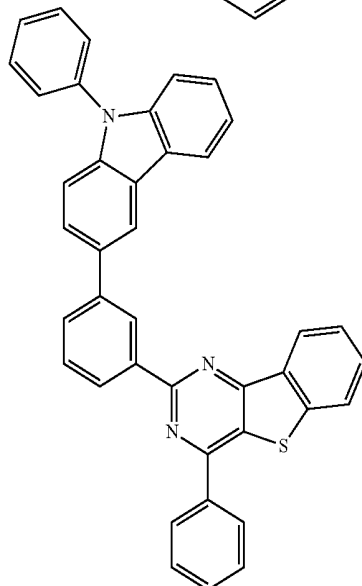
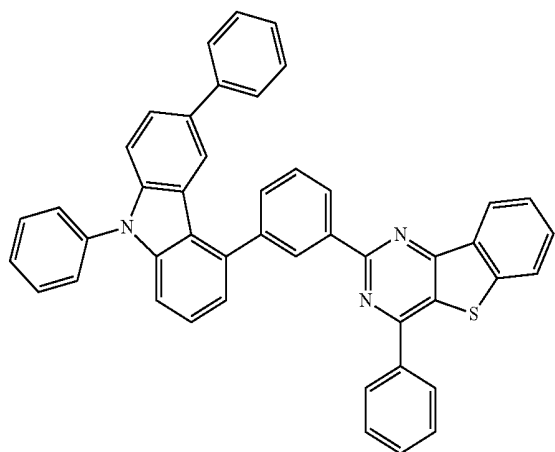


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a-13

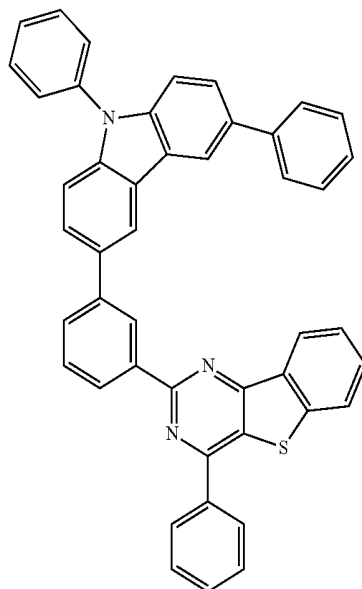
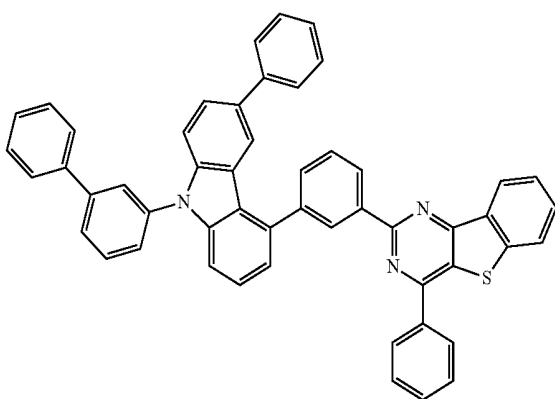


a-10



a-31

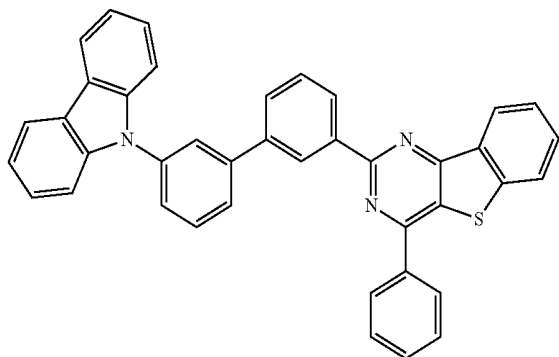
a-12



a-32

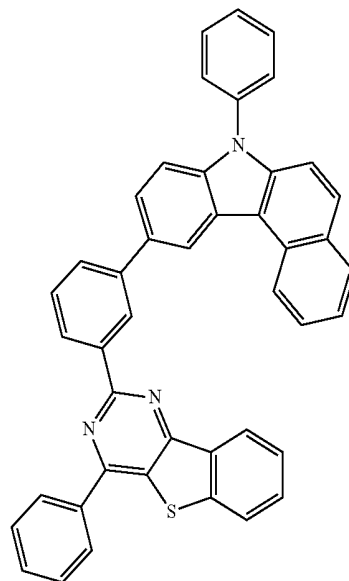
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a-41

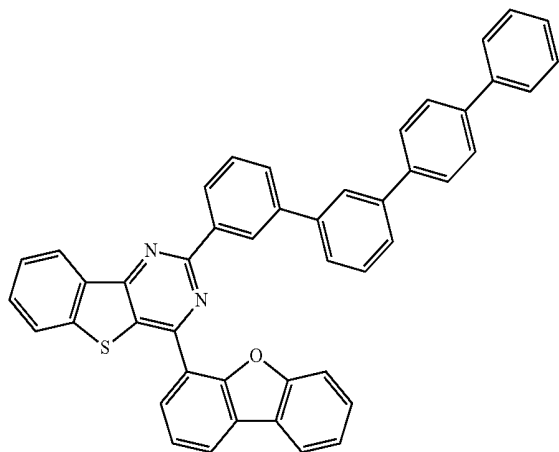


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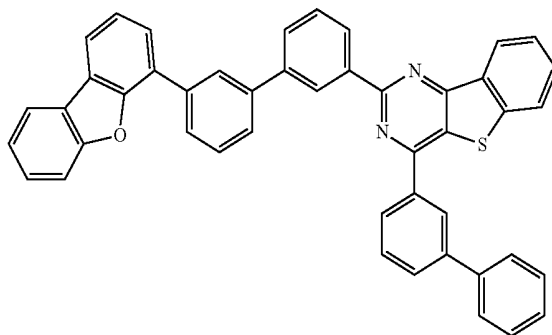
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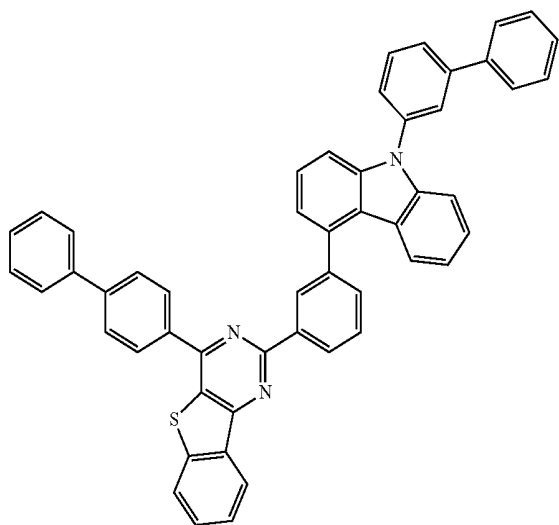
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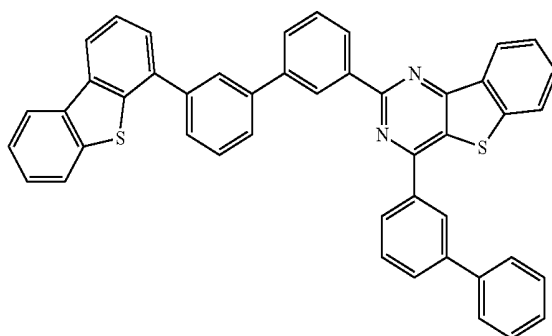
a-73



a-47

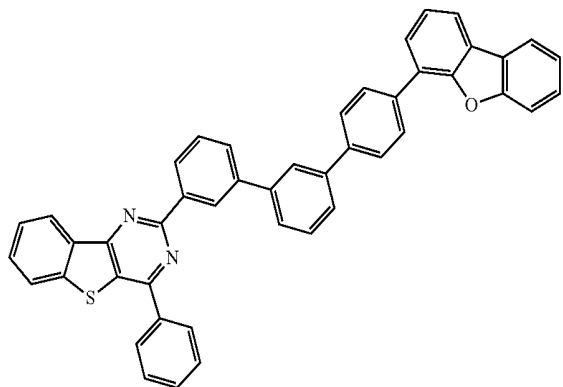


a-74



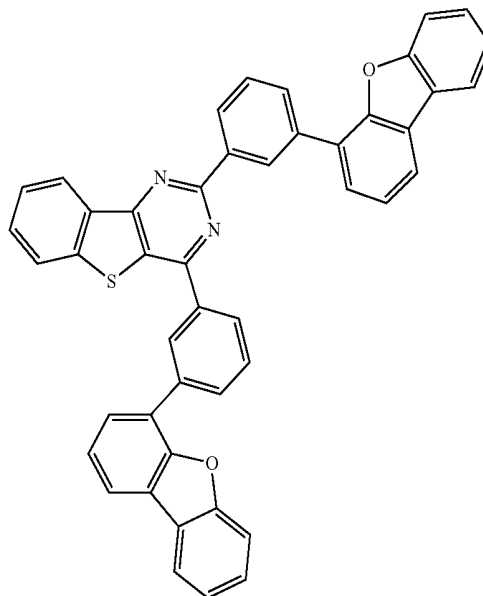
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a-75

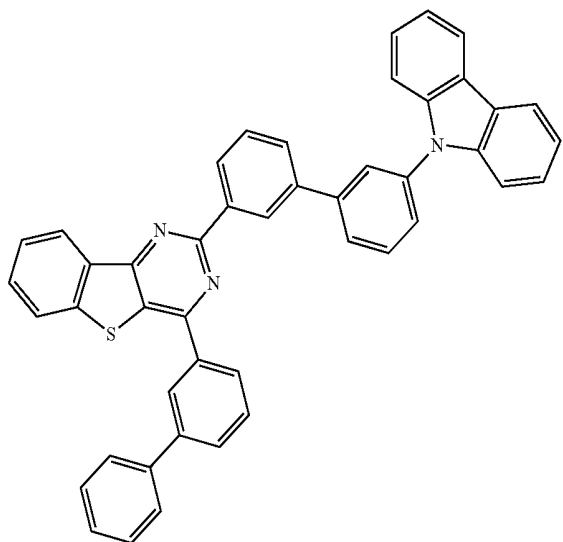


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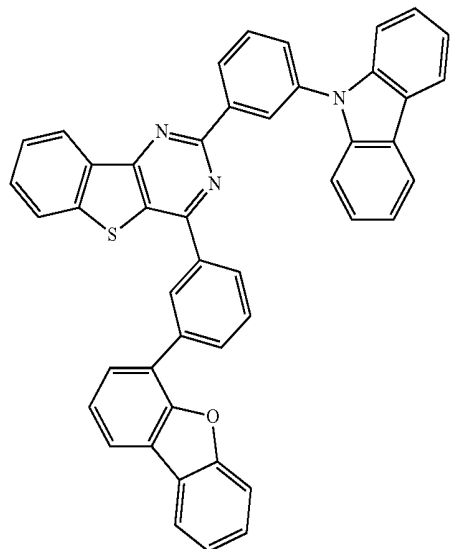
a-84



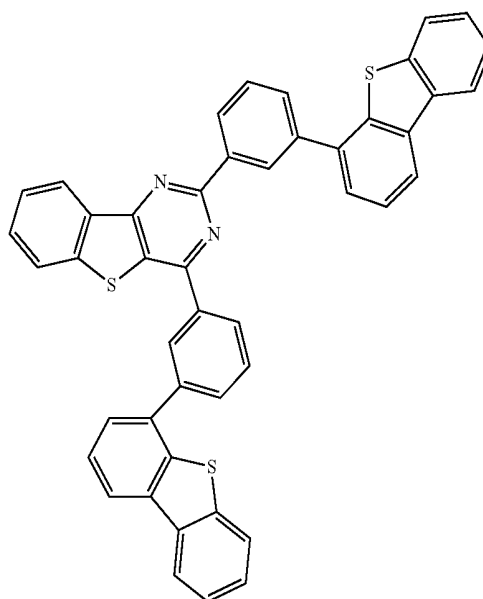
a-79



a-82

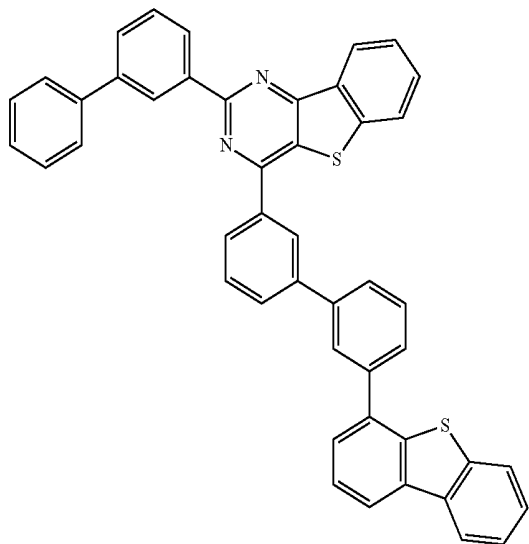


a-85



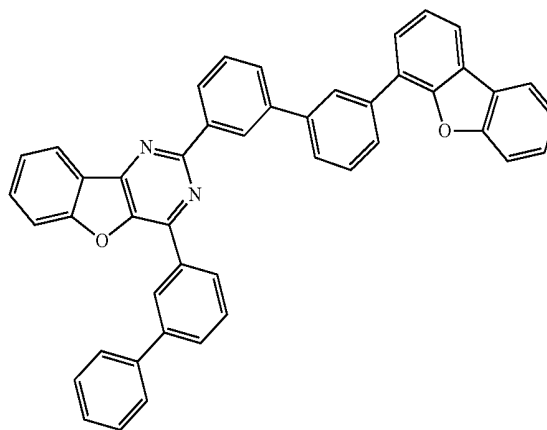
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a-87

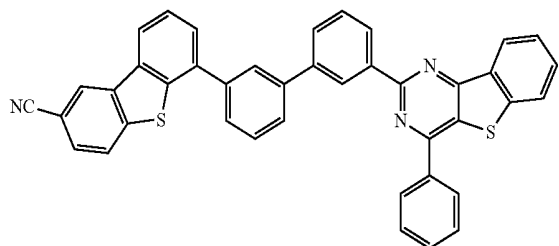


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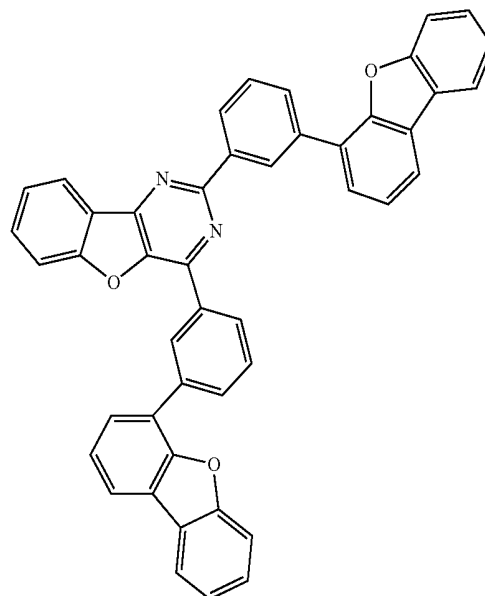
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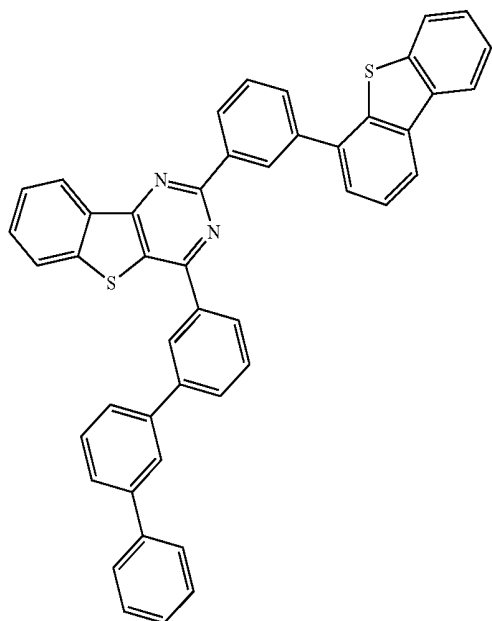
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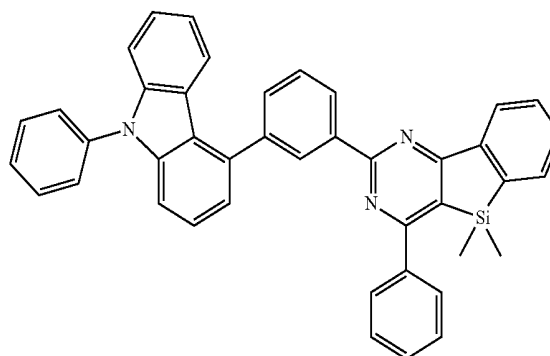
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a-95

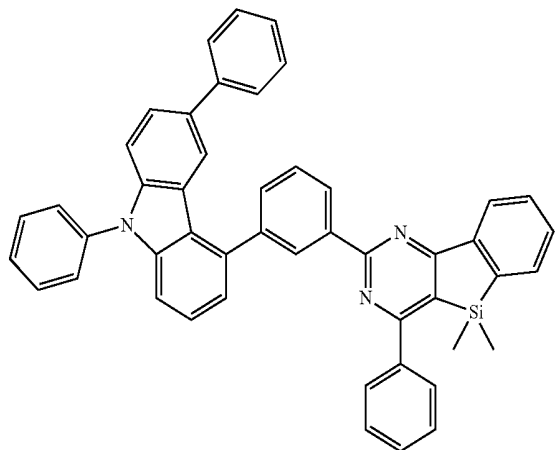


c-9



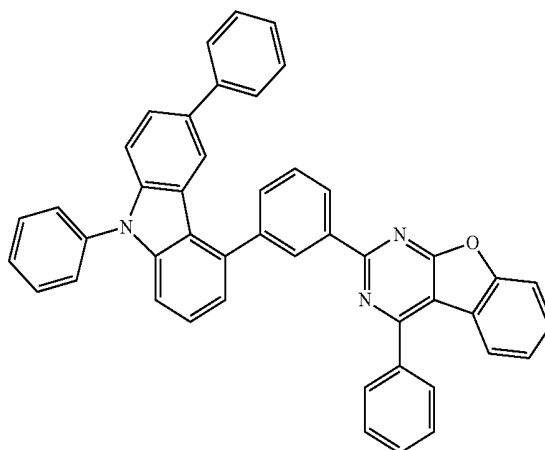
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c-10

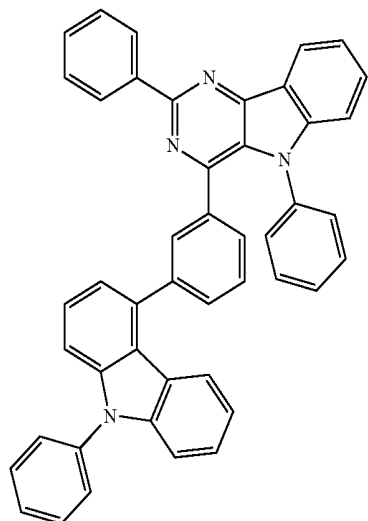


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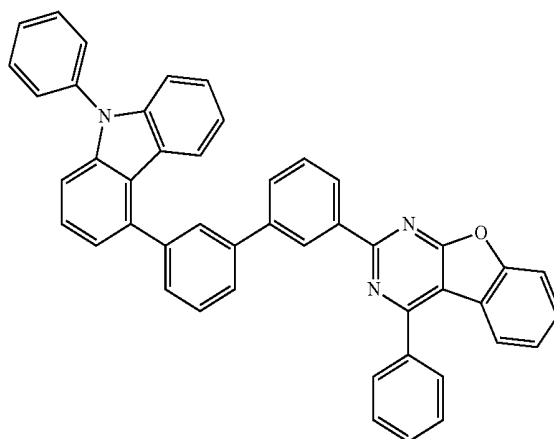
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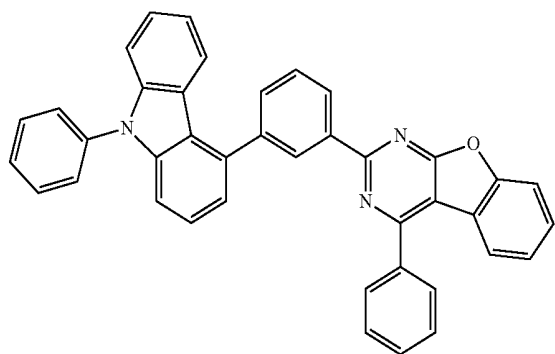
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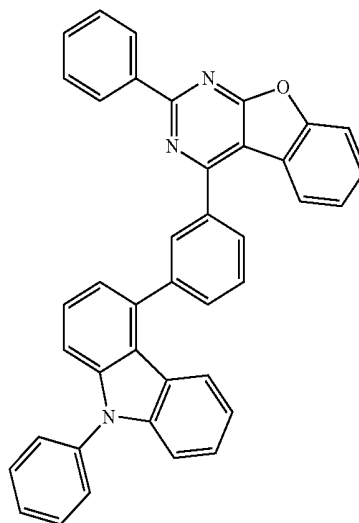
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e-9

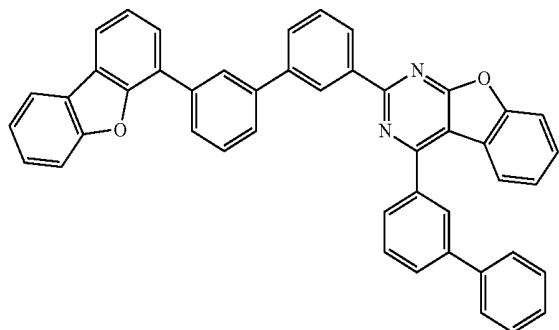


e-23



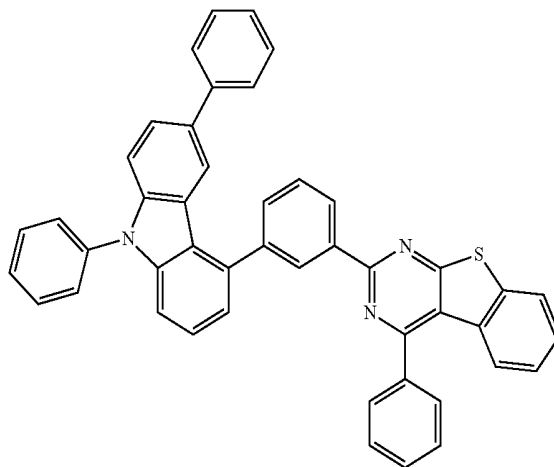
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e-73

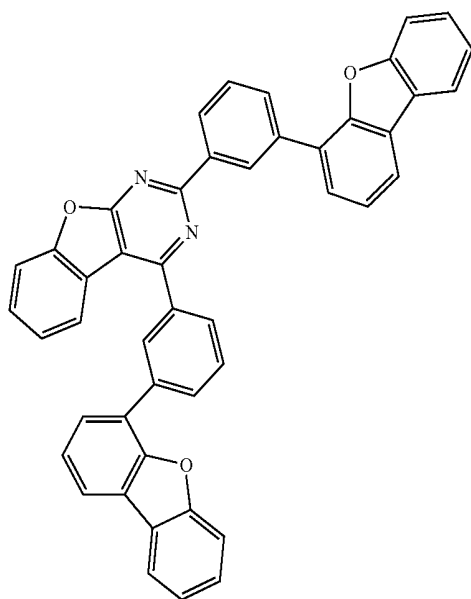


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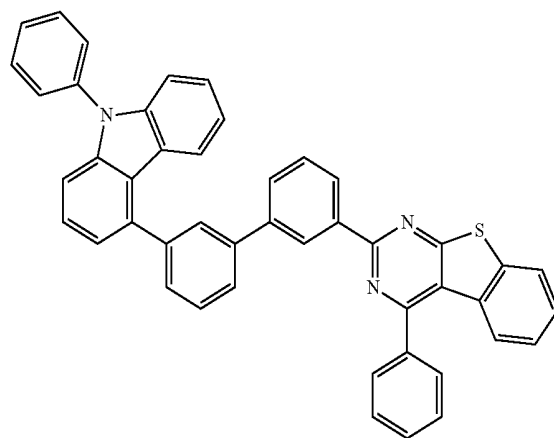
f-10



e-84

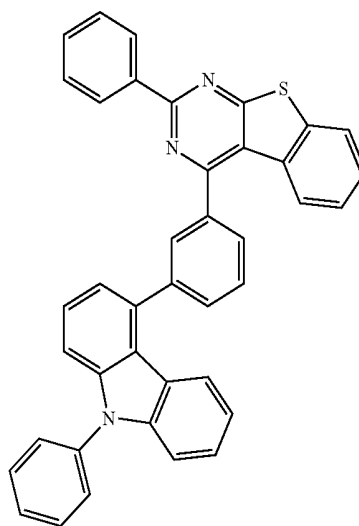
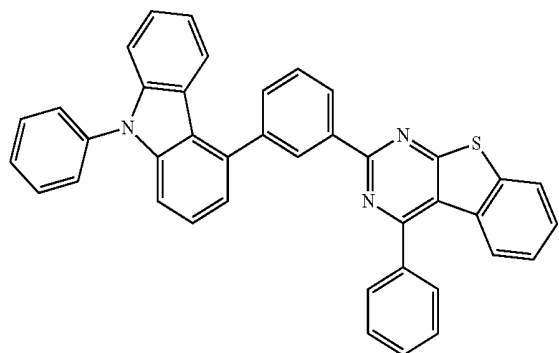


f-15



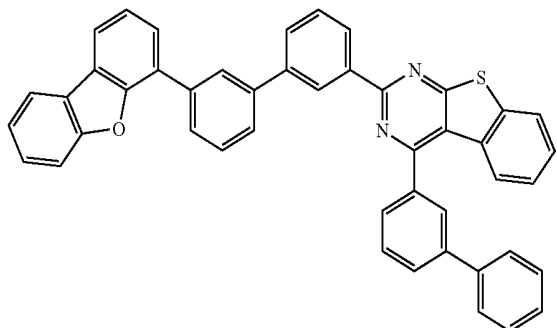
f-23

f-9

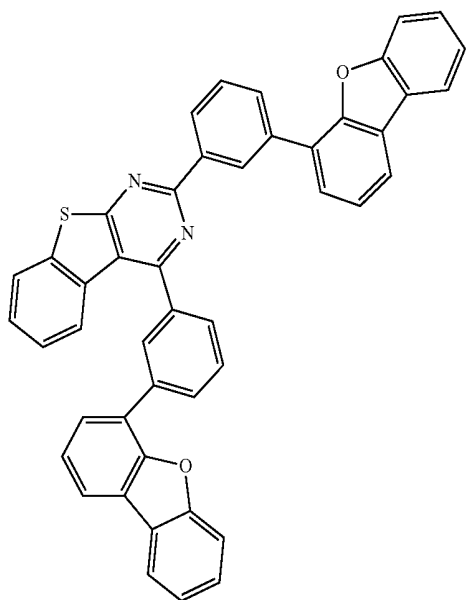


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f-73

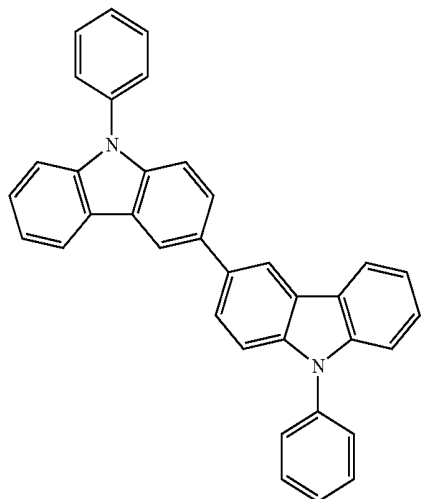


f-84



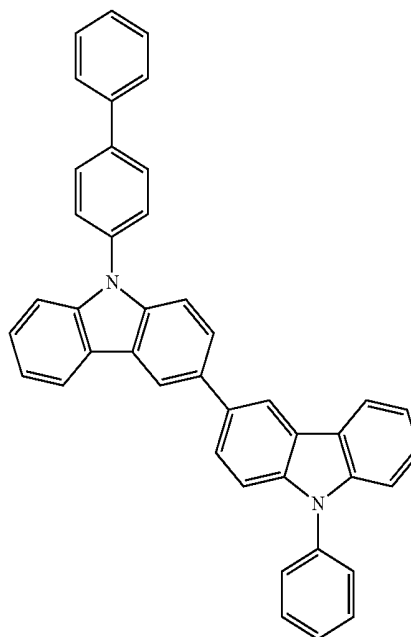
[Group II]

A1

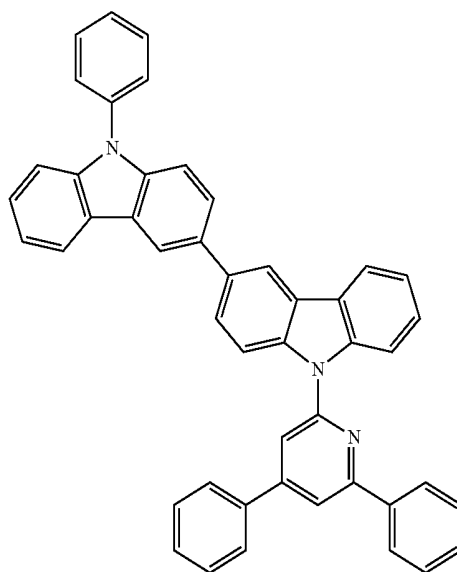


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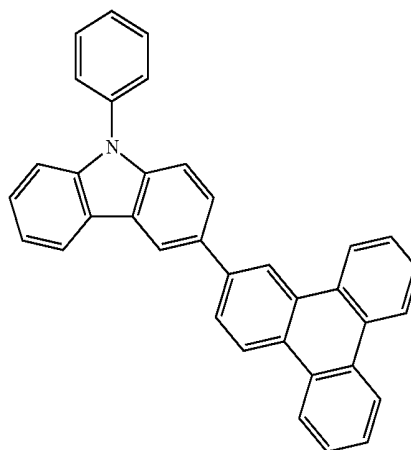
A2



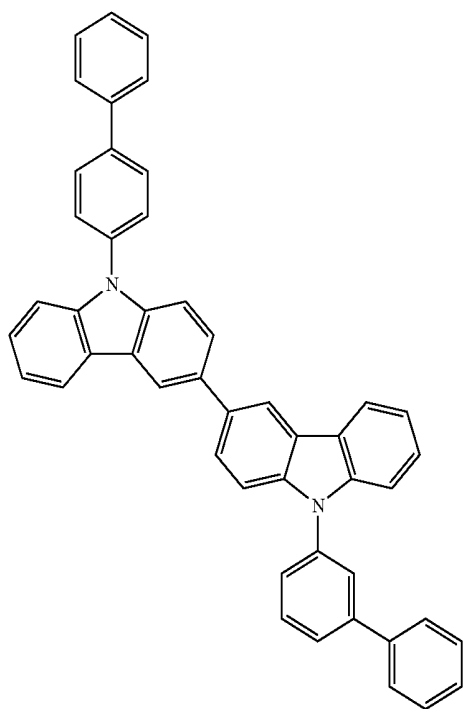
A5



A15

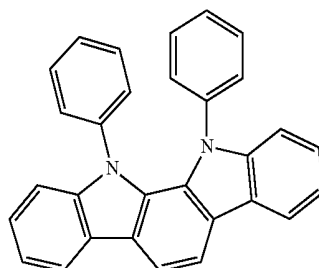


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A17

-continued

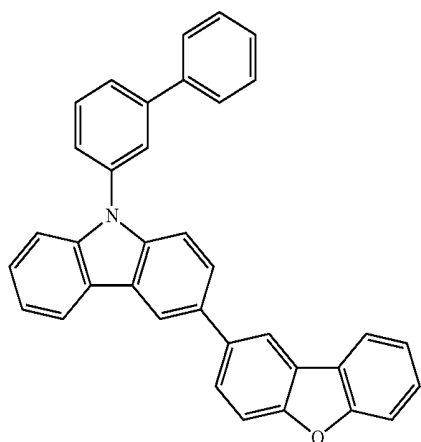


B2

17. The organic light-emitting device of claim of claim 12, wherein the condensed cyclic compound is in the electron transport auxiliary layer of the organic layer, and

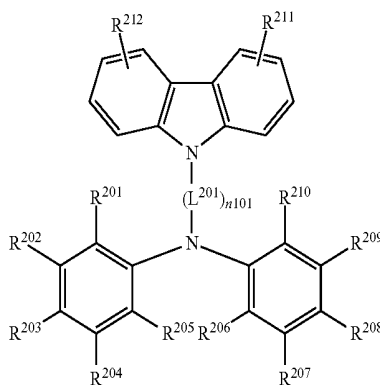
the organic light-emitting device further comprises a hole transport auxiliary layer including a compound represented by the following Formula 2:

A63



A64

<Formula 2>



wherein, in Formula 2,

$L^{201}$  is a substituted or unsubstituted C6 to C30 arylene group, or a substituted or unsubstituted C2 to C30 heteroarylene group,

n101 is an integer selected from 1 to 5,

$R^{201}$  to  $R^{212}$  are each independently hydrogen, a deuterium, a substituted or unsubstituted C1 to C20 alkyl group, a substituted or unsubstituted C6 to C50 aryl group, a substituted or unsubstituted C2 to C50 heteroaryl group or a combination thereof, and

$R^{201}$  to  $R^{212}$  are each independently present or are fused to each other to form a ring.

\* \* \* \* \*

专利名称(译)	缩合环状化合物和包括其的有机发光器件		
公开(公告)号	<a href="#">US20160351826A1</a>	公开(公告)日	2016-12-01
申请号	US15/108066	申请日	2015-01-06
[标]申请(专利权)人(译)	三星电子株式会社		
申请(专利权)人(译)	三星SDI CO. , LTD. SAMSUNG ELECTRONICS CO. , LTD.		
当前申请(专利权)人(译)	三星SDI CO. , LTD. SAMSUNG ELECTRONICS CO. , LTD.		
[标]发明人	KIM BYUNG KU JUNG HO KUK HAN SU JIN KWON O HYUN KIM YOUNG KWON KIM CHANG WOO KIM HYUNG SUN SEO JOO HEE SHIN CHANG JU YU EUN SUN LEE SEUNG JAE CHOI BYOUNG KI HWANG KYU YOUNG		
发明人	KIM, BYUNG-KU JUNG, HO-KUK HAN, SU-JIN KWON, O HYUN KIM, YOUNG-KWON KIM, CHANG-WOO KIM, HYUNG-SUN SEO, JOO-HEE SHIN, CHANG-JU YU, EUN-SUN LEE, SEUNG-JAE CHOI, BYOUNG KI HWANG, KYU YOUNG		
IPC分类号	H01L51/00 C09K11/06 C07F7/08 C07D487/04 C07D495/04 C07D491/048		
CPC分类号	H01L51/0072 C07D495/04 C07D491/048 C07F7/0816 C07D487/04 C09K11/06 H01L51/5056 H01L51/0074 H01L51/0067 H01L51/0054 H01L51/5024 H01L51/5072 H01L51/0073		
优先权	1020140003604 2014-01-10 KR 1020140003605 2014-01-10 KR		
外部链接	<a href="#">Espacenet</a> <a href="#">USPTO</a>		

#### 摘要(译)

提供了稠环化合物和包括该稠环化合物的有机发光器件。

<Formula 1>

