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**(54) ORGANIC LIGHT-EMITTING DEVICE AND DISPLAY APPARATUS COMPRISING THE SAME**

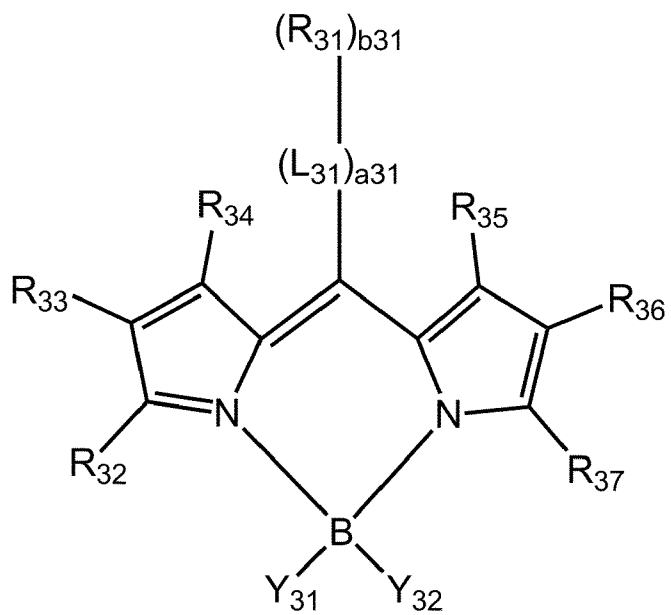
(57) An organic light-emitting device comprises a first electrode; a second electrode; and an organic layer between the first electrode and the second electrode. The organic layer comprises an emission layer. The emission layer comprises a first compound, a second compound, and a third compound. The first compound is represented by Formula 1, the second compound is represented by Formula 2, the third compound is represented by Formula 3, and the first compound and the second compound are different from each other.

Formula 1             $(Y_{11})_{c11}-(L_{11})_{a11}-(Y_{12})_{c12}$

Formula 2             $(Y_{21})_{c21}-(L_{21})_{a21}-(Y_{22})_{c22}$

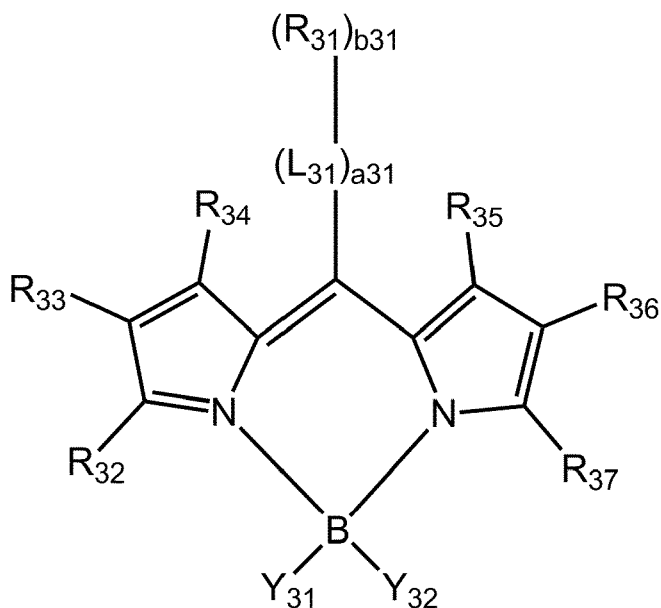
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Formula 3





## Formula 3



In Formulae 1 to 3,

$L_{11}$  is selected from:

a  $\pi$  electron-depleted nitrogen-free cyclic group; and

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$ ,

$a_{11}$  is selected from 0, 1, 2, and 3,

$Y_{12}$  is selected from:

$-\text{F}$ , a cyano group, and a  $\pi$  electron-depleted nitrogen-containing cyclic group;

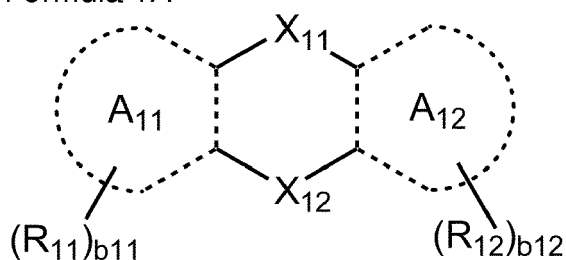
a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic group, each substituted with at least one selected from  $-\text{F}$  and a cyano group; and

a  $\pi$  electron-depleted nitrogen-containing cyclic group substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic group,

$c_{11}$  and  $c_{12}$  are each independently selected from 1, 2, and 3,

$Y_{11}$  is a group represented by Formula 1A,

Formula 1A



$X_{11}$  is selected from a single bond,  $\text{N}(\text{R}_{13})$ , O, and S,

$X_{12}$  is selected from a single bond,  $\text{N}(\text{R}_{14})$ , O, and S,

$X_{11}$  and  $X_{12}$  are not a single bond at the same time,

$A_{11}$  and  $A_{12}$  are each independently a  $\pi$  electron-depleted nitrogen-free cyclic group,

$\text{R}_{11}$  to  $\text{R}_{14}$  are each independently selected from:

a binding site, hydrogen, deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$ ;

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with deuterium, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>); and

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with a  $\pi$  electron-depleted nitrogen-free cyclic group that is substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>), wherein one selected from R<sub>11</sub> to R<sub>14</sub> is a binding site,

b<sub>11</sub> and b<sub>12</sub> are each independently selected from 1, 2, 3, 4, 5, and 6,

L<sub>21</sub> is selected from a substituted or unsubstituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group and a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heterocyclic group,

a<sub>21</sub> is selected from 0, 1, 2, and 3,

Y<sub>22</sub> is selected from:

-F, a cyano group, and a  $\pi$  electron-depleted nitrogen-containing cyclic group;

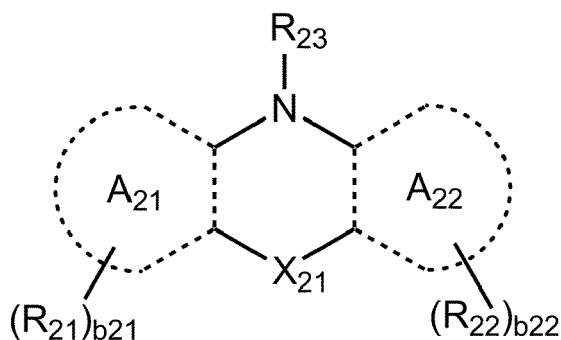
a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic group, each substituted with at least one selected from -F and a cyano group; and

a  $\pi$  electron-depleted nitrogen-containing cyclic group substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic group,

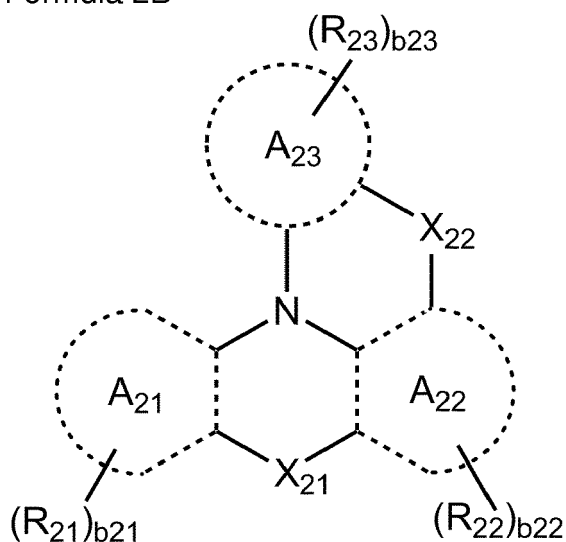
c<sub>21</sub> and c<sub>22</sub> are each independently selected from 1, 2, 3, 4, 5, and 6,

Y<sub>21</sub> is a group represented by one selected from Formulae 2A to 2C,

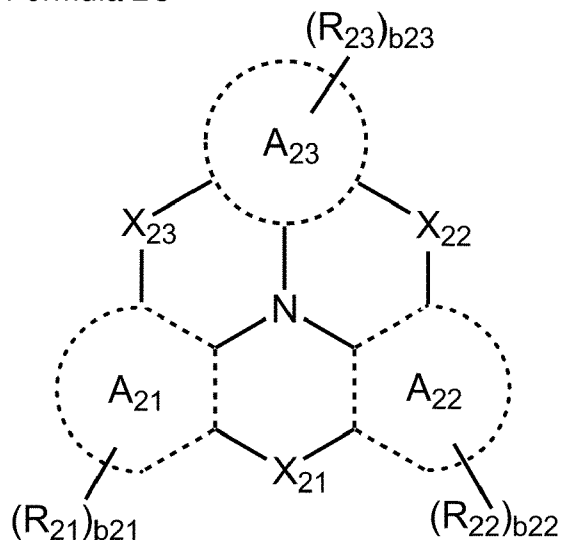
Formula 2A



Formula 2B



## Formula 2C



X<sub>21</sub> is selected from a single bond, N(R<sub>24</sub>), O, and S,

X<sub>22</sub> is selected from a single bond, N(R<sub>25</sub>), O, and S,

X<sub>23</sub> is selected from a single bond, N(R<sub>26</sub>), O, and S,

A<sub>21</sub> to A<sub>23</sub> are each independently a  $\pi$  electron-depleted nitrogen-free cyclic group,

R<sub>21</sub> to R<sub>26</sub> are each independently selected from:

a binding site, hydrogen, deuterium, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, -N(Q<sub>1</sub>)(Q<sub>2</sub>), and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>);

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, -N(Q<sub>31</sub>)(Q<sub>32</sub>), and -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>); and

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with a  $\pi$  electron-depleted nitrogen-free cyclic group that is substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, -N(Q<sub>21</sub>)(Q<sub>22</sub>), and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>), wherein one selected from R<sub>21</sub> to R<sub>24</sub> in Formula 2A may be a binding site, one selected from R<sub>21</sub> to R<sub>25</sub> in Formula 2B may be a binding site, and one selected from R<sub>21</sub> to R<sub>26</sub> in Formula 2C may be a binding site,

b<sub>21</sub> to b<sub>23</sub> are each independently selected from 1, 2, 3, 4, 5, and 6,

L<sub>31</sub> is selected from a substituted or unsubstituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group and a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heterocyclic group,

a<sub>31</sub> is selected from 0, 1, 2, and 3,

R<sub>31</sub> to R<sub>37</sub> are each independently selected from hydrogen, 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 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>1</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>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>), -B(Q<sub>1</sub>)(Q<sub>2</sub>), -N(Q<sub>1</sub>)(Q<sub>2</sub>), -P(Q<sub>1</sub>)(Q<sub>2</sub>), -C(=O)(Q<sub>1</sub>), -S(=O)(Q<sub>1</sub>), -S(=O)<sub>2</sub>(Q<sub>1</sub>), -P(=O)(Q<sub>1</sub>)(Q<sub>2</sub>), and -P(=S)(Q<sub>1</sub>)(Q<sub>2</sub>), wherein R<sub>31</sub> to R<sub>37</sub> may optionally be linked to form a substituted or unsubstituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group or a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heterocyclic group,

b<sub>31</sub> is selected from 1, 2, 3, 4, 5, and 6,

Y<sub>31</sub> and Y<sub>32</sub> are each independently selected from -F, -Cl, -Br, -I, 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>6</sub>-C<sub>60</sub> aryl group, and a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, wherein Y<sub>31</sub> and Y<sub>32</sub> may optionally be linked to form a substituted or unsubstituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group or a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heterocyclic group, and

Q<sub>1</sub> to Q<sub>3</sub>, Q<sub>21</sub> to Q<sub>23</sub>, and Q<sub>31</sub> to Q<sub>33</sub> are each independently selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> hetero aryloxy group, a C<sub>1</sub>-C<sub>60</sub> hetero arylthio group, a monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group, a monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, a biphenyl group, and a terphenyl group.

[0008] The display apparatus of the present invention comprises a thin film transistor (comprising a source electrode, a drain electrode, and an active layer); and the organic light-emitting device of the present invention, wherein the first electrode of the organic light-emitting device is electrically connected to one selected from the source electrode and the drain source of the thin film transistor.

### BRIEF DESCRIPTION OF THE DRAWINGS

[0009] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic cross-sectional view of an organic light-emitting device according to an embodiment;  
 FIG. 2 is a schematic cross-sectional view of an organic light-emitting device according to an embodiment;  
 FIG. 3 is a schematic cross-sectional view of an organic light-emitting device according to an embodiment; and  
 FIG. 4 is a schematic cross-sectional view of an organic light-emitting device according to an embodiment.

### DETAILED DESCRIPTION

[0010] The present disclosure will now be described more fully with reference to exemplary embodiments. The disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the disclosure to those skilled in the art. Enhancements and features of the present invention, and how to achieve them will become apparent by reference to the embodiment that will be described later in more detail, together with the accompanying drawings. This invention may, however, be embodied in many different forms and should not be limited to the exemplary embodiments.

[0011] Hereinafter, embodiments are described in more detail by referring to the attached drawings, and in the drawings, like reference numerals denote like elements, and a redundant explanation thereof will not be provided herein.

[0012] As used herein, the singular forms "a," "an" and "the" are intended to comprise the plural forms as well, unless the context clearly indicates otherwise.

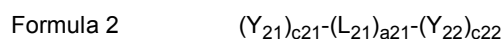
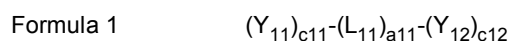
[0013] It will be further understood that the terms "comprises" and/or "comprising" as used herein specify the presence of stated features or components, but do not preclude the presence or addition of one or more other features or components.

[0014] It will be understood that when a layer, region, or component is referred to as being "on" or "onto" another layer, region, or component, it may be directly or indirectly formed on the other layer, region, or component. That is, for example, intervening layers, regions, or components may be present.

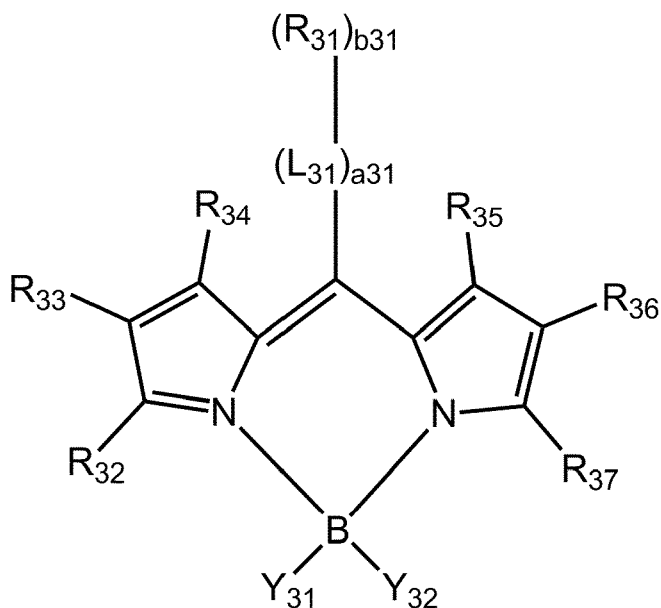
[0015] Sizes of components in the drawings may be exaggerated for convenience of explanation. In other words, because sizes and thicknesses of components in the drawings are arbitrarily illustrated for convenience of explanation, the following embodiments of the present disclosure are not limited thereto.

[0016] The term "organic layer" as used herein refers to a single layer and/or a plurality of layers disposed between the first electrode and the second electrode of the organic light-emitting device. A material comprised in the "organic layer" is not limited to an organic material.

[0017] The organic light-emitting device of the invention comprises: a first electrode; a second electrode; and an organic layer between the first electrode and the second electrode, wherein the organic layer may comprise an emission layer, the emission layer may comprise a first compound, a second compound, and a third compound, the first compound may be represented by Formula 1, the second compound may be represented by Formula 2, the third compound may be represented by Formula 3, and the first compound and the second compound are different from each other:



Formula 3



In Formula 1 to 3, 1A and 2A to 2C,

$L_{11}$  is selected from:

a  $\pi$  electron-depleted nitrogen-free cyclic group; and

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$ ,

$a_{11}$  is selected from 0, 1, 2, and 3,

$Y_{12}$  is selected from:

$-\text{F}$ , a cyano group, and a  $\pi$  electron-depleted nitrogen-containing cyclic group;

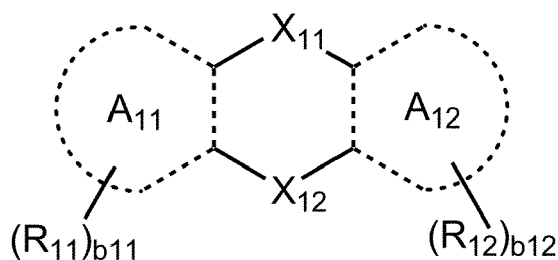
a  $C_1$ - $C_{60}$  alkyl group, and a  $\pi$  electron-depleted nitrogen-free cyclic group, each substituted with at least one selected from  $-\text{F}$  and a cyano group; and

a  $\pi$  electron-depleted nitrogen-containing cyclic group substituted with at least one selected from deuterium,  $-\text{F}$ , a cyano group, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic group,

$c_{11}$  and  $c_{12}$  are each independently selected from 1, 2, and 3,

$Y_{11}$  is a group represented by Formula 1A,

Formula 1A



$X_{11}$  is selected from a single bond,  $\text{N}(\text{R}_{13})$ , O, and S,

$X_{12}$  is selected from a single bond,  $\text{N}(\text{R}_{14})$ , O, and S,

$X_{11}$  and  $X_{12}$  are not a single bond at the same time,

$A_{11}$  and  $A_{12}$  are each independently a  $\pi$  electron-depleted nitrogen-free cyclic group,

$\text{R}_{11}$  to  $\text{R}_{14}$  are each independently selected from:

a binding site (e.g., to  $L_{11}$ ), hydrogen, deuterium, a  $C_1$ - $C_{60}$  alkyl group, and a  $\pi$  electron-depleted nitrogen-free cyclic group and  $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$ ;

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl

group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$ ; and  
 a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with a  $\pi$  electron-depleted nitrogen-free cyclic group  
 that is substituted with at least one selected from deuterium, a  $\text{C}_1\text{-C}_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free  
 cyclic group, and  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ , wherein one selected from  $\text{R}_{11}$  to  $\text{R}_{14}$  may be a binding site (e.g., to  $\text{L}_{11}$ ),  
 b11 and b12 are each independently selected from 1, 2, 3, 4, 5, and 6,

$\text{L}_{21}$  is selected from a substituted or unsubstituted  $\text{C}_5\text{-C}_{60}$  carbocyclic group and a substituted or unsubstituted  
 $\text{C}_1\text{-C}_{60}$  heterocyclic group,

a21 is selected from 0, 1, 2, and 3,

$\text{Y}_{22}$  is selected from:

-F, a cyano group, and a  $\pi$  electron-depleted nitrogen-containing cyclic group;

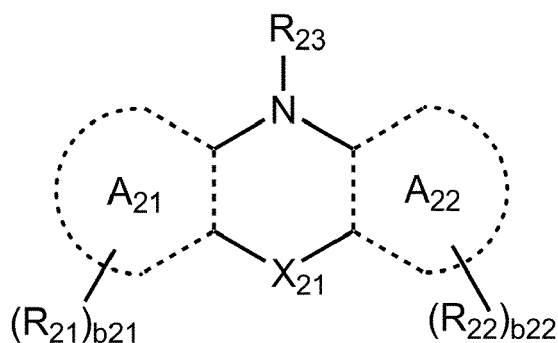
a  $\text{C}_1\text{-C}_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free  
 cyclic group, each substituted with at least one selected from -F and a cyano group; and

a  $\pi$  electron-depleted nitrogen-containing cyclic group substituted with at least one selected from deuterium, a  $\text{C}_1\text{-C}_{60}$   
 alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic  
 group,

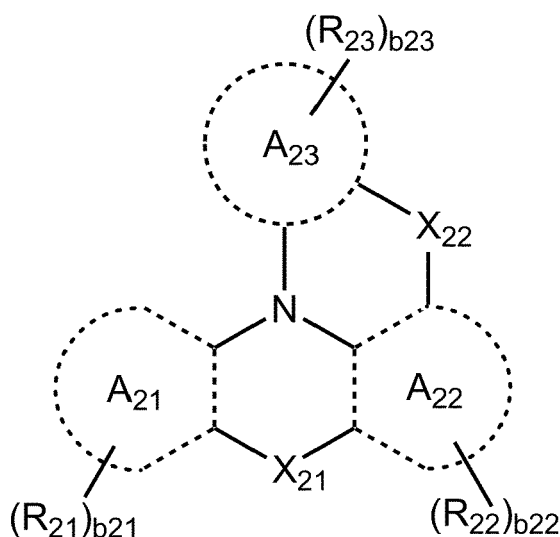
c21 and c22 are each independently selected from 1, 2, 3, 4, 5, and 6,

$\text{Y}_{21}$  is a group represented by one selected from Formulae 2A to 2C,

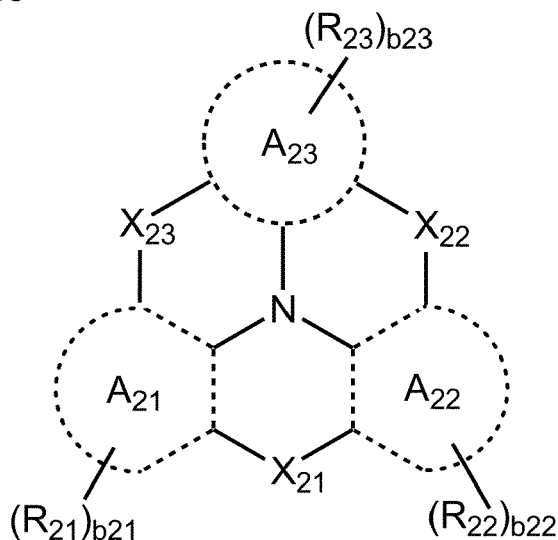
Formula 2A



Formula 2B



## Formula 2C



$X_{21}$  is selected from a single bond, N(R<sub>24</sub>), O, and S,

$X_{22}$  is selected from a single bond, N(R<sub>25</sub>), O, and S,

$X_{23}$  is selected from a single bond, N(R<sub>26</sub>), O, and S,

A<sub>21</sub> to A<sub>23</sub> are each independently a  $\pi$  electron-depleted nitrogen-free cyclic group,

R<sub>21</sub> to R<sub>26</sub> are each independently selected from:

a binding site (e.g., to L<sub>21</sub>), hydrogen, deuterium, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, -N(Q<sub>1</sub>)(Q<sub>2</sub>), and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>);

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, -N(Q<sub>31</sub>)(Q<sub>32</sub>), and -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>); and

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with a  $\pi$  electron-depleted nitrogen-free cyclic group that is substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, -N(Q<sub>21</sub>)(Q<sub>22</sub>), and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>), wherein one selected from R<sub>21</sub> to R<sub>24</sub> in Formula 2A may be a binding site (e.g., to L<sub>21</sub>), one selected from R<sub>21</sub> to R<sub>25</sub> in Formula 2B may be a binding site (e.g., to L<sub>21</sub>), and one selected from R<sub>21</sub> to R<sub>26</sub> in Formula 2C may be a binding site (e.g., to L<sub>21</sub>);

b<sub>21</sub> to b<sub>23</sub> are each independently selected from 1, 2, 3, 4, 5, and 6,

L<sub>31</sub> is selected from a substituted or unsubstituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group and a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heterocyclic group,

a<sub>31</sub> is selected from 0, 1, 2, and 3; and

R<sub>31</sub> to R<sub>37</sub> are each independently selected from hydrogen, 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 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>1</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>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>), -B(Q<sub>1</sub>)(Q<sub>2</sub>), -N(Q<sub>1</sub>)(Q<sub>2</sub>), -P(Q<sub>1</sub>)(Q<sub>2</sub>), -C(=O)(Q<sub>1</sub>), -S(=O)(Q<sub>1</sub>), -S(=O)<sub>2</sub>(Q<sub>1</sub>), -P(=O)(Q<sub>1</sub>)(Q<sub>2</sub>), and -P(=S)(Q<sub>1</sub>)(Q<sub>2</sub>),

R<sub>31</sub> to R<sub>37</sub> may optionally be linked (e.g., to a neighboring group) to form a substituted or unsubstituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group or a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heterocyclic group,

b<sub>31</sub> are selected from 1, 2, 3, 4, 5, and 6,

Y<sub>31</sub> and Y<sub>32</sub> are each independently selected from -F, -Cl, -Br, -I, 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>6</sub>-C<sub>60</sub> aryl group, and a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, wherein Y<sub>31</sub> and Y<sub>32</sub> may optionally be linked to form a substituted or unsubstituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group or a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heterocyclic group, and

Q<sub>1</sub> to Q<sub>3</sub>, Q<sub>21</sub> to Q<sub>23</sub>, and Q<sub>31</sub> to Q<sub>33</sub> are each independently selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a

hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> hetero aryloxy group, a C<sub>1</sub>-C<sub>60</sub> hetero arylthio group, a monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group, a monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, a biphenyl group, and a terphenyl group.

**[0018]** For example, L<sub>11</sub> in Formula 1 may be selected from:

a benzene group, a naphthalene group, a phenalene group, an anthracene group, a fluoranthene group, a triphenylene group, a phenanthrene group, a pyrene group, a chrysene group, a perylene group, a fluorene group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group; and  
 a benzene group, a naphthalene group, a phenalene group, an anthracene group, a fluoranthene group, a triphenylene group, a phenanthrene group, a pyrene group, a chrysene group, a perylene group, a fluorene group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group, each substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, but embodiments of the present disclosure are not limited thereto.

**[0019]** For example, L<sub>21</sub> and L<sub>31</sub> in Formulae 2 and 3 may each independently be selected from:

a benzene group, a naphthalene group, a phenalene group, an anthracene group, a fluoranthene group, a triphenylene group, a phenanthrene group, a pyrene group, a chrysene group, a perylene group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a benzoisoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a benzoquinoxaline group, a quinazoline group, a benzoquinazoline group, a fluorene group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group; and  
 a benzene group, a naphthalene group, a phenalene group, an anthracene group, a fluoranthene group, a triphenylene group, a phenanthrene group, a pyrene group, a chrysene group, a perylene group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a benzoisoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a benzoquinoxaline group, a quinazoline group, a benzoquinazoline group, a fluorene group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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 biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

**[0020]** For example, a<sub>11</sub>, a<sub>21</sub>, and a<sub>31</sub> in Formulae 1 to 3 may each independently be selected from 0 and 1, but embodiments of the present disclosure are not limited thereto.

**[0021]** In embodiments where a<sub>31</sub> is 0, b<sub>31</sub> is typically 1.

**[0022]** For example, in Formula 1A, X<sub>11</sub> may be selected from N(R<sub>13</sub>), O, and S, and

**[0023]** X<sub>12</sub> may be a single bond, but embodiments of the present disclosure are not limited thereto.

**[0024]** For example, in Formula 1A, A<sub>11</sub> and A<sub>12</sub> may each independently be selected from a benzene group, a naphthalene group, a fluorene group, a carbazole group, a dibenzofuran group, a dibenzothiophene group, a benzofluorene group, a benzocarbazole group, a benzonaphthofuran group, a benzonaphthothiophene group, an indolofluorene group, an indolocarbazole group, an indolodibenzofuran group, an indolodibenzothiophene group, an indenofluorene group, an indenocarbazole group, an indenodibenzofuran group, an indenodibenzothiophene group, a benzofuranoflu-

orene group, a benzofuranocarbazole group, a benzofuranodibenzofuran group, a benzofuranodibenzothiophene group, a benzothienofluorene group, a benzothienocarbazole group, a benzothienodibenzofuran group, and a benzothienodibenzothiophene group, but embodiments of the present disclosure are not limited thereto.

**[0025]** For example, in Formula 1A,  $R_{11}$  to  $R_{14}$  may each independently be selected from:

5 a binding site, hydrogen, deuterium, a  $C_1$ - $C_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzo-  
 10 carbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, and  $-Si(Q_1)(Q_2)(Q_3)$ ;  
 a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzo-  
 15 thiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, each substituted with at least one selected from deuterium, a  $C_1$ - $C_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzo-  
 20 thiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, and  $-Si(Q_{31})(Q_{32})(Q_{33})$ ; and  
 a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzo-  
 25 thiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and dinaphthothiophenyl group, each substituted with at least one selected from a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group that are each substituted  
 30 with at least one selected from deuterium, a  $C_1$ - $C_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, and  $-Si(Q_{21})(Q_{22})(Q_{23})$ ,  
 35 one selected from  $R_{11}$  to  $R_{14}$  may be a binding site,  
 $Q_1$  to  $Q_3$ ,  $Q_{21}$  to  $Q_{23}$ , and  $Q_{31}$  to  $Q_{33}$  may each independently be selected from a  $C_1$ - $C_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzo-  
 40 thiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, but embodiments of the present disclosure are not limited thereto.

**[0026]** The binding site in  $R_{11}$  to  $R_{14}$  is typically the site at which the  $Y_{11}$  group is bound to the remaining portion of the first compound as defined in Formula 1.

45 **[0027]** In embodiments where  $a_{11}$  is 0 and  $c_{12}$  is greater than 1, more than one of  $R_{11}$  to  $R_{14}$  is a binding site (i.e. the number of binding sites in  $R_{11}$  to  $R_{14}$  is equal to the value of  $c_{12}$ ).

**[0028]**  $c_{11}$  and  $c_{12}$  are typically both 1 when  $a_{11}$  is 0.

**[0029]** In one embodiment, in Formula 1A,  $R_{11}$  to  $R_{14}$  may each independently be selected from:

50 a binding site, hydrogen, deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and  $-Si(Q_1)(Q_2)(Q_3)$ ;  
 55 a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzo-

thiophenyl group, and  $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$ ; and

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, are each substituted with at least one selected from deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ ,

one selected from  $\text{R}_{11}$  to  $\text{R}_{14}$  may be a binding site,

$\text{Q}_1$  to  $\text{Q}_3$ ,  $\text{Q}_{21}$  to  $\text{Q}_{23}$ , and  $\text{Q}_{31}$  to  $\text{Q}_{33}$  may each independently be selected from a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

**[0030]** For example, in Formula 1,  $\text{Y}_{12}$  may be selected from:

-F, a cyano group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazoliny group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group;

a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazoliny group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from -F and a cyano group; and

a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazoliny group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from deuterium, a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazoliny group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

**[0031]** In one embodiment,  $\text{Y}_{12}$  in Formula 1 may be selected from:

-F, a cyano group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazoliny group;

a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazoliny group, each substituted with at least one selected from -F and a cyano group; and

a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl group, each substituted with at least one selected from deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl group, but embodiments of the present disclosure are not limited thereto.

**[0032]** For example, in Formula 1, c<sub>11</sub> and c<sub>12</sub> may each independently be 1, but embodiments of the present disclosure are not limited thereto.

**[0033]** For example, in Formulae 2A to 2C, X<sub>21</sub> may be a single bond, X<sub>22</sub> may be a single bond, and X<sub>23</sub> may be a single bond, but embodiments of the present disclosure are not limited thereto.

**[0034]** For example, in Formulae 2A to 2C, A<sub>21</sub> to A<sub>23</sub> may each independently be selected from a benzene group, a naphthalene group, a fluorene group, a carbazole group, a dibenzofuran group, a dibenzothiophene group, an indolofluorene group, an indolocarbazole group, an indolodibenzofuran group, an indolodibenzothiophene group, an indenofluorene group, an indenocarbazole group, an indenodibenzofuran group, an indenodibenzothiophene group, a benzofuranofluorene group, a benzofuranocarbazole group, a benzofuranodibenzofuran group, a benzofuranodibenzothiophene group, a benzothienofluorene group, a benzothienocarbazole group, a benzothienodibenzofuran group, and a benzothienodibenzothiophene group, but embodiments of the present disclosure are not limited thereto.

**[0035]** In one embodiment, in Formula 2, Y<sub>21</sub> may be a group represented by Formula 2A, but embodiments of the present disclosure are not limited thereto.

**[0036]** For example, in Formulae 2A to 2C, R<sub>21</sub> to R<sub>26</sub> may each independently be selected from:

a binding site, hydrogen, deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, -N(Q<sub>1</sub>)(Q<sub>2</sub>), and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>); a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, each substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, -N(Q<sub>31</sub>)(Q<sub>32</sub>), and -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>); and

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, each substituted with at least one selected from a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group that are each independently substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, -N(Q<sub>21</sub>)(Q<sub>22</sub>), and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>).

one selected from R<sub>21</sub> to R<sub>24</sub> in Formula 2A may be a binding site,

one selected from R<sub>21</sub> to R<sub>25</sub> in Formula 2B may be a binding site,

one selected from R<sub>21</sub> to R<sub>26</sub> in Formula 2C may be a binding site, and

5  $Q_1$  to  $Q_3$ ,  $Q_{21}$  to  $Q_{23}$ , and  $Q_{31}$  to  $Q_{33}$  may each independently be selected from a  $C_1$ - $C_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, but embodiments of the present disclosure are not limited thereto.

[0037] The binding site in  $R_{21}$  to  $R_{26}$  is typically the site at which the  $Y_{21}$  group is bound to the remaining portion of the second compound as defined in Formula 2.

10 [0038] In embodiments where  $a_{21}$  is 0 and  $c_{22}$  is greater than 1, more than one of  $R_{21}$  to  $R_{26}$  is a binding site (i.e. the number of binding sites in  $R_{21}$  to  $R_{26}$  is equal to the value of  $c_{22}$ ).

[0039]  $c_{21}$  and  $c_{22}$  are typically both 1 when  $a_{21}$  is 0.

[0040] In one embodiment, in Formulae 2A to 2C,  $R_{21}$  to  $R_{26}$  may each independently be selected from:

15 a binding site, hydrogen, deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group,  $-N(Q_1)(Q_2)$ , and  $-Si(Q_1)(Q_2)(Q_3)$ ;

20 a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group,  $-N(Q_{31})(Q_{32})$ , and  $-Si(Q_{31})(Q_{32})(Q_{33})$ ; and

25 a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group that are each substituted with at least one selected from deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group,  $-N(Q_{21})(Q_{22})$ , and  $-Si(Q_{21})(Q_{22})(Q_{23})$ .

30 one selected from  $R_{21}$  to  $R_{24}$  in Formula 2A may be a binding site,

one selected from  $R_{21}$  to  $R_{25}$  in Formula 2B may be a binding site,

35 one selected from  $R_{21}$  to  $R_{26}$  in Formula 2C may be a binding site, and

$Q_1$  to  $Q_3$ ,  $Q_{21}$  to  $Q_{23}$ , and  $Q_{31}$  to  $Q_{33}$  may each independently be selected from a  $C_1$ - $C_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

40 [0041] For example, in Formula 2,  $Y_{22}$  may be selected from:

45 -F, a cyano group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazoliny group, an azafuorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group;

50 a  $C_1$ - $C_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazoliny group, an azafuorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from -F and a cyano group; and

55 a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group,

an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

**[0042]** In one embodiment, in Formula 2, Y<sub>22</sub> may be selected from:

-F, a cyano group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl group;

a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl group, each substituted with at least one selected from -F and a cyano group; and

a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl group, each substituted with at least one selected from deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl group, but embodiments of the present disclosure are not limited thereto.

**[0043]** For example, in Formula 2, c<sub>21</sub> and c<sub>22</sub> may each independently be selected from 1, 2, and 3, but embodiments of the present disclosure are not limited thereto.

**[0044]** For example, in Formula 3, R<sub>31</sub> to R<sub>37</sub> may each independently be selected from:

hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano 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 phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group;

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a cyano

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 biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazocarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group; and

-B(Q<sub>1</sub>)(Q<sub>2</sub>) and -N(Q<sub>1</sub>)(Q<sub>2</sub>), and

Q<sub>1</sub> and Q<sub>2</sub> may each independently be selected from:

hydrogen, deuterium, and a C<sub>1</sub>-C<sub>20</sub> alkyl group;

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazocarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group; and

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazocarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazocarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

**[0045]** In one embodiment, in Formula 3, R<sub>31</sub> to R<sub>37</sub> may each independently be selected from:

hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano group, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a methoxy group, an ethoxy group, a propoxy group, and a butoxy group;

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a cyano group, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

-B(Q<sub>1</sub>)(Q<sub>2</sub>) and -N(Q<sub>1</sub>)(Q<sub>2</sub>), and

Q<sub>1</sub> and Q<sub>2</sub> may each independently be selected from:

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hydrogen, deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, and a tert-butyl group;

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

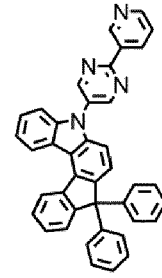
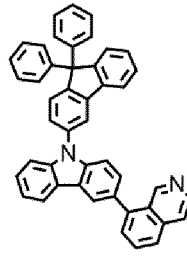
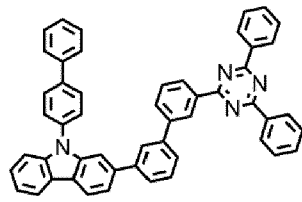
**[0046]** For example, in Formula 3,  $Y_{31}$  and  $Y_{32}$  may each independently be selected from -F, -Cl, -Br, -I, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group, but embodiments of the present disclosure are not limited thereto.

**[0047]** In one embodiment, in Formula 3,  $Y_{31}$  and  $Y_{32}$  may each independently be selected from -F, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a methoxy group, an ethoxy group, a propoxy group, and a butoxy group, but embodiments of the present disclosure are not limited thereto.

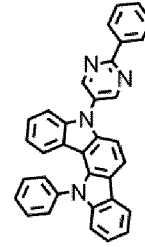
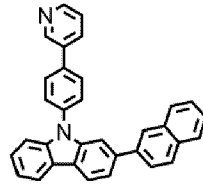
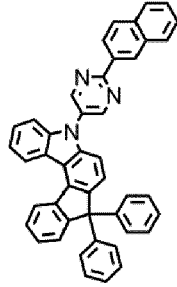
**[0048]** In one embodiment, the first compound may be selected from compounds of Group I:

<Group I>

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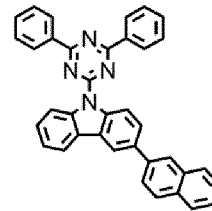
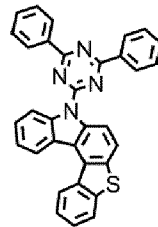
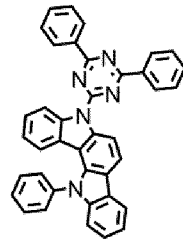
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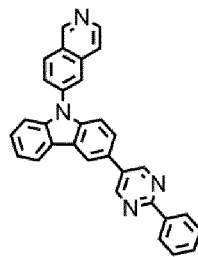
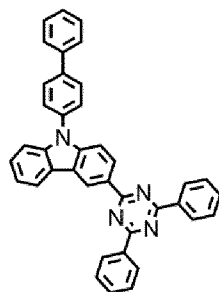
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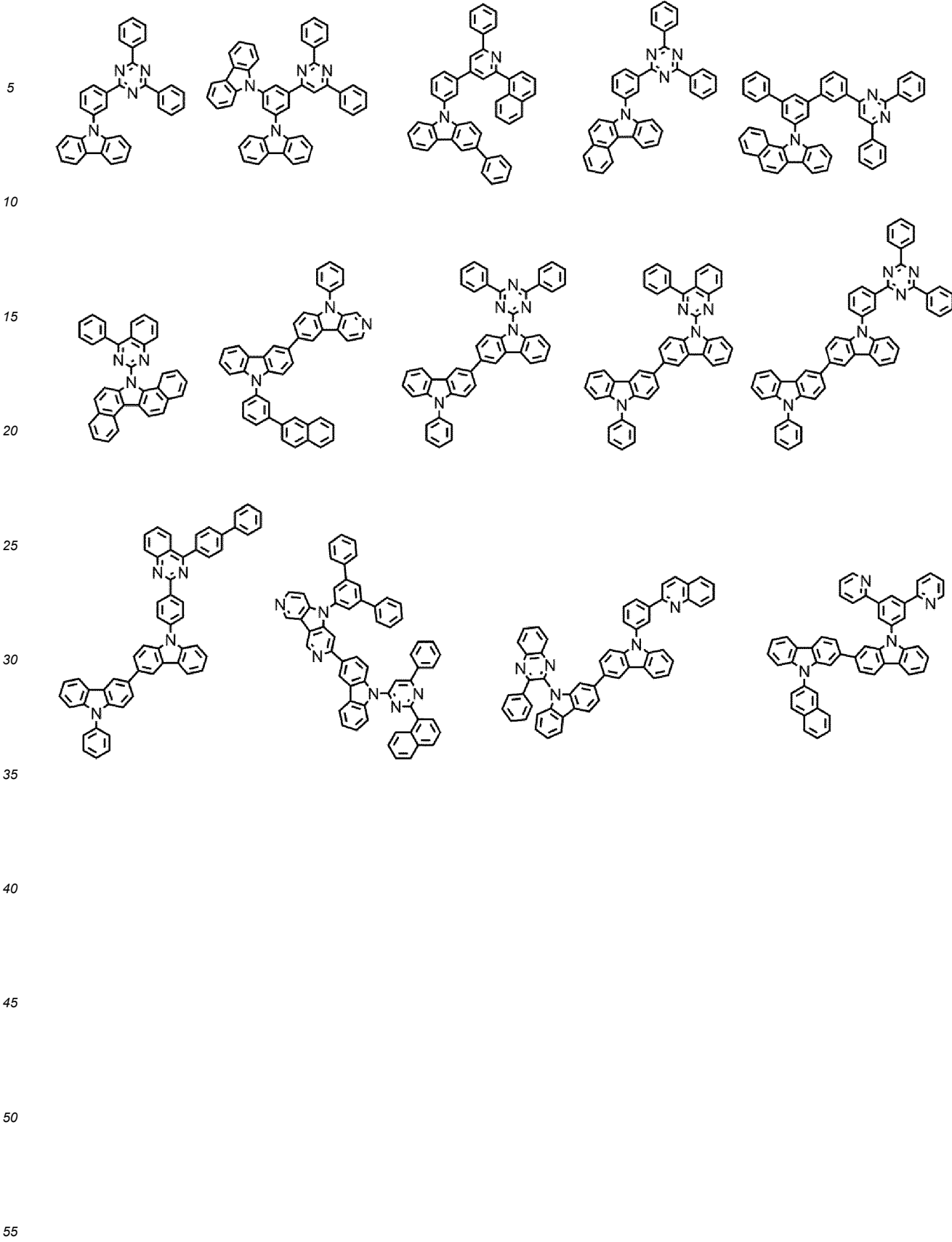
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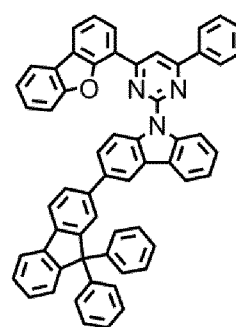
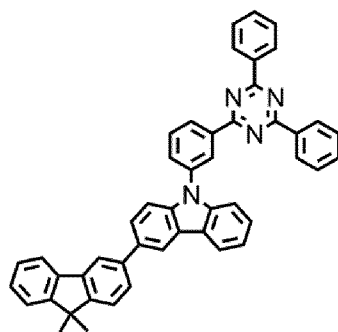
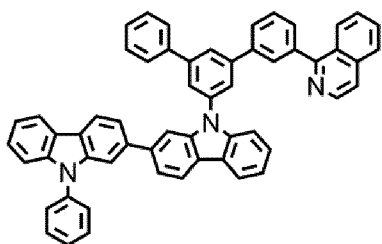
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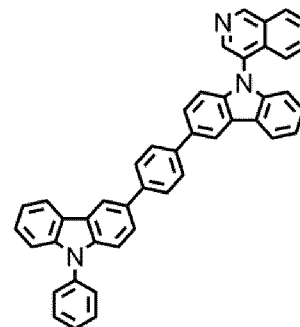
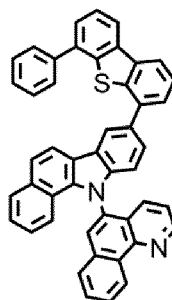
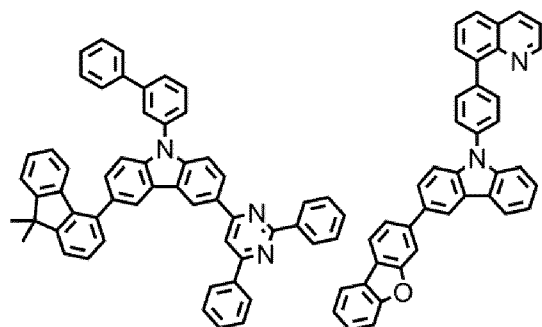


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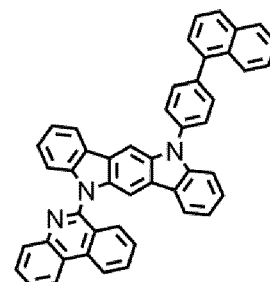
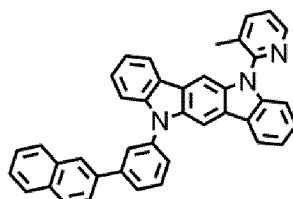
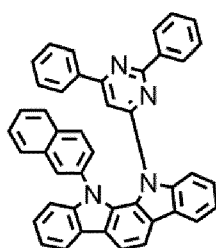
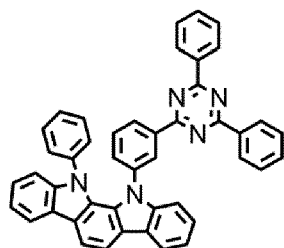
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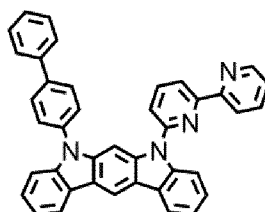
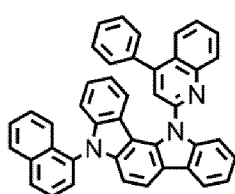
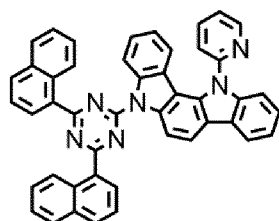
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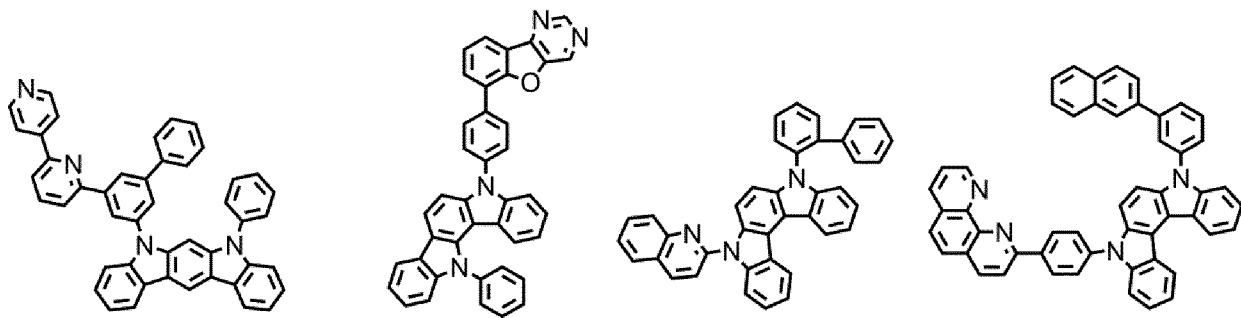
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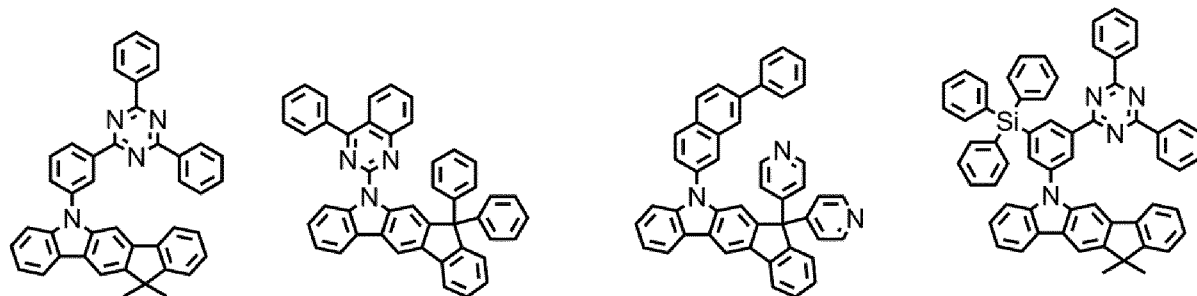
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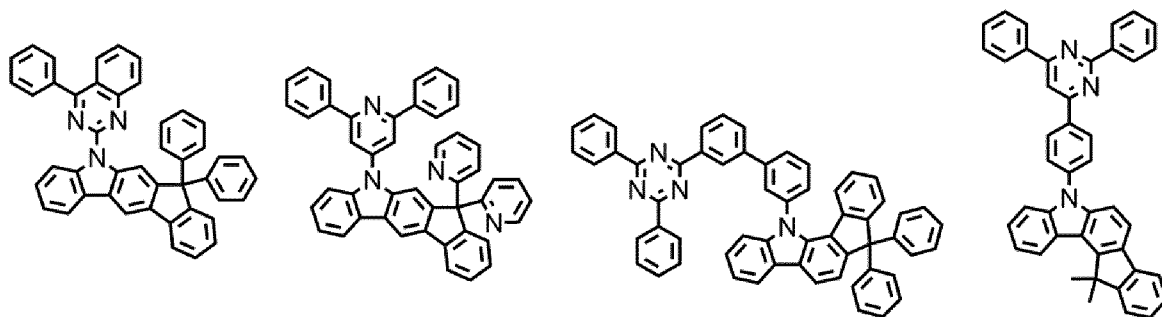
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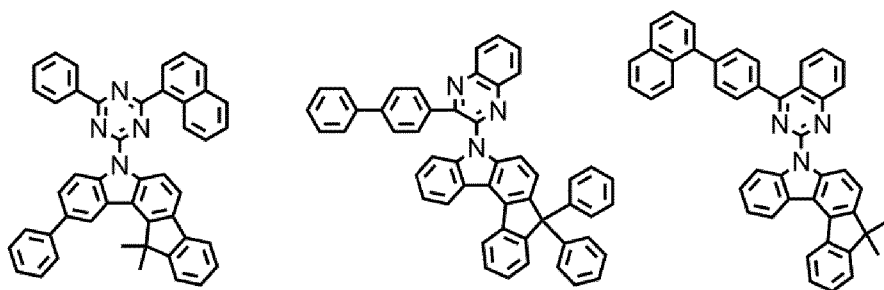
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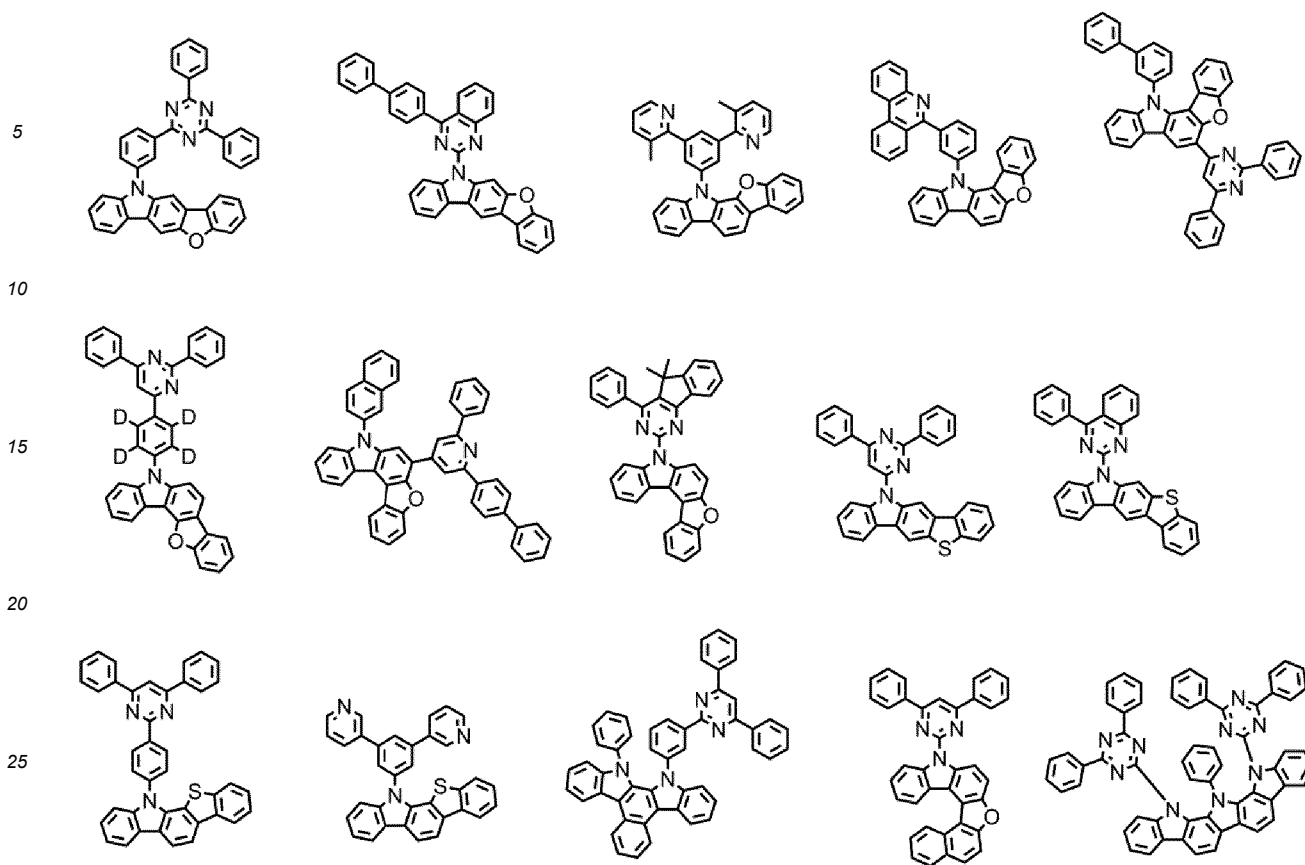


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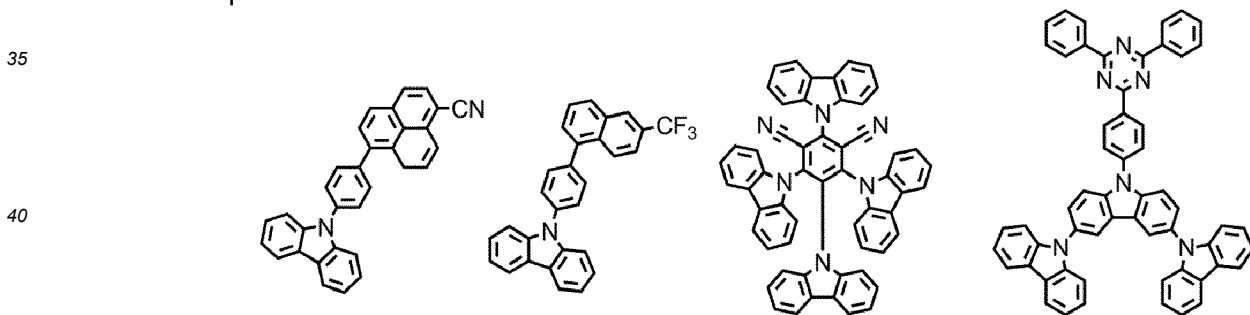
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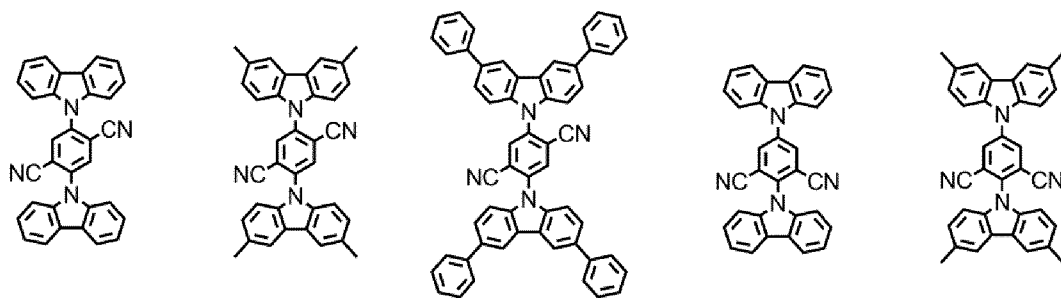


30 **[0049]** In one embodiment, the second compound may be selected from groups of Group II:

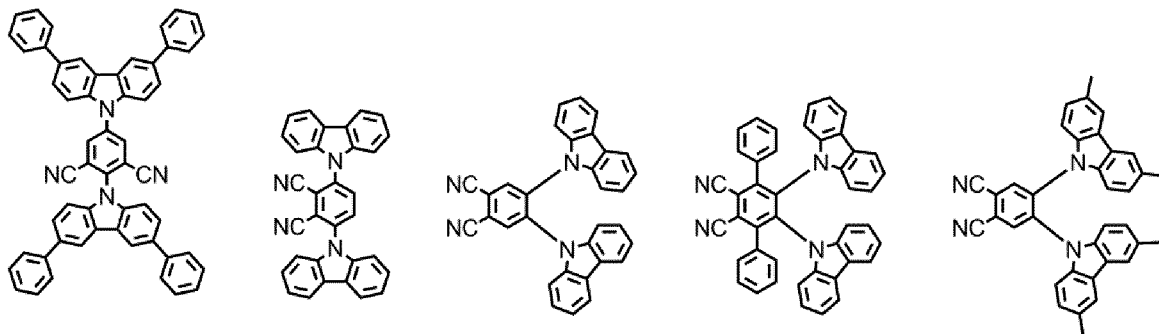
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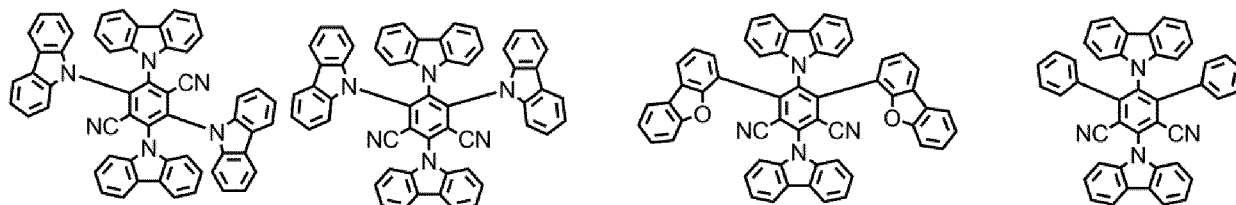
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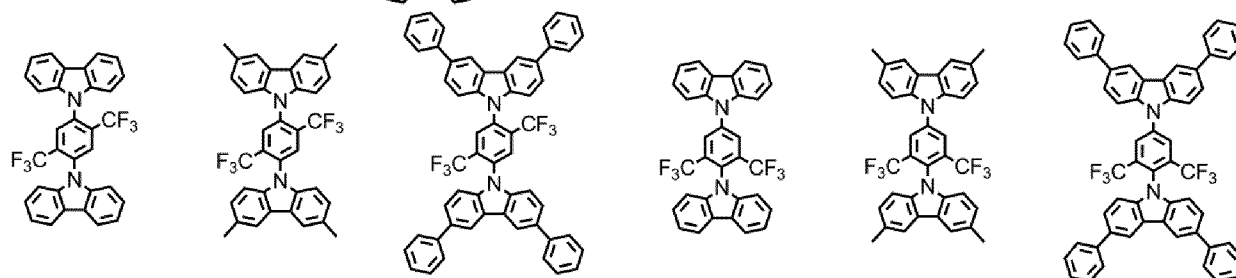
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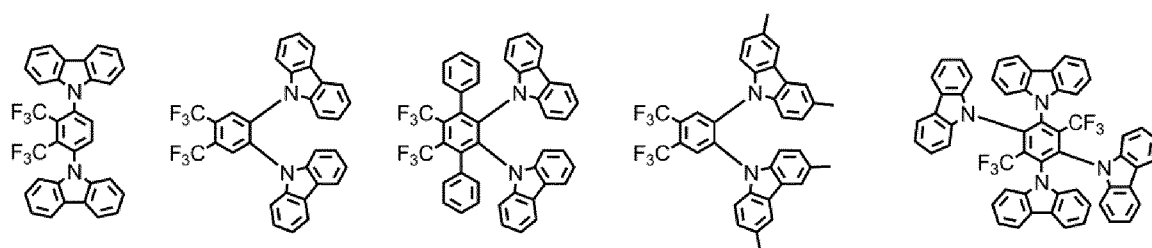
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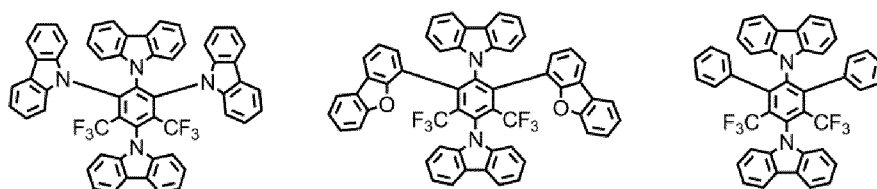
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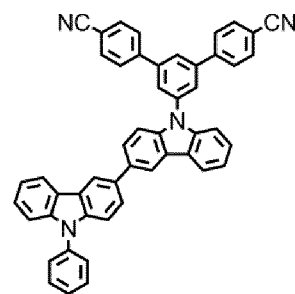
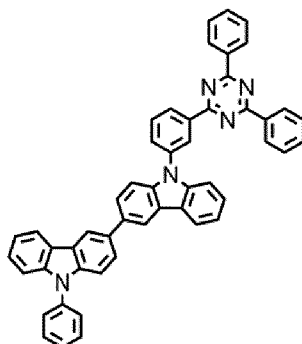
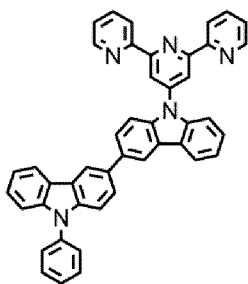
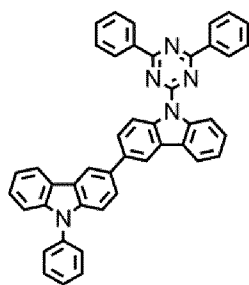


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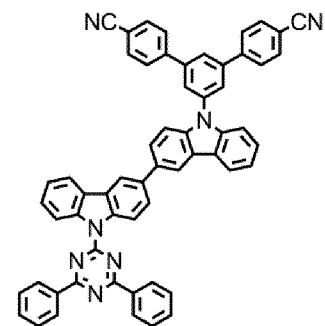
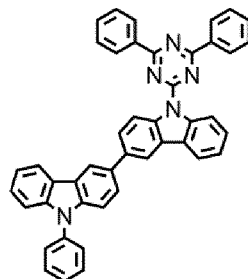
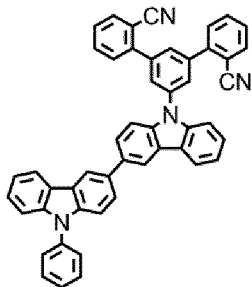
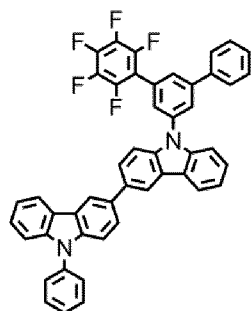


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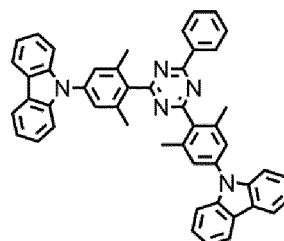
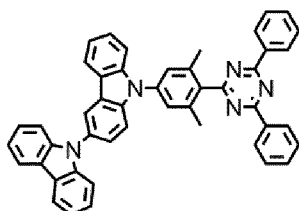
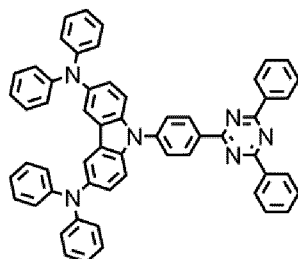
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[0050] In one embodiment, the third compound may be selected from groups of Group III:

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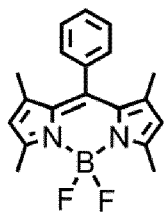
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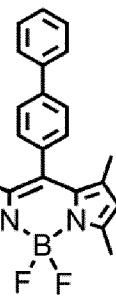
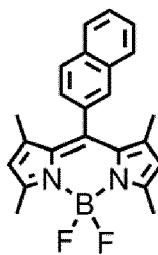
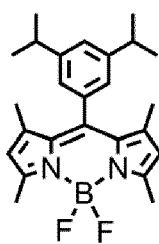
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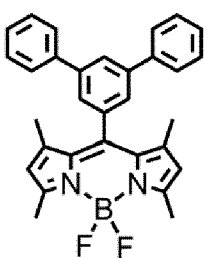
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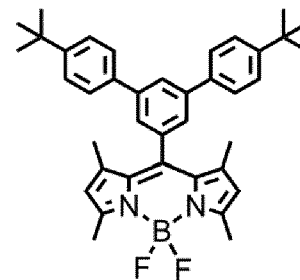
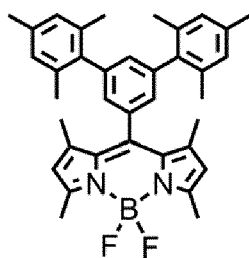
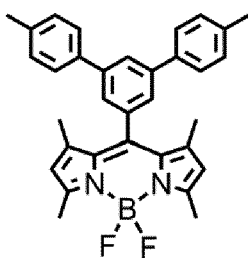
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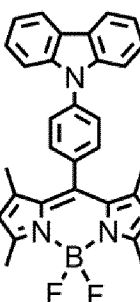
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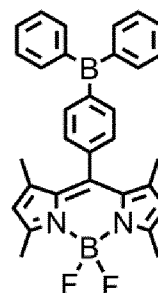
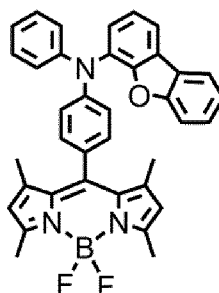
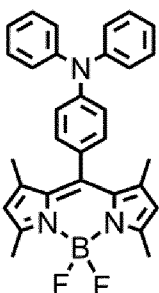
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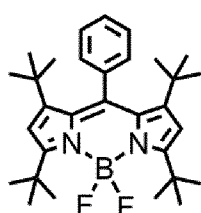


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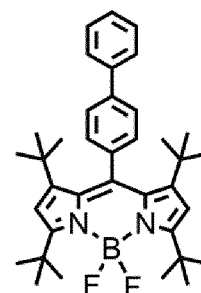
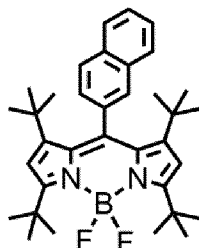
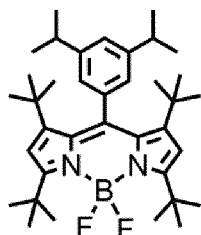


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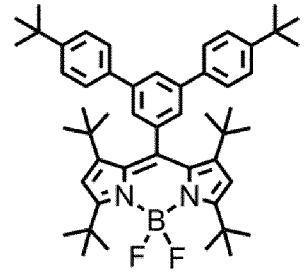
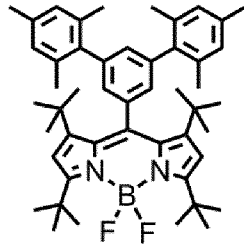
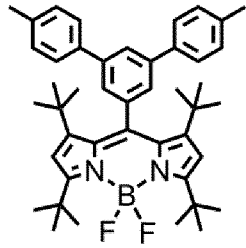
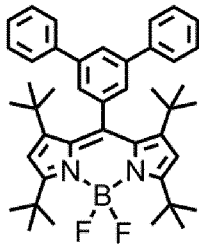
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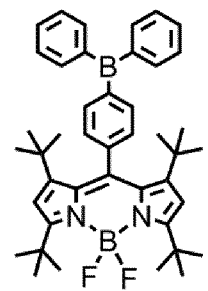
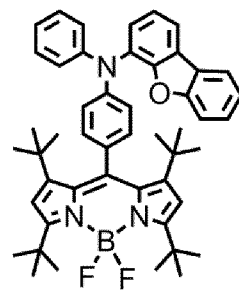
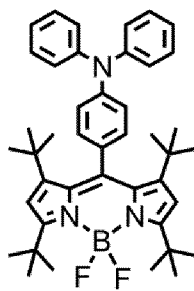
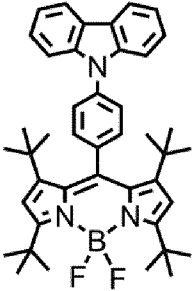
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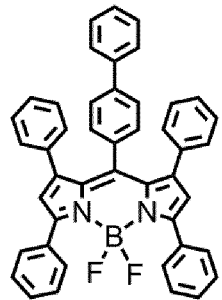
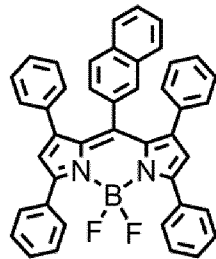
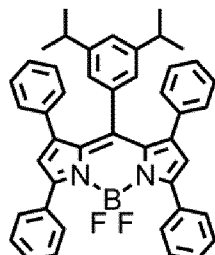
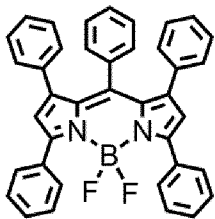
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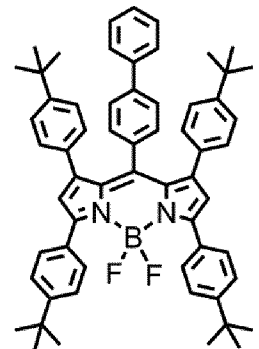
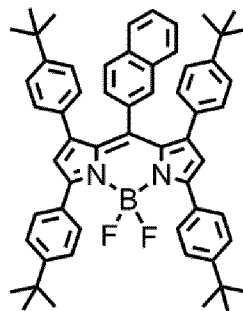
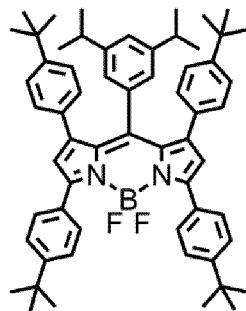
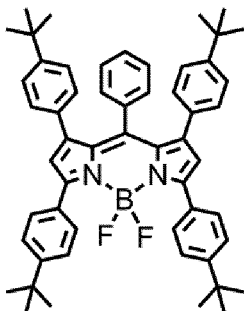
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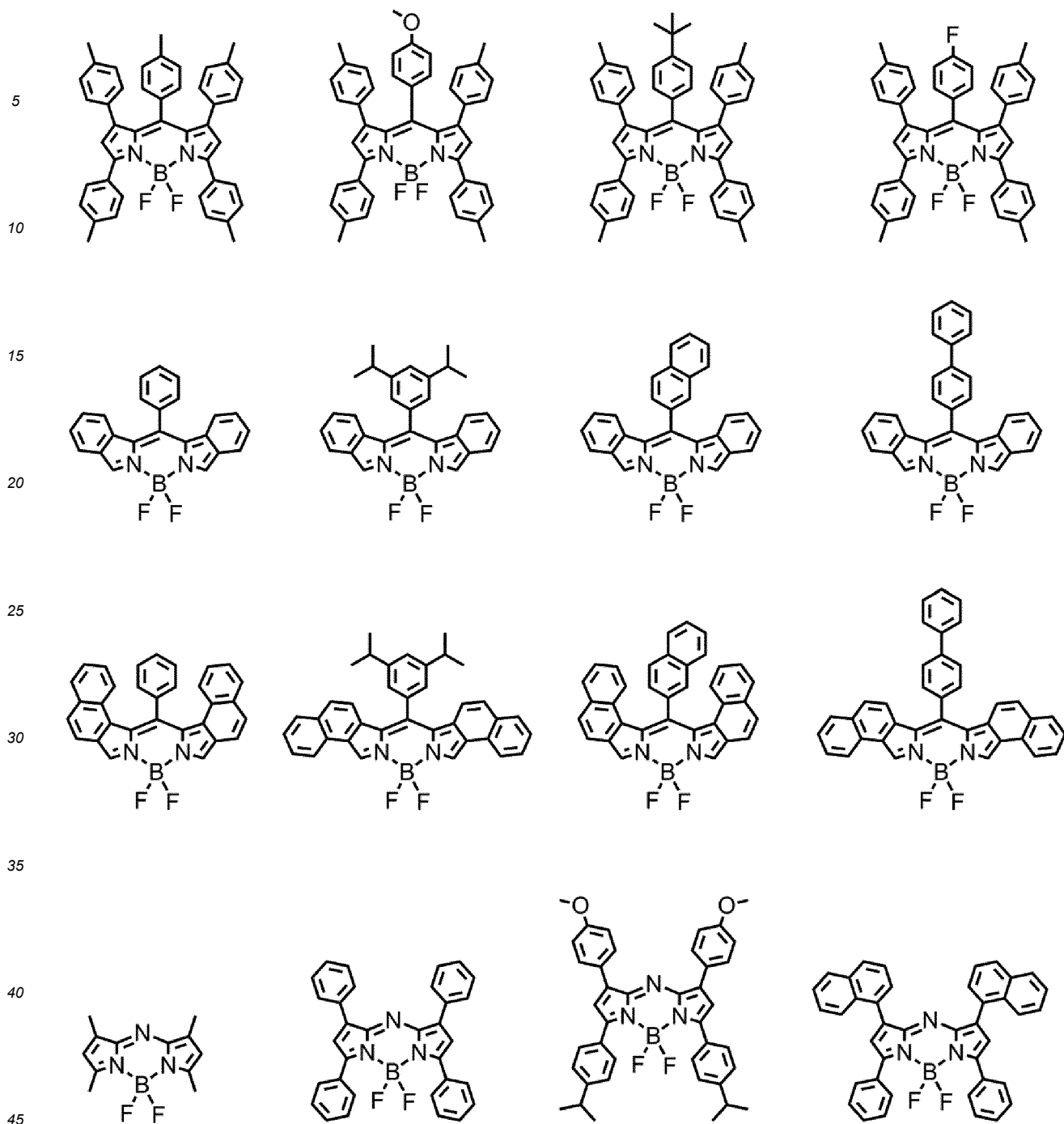
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[0051] Because the first compound is a compound comprising both the electron transport moiety and the hole transport moiety, an organic light-emitting device comprising the first compound may improve charge balance of electrons and holes. Therefore, the organic light-emitting device may provide improved efficiency and/or improved lifespan.

[0052] The second compound may satisfy Condition 1:

Condition 1

$$\Delta E_{\text{ST}}(\text{C2}) \leq 0.3 \text{ eV.}$$

[0053] In Condition 1,

$\Delta E_{ST}(C2)$  represents a difference between a lowest excitation singlet energy level of the second compound ( $E_{S1}(C2)$ ) and a lowest excitation triplet energy level of the second compound ( $E_{T1}(C2)$ ).

[0054]  $E_{S1}(C2)$  and  $E_{T1}(C2)$  may be evaluated by utilizing a density functional theory (DFT) method of Gaussian program structurally optimized at a level of B3LYP/6-31G(d,p).

[0055] When the second compound satisfies Condition 1, the second compound may have suitable (e.g., sufficiently high) reverse intersystem crossing (RISC) efficiency at room temperature.

[0056] The third compound may have a maximum emission wavelength in a range of about 520 nm to about 780 nm, but embodiments of the present disclosure are not limited thereto. For example, the third compound in the emission layer does not directly participate in the formation of excitons, and receives energy from formed excitons and emits red fluorescence.

[0057] As used herein the maximum emission wavelength of an emission layer is the wavelength of light emitted by the emission layer with maximum intensity.

[0058] The organic light-emitting device may emit fluorescence in a range of about 520 nm to about 780 nm, but embodiments of the present disclosure are not limited thereto.

[0059] Because the organic light-emitting device has an energy level enough to emit fluorescence from the third compound, the organic light-emitting device may have suitable (e.g., high) color purity. In addition, because the second compound has suitable (e.g., sufficiently high) RISC efficiency at room temperature, all the triplet energy of the first compound that may not participate in light emission may be transmitted to the third compound. Because it is possible to reduce or minimize excitons that disappear without participating in light emission, the efficiency of the organic light-emitting device may be improved.

[0060] The amount of the first compound in the emission layer may be in a range of about 60 wt% to about 90 wt% based on the total weight of the emission layer, but embodiments of the present disclosure are not limited thereto.

[0061] The amount of the second compound in the emission layer may be in a range of about 10 wt% to about 40 wt% based on the total weight of the emission layer, but embodiments of the present disclosure are not limited thereto.

[0062] The amount of the third compound in the emission layer may be in a range of about 0.5 wt% to about 5 wt% based on the total weight of the emission layer, but embodiments of the present disclosure are not limited thereto.

[0063] When the first compound, the second compound, and the third compound are within these ranges, an organic light-emitting device having both improved efficiency and improved lifespan may be provided.

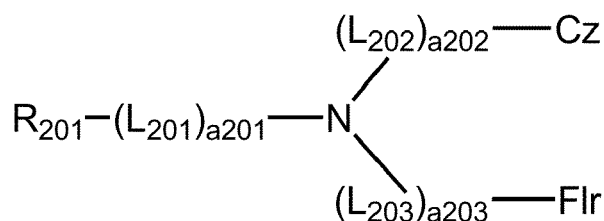
[0064] In one embodiment, the emission layer may comprise or consist of (i.e., comprise only) the first compound, the second compound, and the third compound, but embodiments of the present disclosure are not limited thereto.

[0065] In one embodiment, the organic layer may further comprise a hole transport region; the hole transport region may be disposed between the first electrode and the emission layer; the hole transport region may comprise a first hole transport layer and a second hole transport layer; the first hole transport layer may comprise a first hole transport material; the second hole transport layer may comprise a second hole transport material; and the first hole transport material and the second hole transport material may be different from each other.

[0066] Because the organic light-emitting device comprises the first hole transport layer and the second hole transport layer, hole injection from the anode may be facilitated, and the lifespan and the efficiency of the organic light-emitting device may be improved.

[0067] For example, the first hole transport material may be represented by Formula 201:

Formula 201



In Formula 201,

$L_{201}$  to  $L_{203}$  may each independently be selected from a substituted or unsubstituted  $C_5$ - $C_{60}$  carbocyclic group, and a substituted or unsubstituted  $C_1$ - $C_{60}$  heterocyclic group,

$a_{201}$  to  $a_{203}$  may each independently be selected from 0, 1, 2, and 3,

Cz may be a substituted or unsubstituted carbazolyl group,

Flr may be selected from a substituted or unsubstituted fluorenyl group and a substituted or unsubstituted a spiro-

bifluorenyl group, and

R<sub>201</sub> may be selected from a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>1</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>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group.

**[0068]** For example, in Formula 201, L<sub>201</sub> to L<sub>203</sub> may each independently be selected from 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-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene 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, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a thiophenylene group, a furanylene group, a carbazolyene group, an indolyene group, an isoindolyene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolyene group, a dibenzocarbazolyene group, a dibenzosilolyene group, and a pyridinylene group; and

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-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene 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, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a thiophenylene group, a furanylene group, a carbazolyene group, an indolyene group, an isoindolyene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolyene group, a dibenzocarbazolyene group, a dibenzosilolyene group, and a pyridinylene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, 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-bifluorenyl 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), and -N(Q<sub>31</sub>)(Q<sub>32</sub>), and

Q<sub>31</sub> to Q<sub>33</sub> may each independently be selected from a C<sub>1</sub>-C<sub>10</sub> alkyl group, a C<sub>1</sub>-C<sub>10</sub> alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group, but embodiments of the present disclosure are not limited thereto.

**[0069]** For example, in Formula 201, a<sub>201</sub> to a<sub>203</sub> may each independently be selected from 0, 1, and 2, but embodiments of the present disclosure are not limited thereto.

**[0070]** For example, in Formula 201, Cz may be selected from:

a carbazolyl group; and

a carbazolyl group substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, 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-bifluorenyl 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl

group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group,  $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$ , and  $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$ , and  $\text{Q}_{31}$  to  $\text{Q}_{33}$  are the same as described above with respect to  $\text{L}_{201}$  to  $\text{L}_{203}$ , but embodiments of the present disclosure are not limited thereto.

5 **[0071]** In one embodiment, in Formula 201, Cz may be selected from:

a carbazolyl group; and  
 a carbazolyl group substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a  $\text{C}_1$ - $\text{C}_{20}$  alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a  $\text{C}_1$ - $\text{C}_{10}$  alkyl group, a phenyl group substituted with -F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

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**[0072]** For example, in Formula 201, Flr may be selected from:

a fluorenyl group and a spiro-bifluorenyl group; and  
 a fluorenyl group and a spiro-bifluorenyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a  $\text{C}_1$ - $\text{C}_{20}$  alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a  $\text{C}_1$ - $\text{C}_{10}$  alkyl group, a phenyl group substituted with -F, 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-bifluorenyl 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group,  $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$ , and  $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$ , and  $\text{Q}_{31}$  to  $\text{Q}_{33}$  are the same as described above with respect to  $\text{L}_{201}$  to  $\text{L}_{203}$ , but embodiments of the present disclosure are not limited thereto.

35 **[0073]** In one embodiment, in Formula 201, Flr may be selected from:

a fluorenyl group and a spiro-bifluorenyl group; and  
 a fluorenyl group and a spiro-bifluorenyl group, each substituted with at least one selected from a fluorenyl group and a spiro-bifluorenyl group deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a  $\text{C}_1$ - $\text{C}_{20}$  alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a  $\text{C}_1$ - $\text{C}_{10}$  alkyl group, a phenyl group substituted with -F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

45

**[0074]** For example, in Formula 201,  $\text{R}_{201}$  may be selected from:

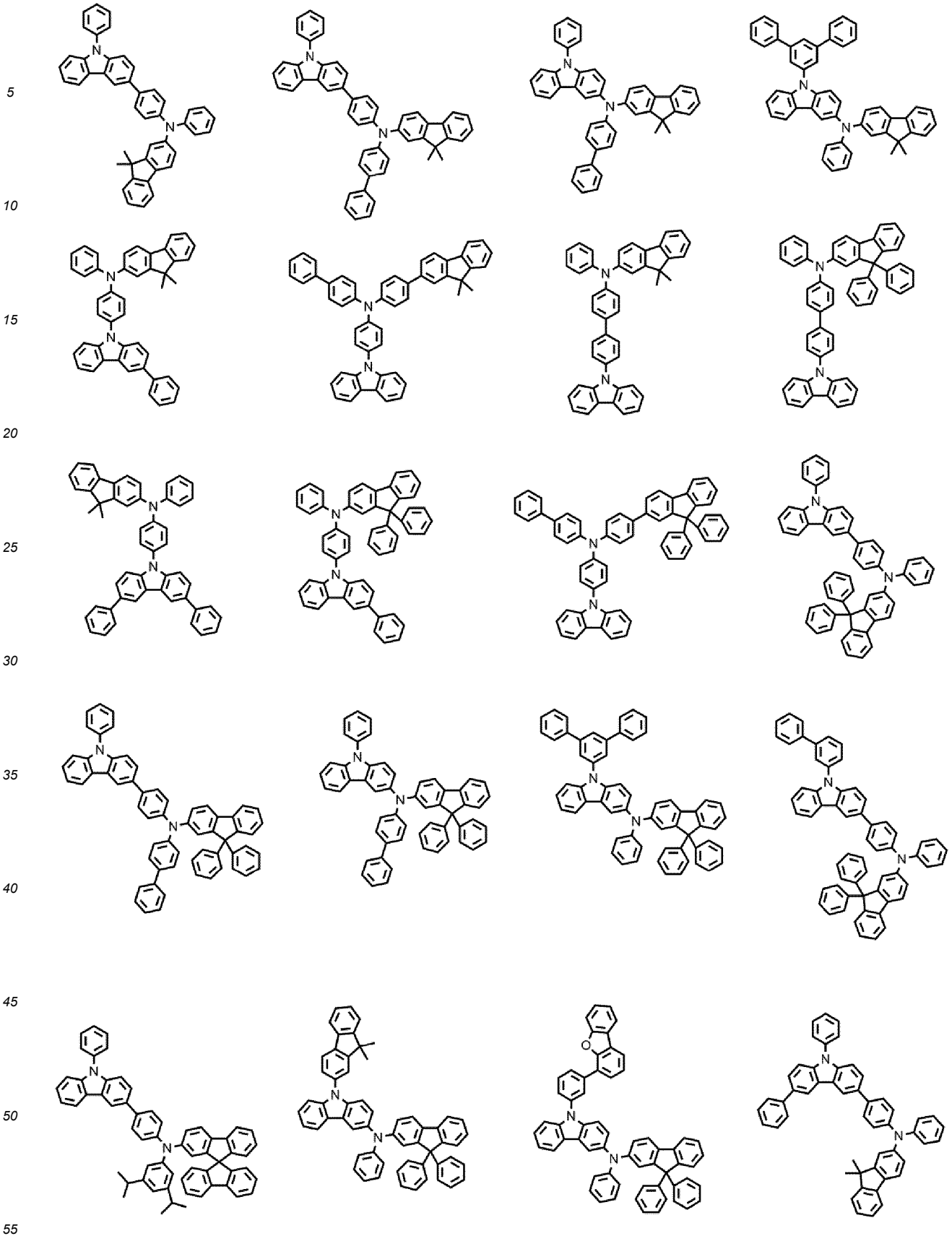
a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group; and  
 a phenyl group, a biphenyl group, a terphenyl 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-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl

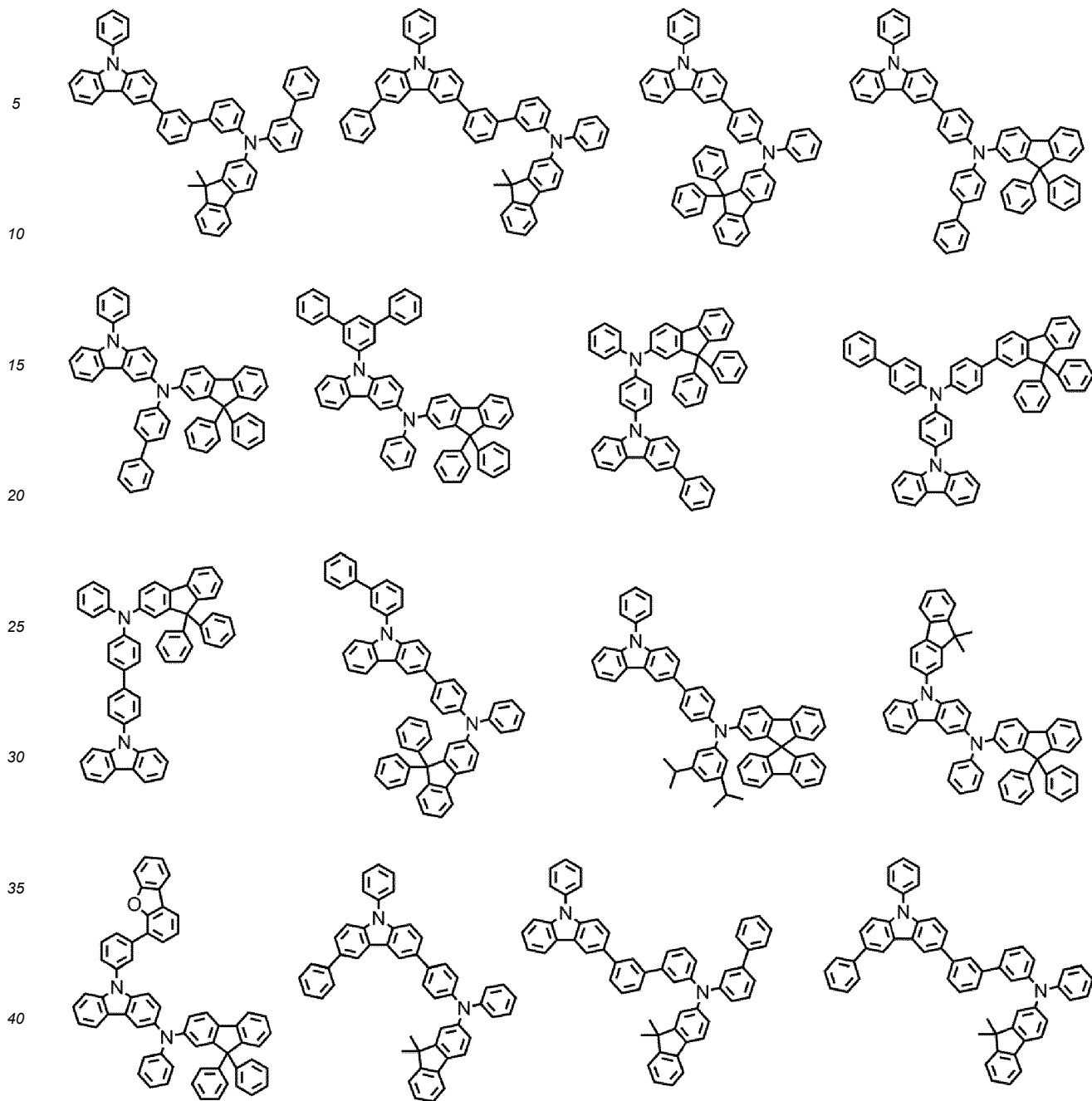
55

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 thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, 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-bifluorenyl 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), and -N(Q<sub>31</sub>)(Q<sub>32</sub>), and Q<sub>31</sub> to Q<sub>33</sub> are the same as described above with respect to L<sub>201</sub> to L<sub>203</sub>.

**[0075]** In one embodiment, the first hole transport material may be selected from groups of Group IV, but embodiments of the present disclosure are not limited thereto:

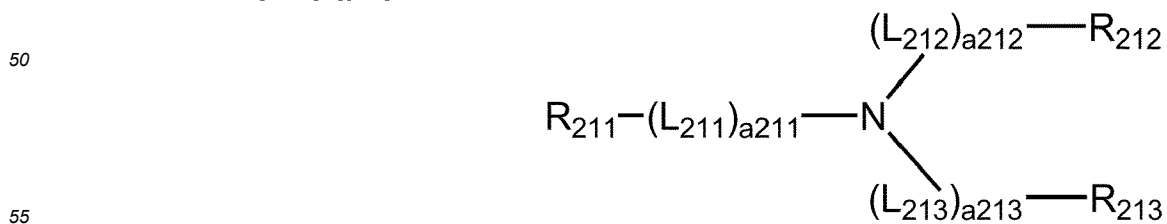
<Group IV>





45 **[0076]** For example, the second hole transport material may be represented by Formula 202:

Formula 202



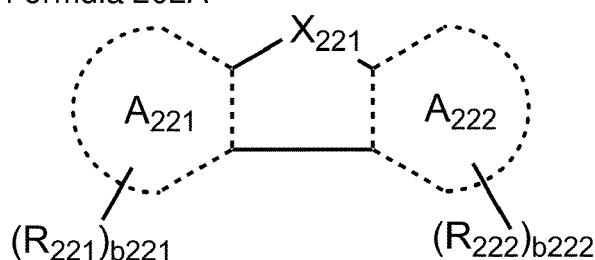
In Formula 202

L<sub>211</sub> to L<sub>213</sub> may each independently be selected from a substituted or unsubstituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group, and a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heterocyclic group

a<sub>211</sub> to a<sub>213</sub> may each independently be selected from 0, 1, 2, and 3,

R<sub>211</sub> to R<sub>213</sub> may each independently be selected from a group represented by Formula 202A, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>1</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>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, wherein at least one selected from R<sub>211</sub> to R<sub>213</sub> may be a group represented by Formula 202A,

Formula 202A



X<sub>221</sub> may be selected from N(R<sub>223</sub>), C(R<sub>223</sub>)(R<sub>224</sub>), O, and S,

A<sub>221</sub> and A<sub>222</sub> may each independently be selected from i) a 6-membered ring, ii) a condensed ring in which two or more 6-membered rings are condensed with each other, and iii) a condensed ring in which at least one 6-membered ring and at least one 5-membered ring are condensed with each other,

R<sub>221</sub> to R<sub>224</sub> may each independently be selected from a binding site (e.g., to a respective L<sub>211</sub> to L<sub>213</sub>), hydrogen, 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 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>1</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>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, wherein one selected from R<sub>221</sub> to R<sub>224</sub> may be a binding site, and

b<sub>221</sub> and b<sub>222</sub> may each independently be selected from 1, 2, 3, 4, 5, and 6.

**[0077]** For example, L<sub>211</sub> to L<sub>213</sub> in Formula 202 may each independently be the same as defined in connection with L<sub>201</sub>.

**[0078]** For example, a<sub>211</sub> to a<sub>213</sub> in Formula 202 may each independently be the same as defined in connection with a<sub>201</sub>.

**[0079]** For example, in Formula 202, R<sub>211</sub> to R<sub>213</sub> may each independently be selected from:

a group represented by Formula 202A, a phenyl group, a biphenyl group, a terphenyl 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-bifluorenyl 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group; and

a phenyl group, a biphenyl group, a terphenyl 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-bifluorenyl

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 hexaceny group, a pentaceny group, a rubiceny group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, 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-bifluorenyl 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 hexaceny group, a pentaceny group, a rubiceny group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), and -N(Q<sub>31</sub>)(Q<sub>32</sub>), at least one selected from R<sub>211</sub> to R<sub>213</sub> may be a group represented by Formula 202A, and Q<sub>31</sub> to Q<sub>33</sub> are the same as described above with respect to L<sub>201</sub> to L<sub>203</sub>.

**[0080]** For example, in Formula 202A, X<sub>221</sub> may be selected from C(R<sub>223</sub>)(R<sub>224</sub>) and O.

**[0081]** For example, in Formula 202A, the 6-membered ring may be selected from a benzene group, a pyridine group, a pyrimidine group, a pyridazine group, and a triazine group, and the 5-membered ring may be selected from a furan group, a thiophene group, a pyrrole group, and a cyclopentadiene group, but embodiments of the present disclosure are not limited thereto.

**[0082]** In one embodiment, in Formula 202A, A<sub>221</sub> and A<sub>222</sub> may each independently be selected from a benzene group, a naphthalene group, a pyridine group, a pyrimidine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a fluorene group, a carbazole group, a dibenzothiophene group, and a dibenzofuran group, but embodiments of the present disclosure are not limited thereto.

**[0083]** For example, in Formula 202, R<sub>221</sub> to R<sub>224</sub> may each independently be selected from:

a binding site, hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano 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 phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group; and a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a cyano 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 biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group.

bazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, and one selected from R<sub>221</sub> to R<sub>224</sub> may be a binding site, but embodiments of the present disclosure are not limited thereto.

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**[0084]** In one embodiment, in Formula 202, R<sub>221</sub> to R<sub>224</sub> may each independently be selected from:

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a binding site, hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano group, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a methoxy group, an ethoxy group, a propoxy group, and a butoxy group;

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a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazoyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

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a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazoyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a cyano group, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazoyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, and

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**[0085]** In embodiment, the second hole transport material may be selected from groups of Group V, but embodiments of the present disclosure are not limited thereto:

<Group V>

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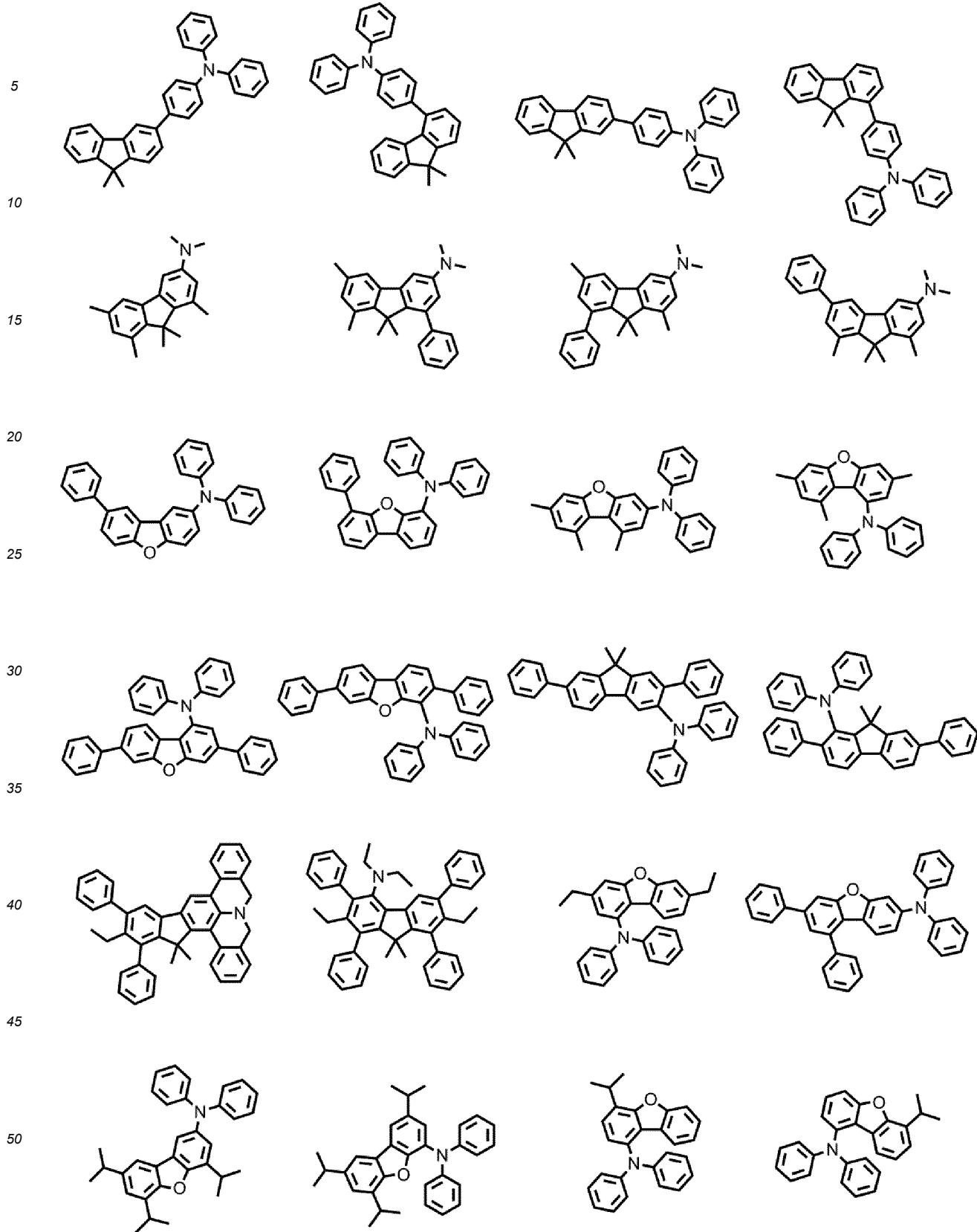
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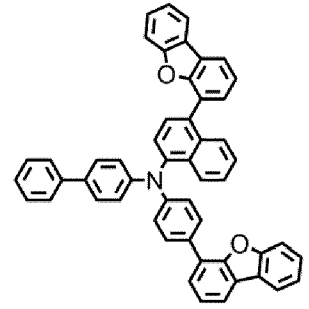
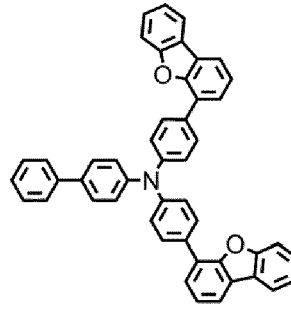
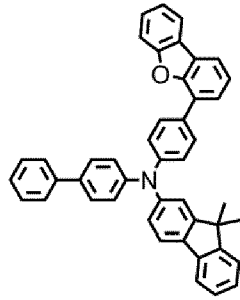
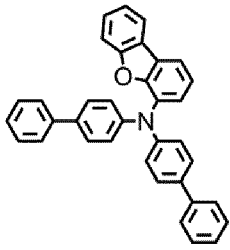
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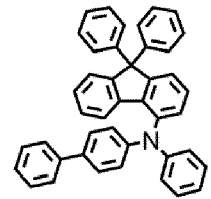
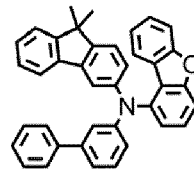
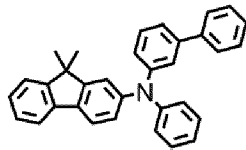
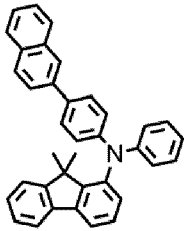


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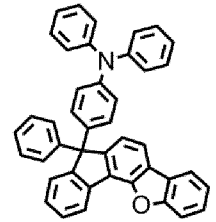
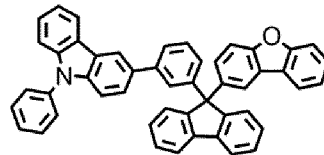
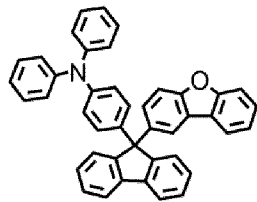
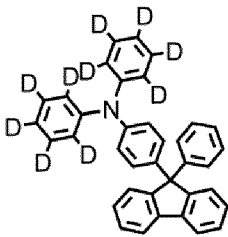
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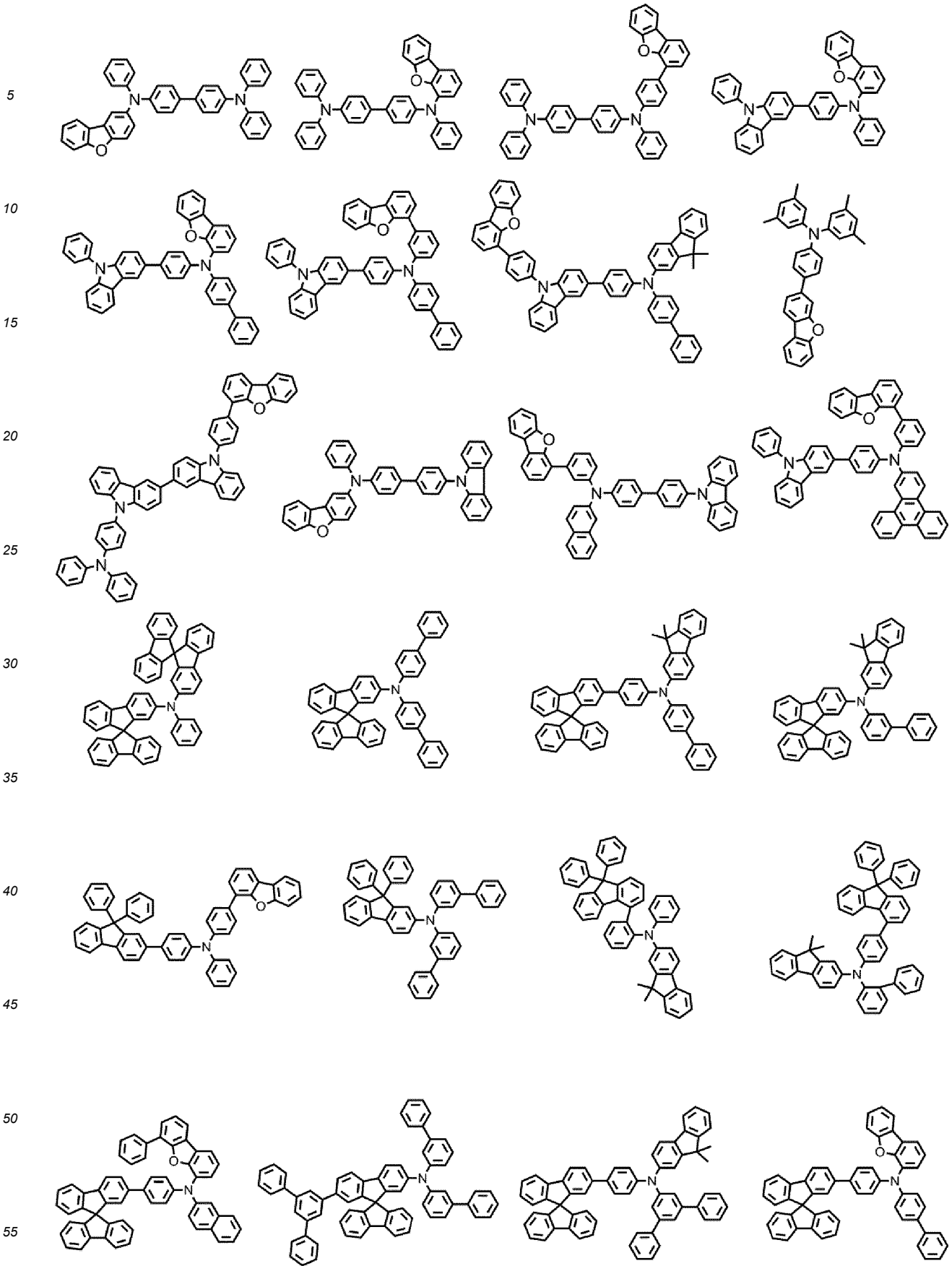
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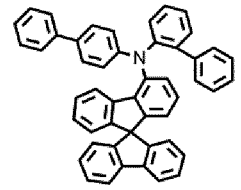
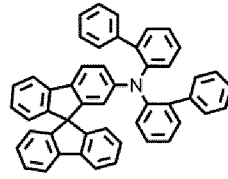
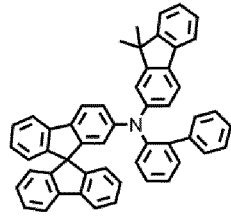
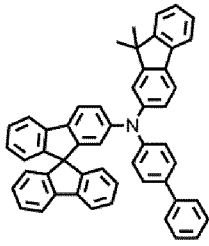
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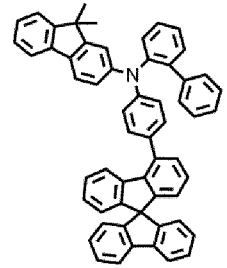
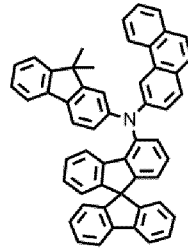
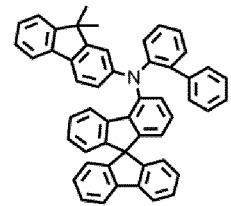
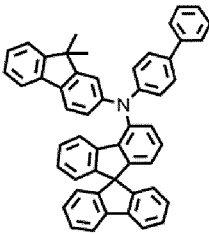
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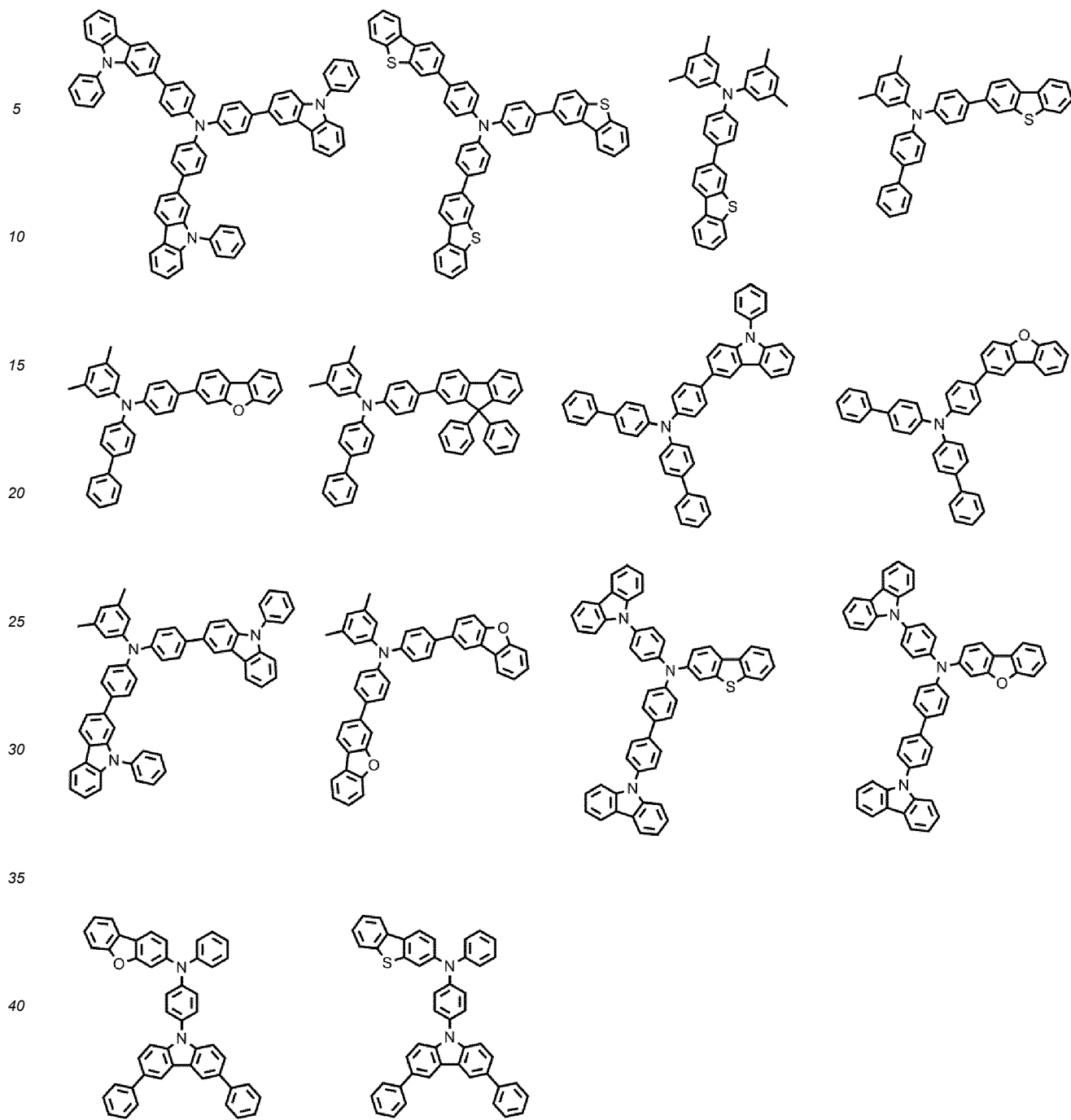
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[0086] In one embodiment, the organic layer may further comprise an electron transport region, the electron transport region may be disposed between the emission layer and the second electrode, and the electron transport region may comprise a hole blocking layer, an electron transport layer, an electron injection layer, or any combination thereof, but embodiments of the present disclosure are not limited thereto.

#### Description of FIG. 1

[0087] FIG. 1 is a schematic view of an organic light-emitting device 10 according to an embodiment. The organic light-emitting device 10 comprises a first electrode 110, an organic layer 150, and a second electrode 190.

[0088] Hereinafter, the structure of the organic light-emitting device 10 according to an embodiment and a method of manufacturing the organic light-emitting device 10 will be described in connection with FIG. 1.

**First electrode 110**

**[0089]** In FIG. 1, a substrate may be additionally disposed under the first electrode 110 or above the second electrode 190. The substrate may be a glass substrate or a plastic substrate, each having excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and/or water resistance.

**[0090]** The first electrode 110 may be formed by depositing or sputtering a material for forming the first electrode 110 on the substrate. When the first electrode 110 is an anode, the material for the first electrode may be selected from materials with a high work function to facilitate hole injection.

**[0091]** The first electrode 110 may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. When the first electrode 110 is a transmissive electrode, a material for forming the first electrode may be selected from indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO<sub>2</sub>), zinc oxide (ZnO), and any combinations thereof, but embodiments of the present disclosure are not limited thereto. In one or more embodiments, when the first electrode 110 is a semi-transmissive electrode or a reflectable electrode, a material for forming the first electrode may be selected from magnesium (Mg), silver (Ag), aluminum (Al), aluminum-lithium (Al-Li), calcium (Ca), magnesium-indium (Mg-In), magnesium-silver (Mg-Ag), and any combinations thereof, but embodiments of the present disclosure are not limited thereto.

**[0092]** The first electrode 110 may have a single-layered structure, or a multi-layered structure comprising two or more layers. For example, the first electrode 110 may have a three-layered structure of ITO/Ag/ITO, but the structure of the first electrode 110 is not limited thereto.

**Organic layer 150**

**[0093]** The organic layer 150 is disposed on the first electrode 110. The organic layer 150 may comprise an emission layer.

**[0094]** The organic layer 150 may further comprise a hole transport region between the first electrode 110 and the emission layer, and an electron transport region between the emission layer and the second electrode 190.

**Hole transport region in organic layer 150**

**[0095]** The hole transport region may have i) a single-layered structure comprising a single layer comprising a single material, ii) a single-layered structure comprising a single layer comprising a plurality of different materials, or iii) a multi-layered structure having a plurality of layers comprising a plurality of different materials.

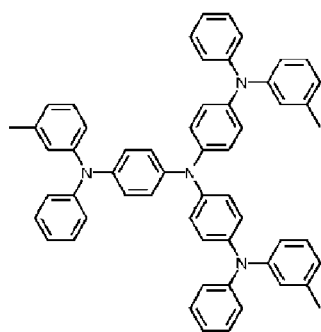
**[0096]** The hole transport region may comprise at least one layer selected from a hole injection layer, a hole transport layer, an emission auxiliary layer, and an electron blocking layer.

**[0097]** For example, the hole transport region may have a single-layered structure comprising a single layer comprising a plurality of different materials, or a multi-layered structure having a hole injection layer/hole transport layer structure, a hole injection layer/hole transport layer/emission auxiliary layer structure, a hole injection layer/emission auxiliary layer structure, a hole transport layer/emission auxiliary layer structure, or a hole injection layer/hole transport layer/electron blocking layer structure, wherein for each structure, constituting layers are sequentially stacked (e.g., laminated) from the first electrode 110 in the stated order, but the structure of the hole transport region is not limited thereto.

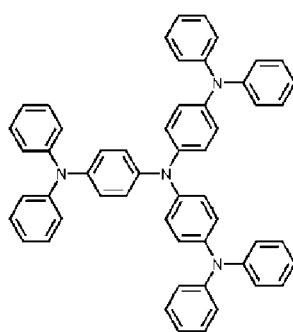
**[0098]** The hole transport region may comprise at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB(NPD), β-NPB, TPD, Spiro-TPD, Spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201-1, and a compound represented by Formula 202-1.

**[0099]** For example, when the hole transport region comprises the first hole transport material and the second hole transport material, the hole transport region may further comprise a compound represented by Formula 201-1 and/or a compound represented by Formula 202-1, wherein the compound represented by Formula 201-1 and the compound represented by Formula 202-1 are different from the first hole transport material and the second hole transport material:

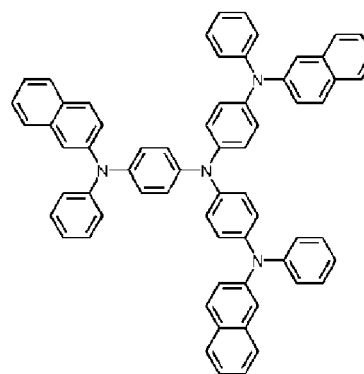
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m-MTDATA



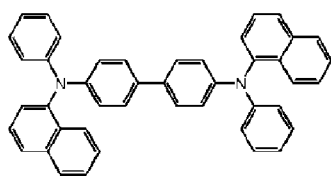
TDATA



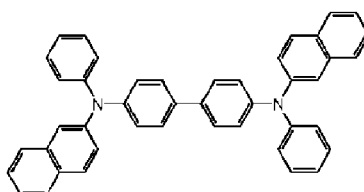
2-TNATA

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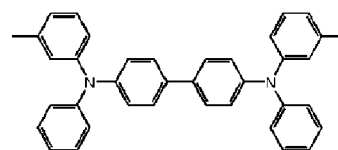
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NPB



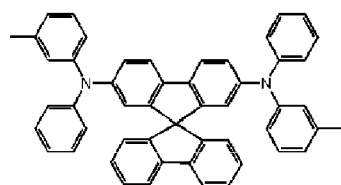
$\beta$ -NPB



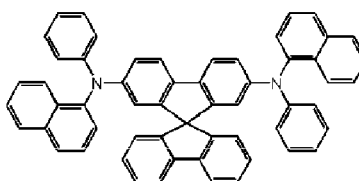
TPD

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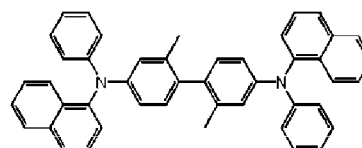
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Spiro-TPD



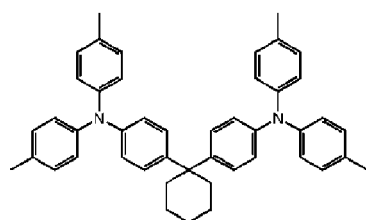
Spiro-NPB



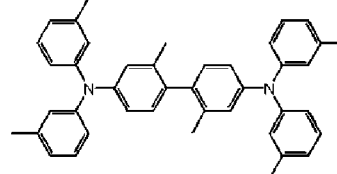
methylated NPB

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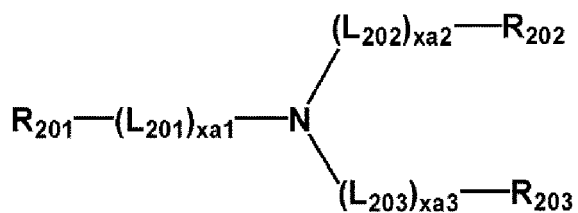
TAPC



HMTPD

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Formula 201-1



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## EP 3 671 884 A1

a benzocarbazolylylene group, a dibenzocarbazolylylene group, a dibenzosilolylylene group, and a pyridinylylene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, 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-bifluorenyl 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolylyl group, an indolylyl group, an isoindolylyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolylyl group, a dibenzocarbazolylyl group, a dibenzosilolylyl group, a pyridinylyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), and -N(Q<sub>31</sub>)(Q<sub>32</sub>), and Q<sub>31</sub> to Q<sub>33</sub> may each independently be selected from a C<sub>1</sub>-C<sub>10</sub> alkyl group, a C<sub>1</sub>-C<sub>16</sub> alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

**[0102]** In one or more embodiments, xa1 to xa4 may each independently be 0, 1, or 2.

**[0103]** In one or more embodiments, xa5 may be 1, 2, 3, or 4.

**[0104]** In one or more embodiments, R<sub>201</sub> to R<sub>204</sub> and Q<sub>201</sub> may each independently be selected from:

a phenyl group, a biphenyl group, a terphenyl 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-bifluorenyl 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolylyl group, an indolylyl group, an isoindolylyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolylyl group, a dibenzocarbazolylyl group, a dibenzosilolylyl group, and a pyridinylyl group; and a phenyl group, a biphenyl group, a terphenyl 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-bifluorenyl 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolylyl group, an indolylyl group, an isoindolylyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolylyl group, a dibenzocarbazolylyl group, a dibenzosilolylyl group, and a pyridinylyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, 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-bifluorenyl 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, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolylyl group, an indolylyl group, an isoindolylyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolylyl group, a dibenzocarbazolylyl group, a dibenzosilolylyl group, a pyridinylyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), and -N(Q<sub>31</sub>)(Q<sub>32</sub>), and Q<sub>31</sub> to Q<sub>33</sub> are the same as described above with respect to L<sub>201</sub> to L<sub>205</sub>.

**[0105]** In one or more embodiments, in Formula 201-1, at least one selected from R<sub>201</sub> to R<sub>203</sub> may each independently be selected from:

a fluorenyl group, a spiro-bifluorenyl group, a carbazolylyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and a fluorenyl group, a spiro-bifluorenyl group, a carbazolylyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group,

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group,

but embodiments of the present disclosure are not limited thereto.

**[0106]** In one or more embodiments, in Formula 202-1, i) R<sub>201</sub> and R<sub>202</sub> may be linked via a single bond, and/or ii) R<sub>203</sub> and R<sub>204</sub> may be linked via a single bond.

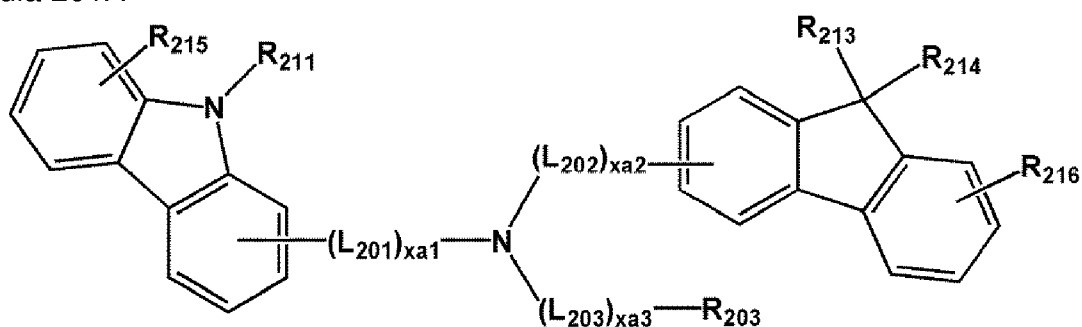
**[0107]** In one or more embodiments, in Formula 202-1, at least one selected from R<sub>201</sub> to R<sub>204</sub> may be selected from:

a carbazolyl group; and

a carbazolyl group substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

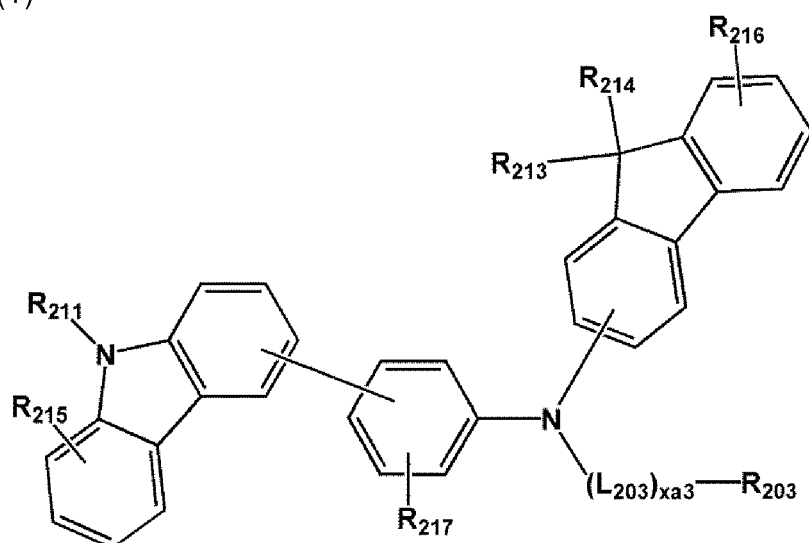
**[0108]** The compound represented by Formula 201-1 may be represented by Formula 201A:

Formula 201A



**[0109]** In one embodiment, the compound represented by Formula 201-1 may be represented by Formula 201A(1), but embodiments of the present disclosure are not limited thereto:

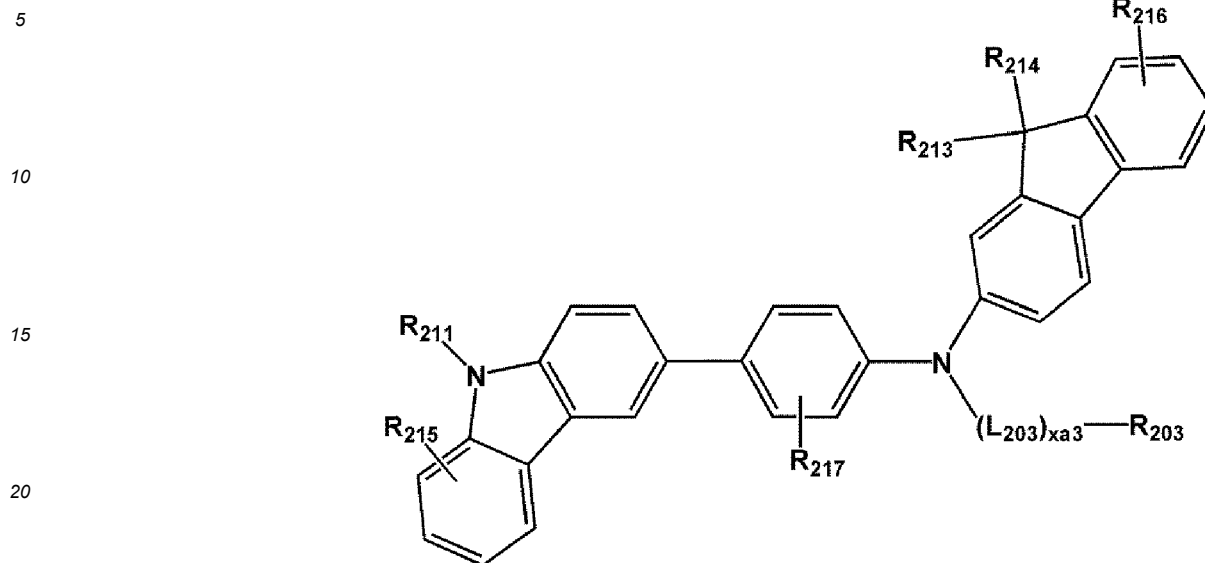
Formula 201A(1)



**[0110]** In one embodiment, the compound represented by Formula 201-1 may be represented by Formula 201A-1,

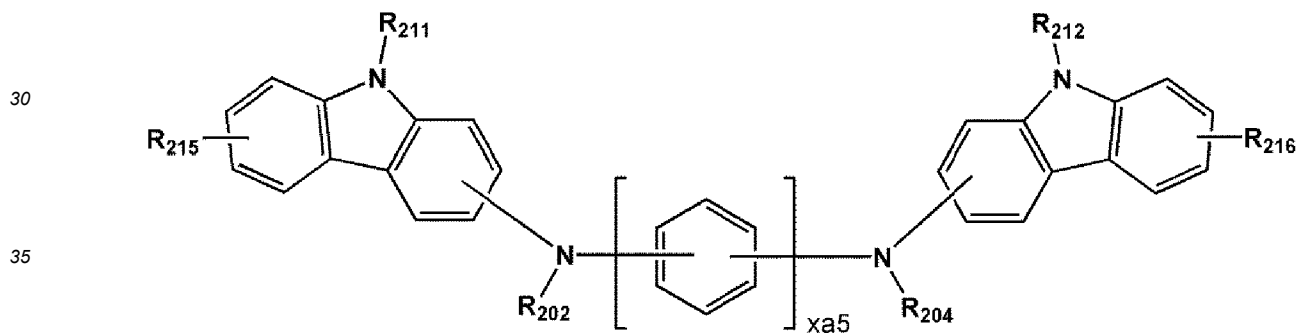
but embodiments of the present disclosure are not limited thereto:

Formula 201A-1



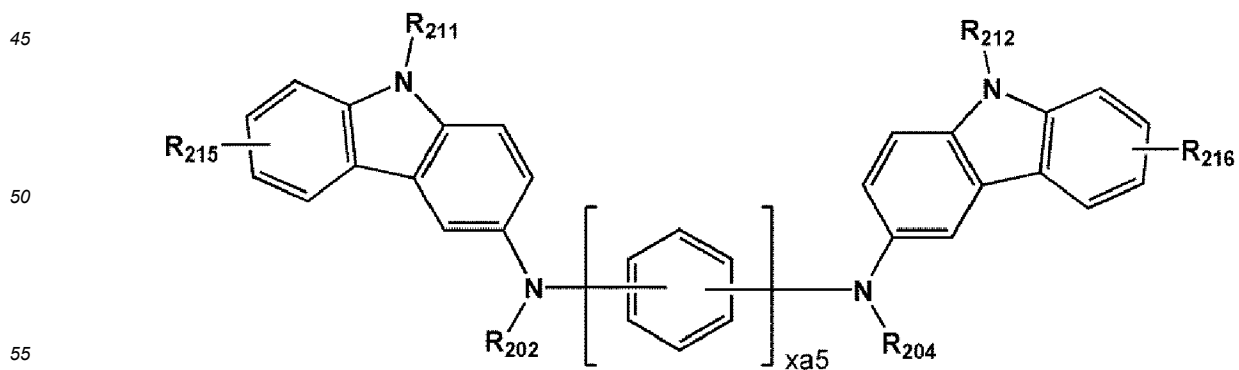
[0111] In one embodiment, the compound represented by Formula 202-1 may be represented by Formula 202AA:

Formula 202AA



[0112] In one embodiment, the compound represented by Formula 202-1 may be represented by Formula 202A-1:

Formula 202A-1

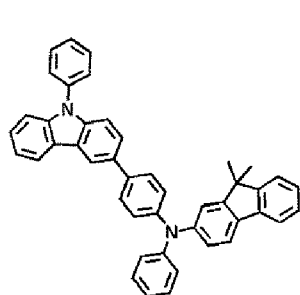


[0113] In Formulae 201A, 201A(1), 201A-1, 202AA, and 202A-1,

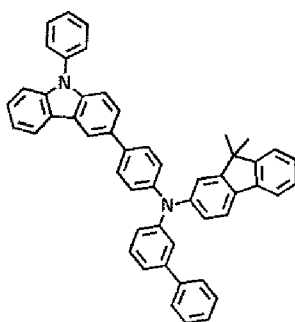
L<sub>201</sub> to L<sub>203</sub>, xa1 to xa3, xa5, and R<sub>202</sub> to R<sub>204</sub> are the same as described above with respect to Formulae 201-1 and 202-1,

R<sub>211</sub> and R<sub>212</sub> may each independently be the same as defined in connection with R<sub>203</sub> of Formulae 201-1 and 202-1  
 R<sub>213</sub> to R<sub>217</sub> may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, 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-bifluorenyl 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 hexacacenyl group, a pentacacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group.

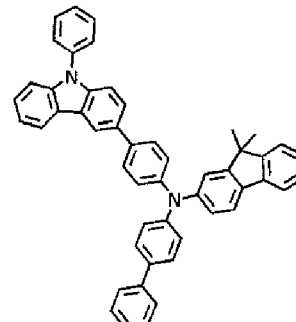
**[0114]** The hole transport region may comprise at least one compound selected from Compounds HT1 to HT39, but embodiments of the present disclosure are not limited thereto:



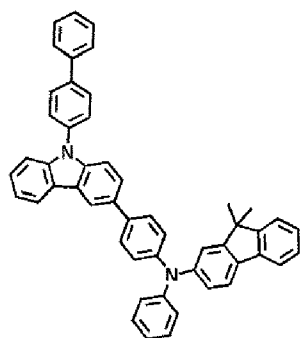
HT1



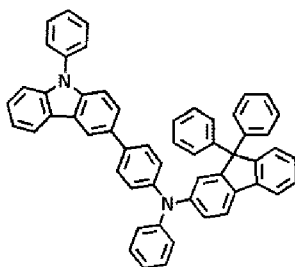
HT2



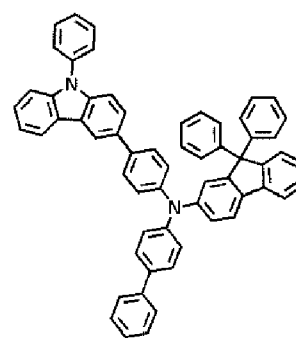
HT3



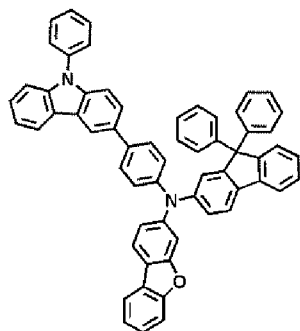
HT4



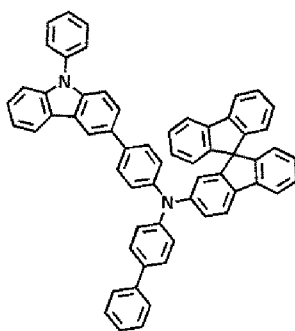
HT5



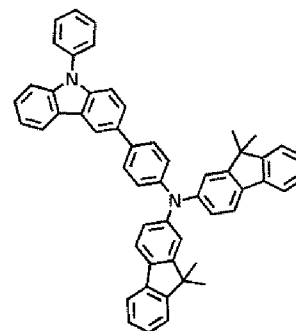
HT6



HT7

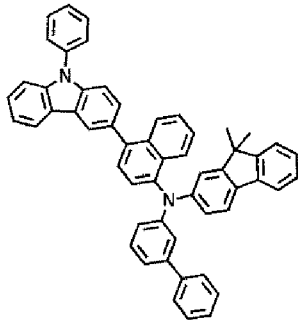


HT8



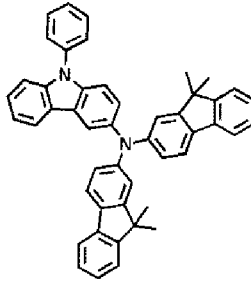
HT9

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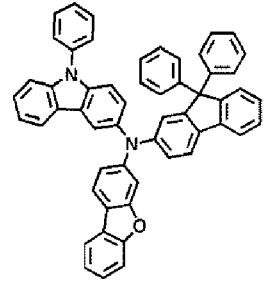


HT10

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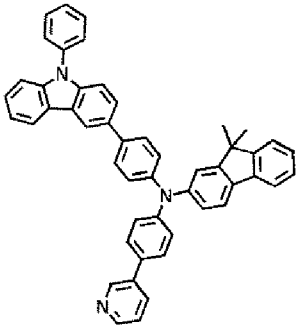


HT11



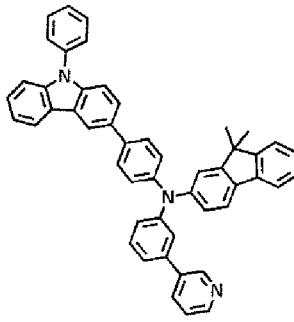
HT12

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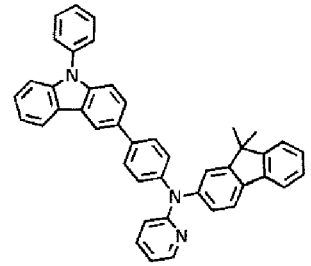


HT13

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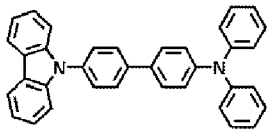
HT14



HT15

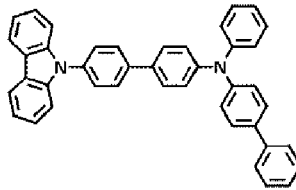
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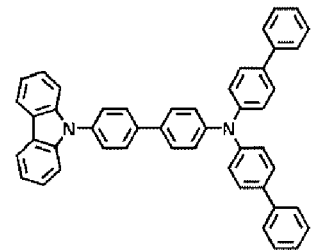


HT16

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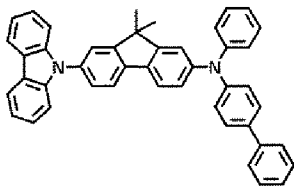


HT17



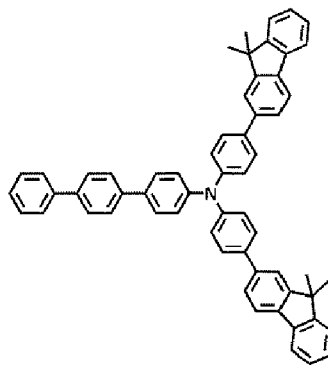
HT18

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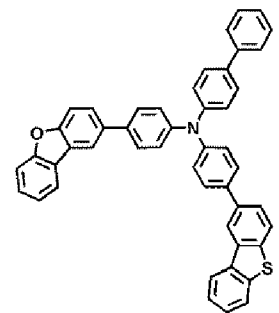
HT19

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HT20

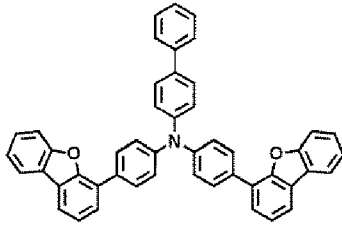
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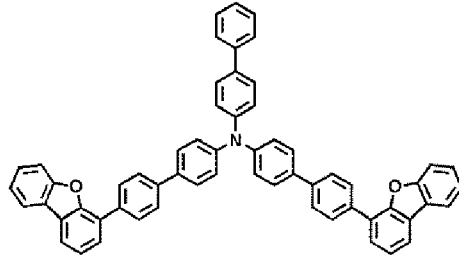
HT21

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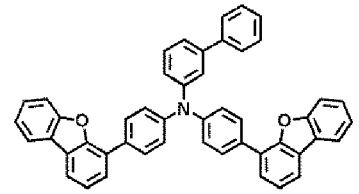
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HT22



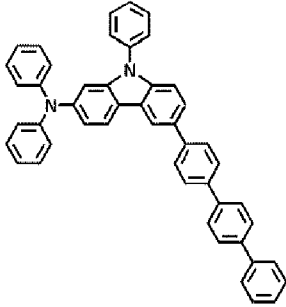
HT23



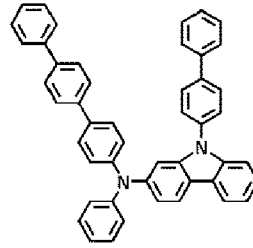
HT24

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HT25



HT26

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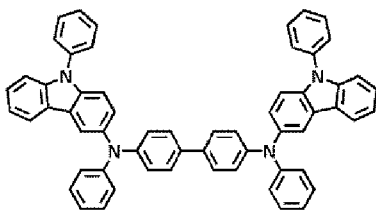
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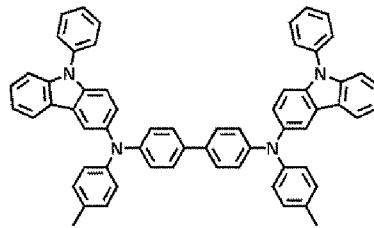
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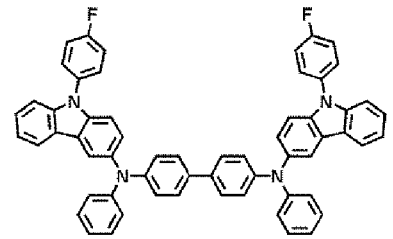
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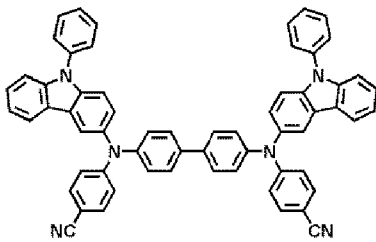
HT28



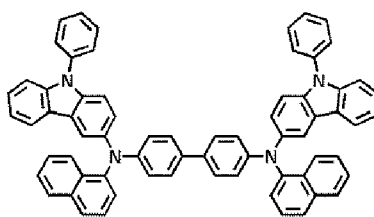
HT29



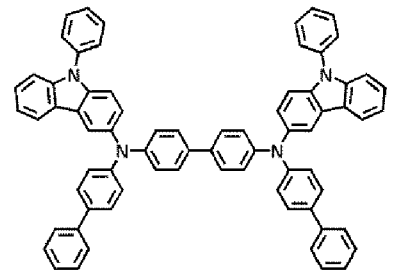
HT30



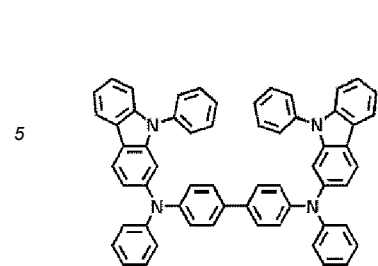
HT31



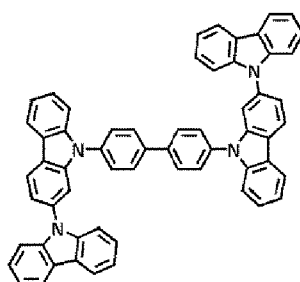
HT32



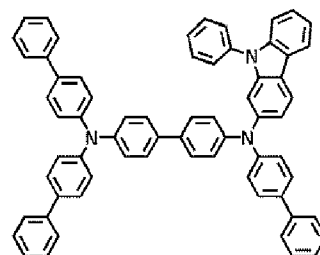
HT33



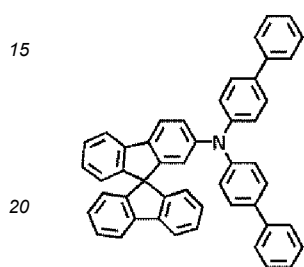
HT34



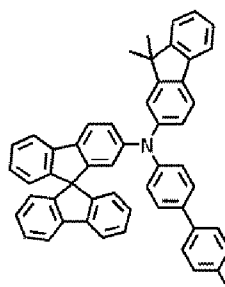
HT35



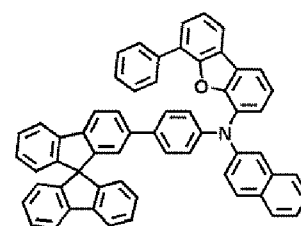
HT36



HT37



HT38



HT39

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[0115] A thickness of the hole transport region may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å. When the hole transport region comprises at least one of a hole injection layer and a hole transport layer, a thickness of the hole injection layer may be in a range of about 100 Å to about 9,000 Å, for example, about 100 Å to about 1,000 Å, and a thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, for example, about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are within these ranges, satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

30

[0116] The emission auxiliary layer may increase light-emission efficiency by compensating for an optical resonance distance according to the wavelength of light emitted by an emission layer, and the electron blocking layer may block the flow of electrons from an electron transport region. The emission auxiliary layer and the electron blocking layer may comprise the materials as described above.

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### p-dopant

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[0117] The hole transport region may further comprise, in addition to these materials, a charge-generation material for the improvement of conductive properties. The charge-generation material may be homogeneously or non-homogeneously dispersed in the hole transport region.

[0118] The charge-generation material may be, for example, a p-dopant.

45

[0119] In one embodiment, the p-dopant may have a lowest unoccupied molecular orbital (LUMO) level of -3.5 eV or less.

[0120] The p-dopant may comprise at least one selected from a quinone derivative, a metal oxide, and a cyano group-containing compound, but embodiments of the present disclosure are not limited thereto.

[0121] For example, the p-dopant may comprise at least one selected from:

50

a quinone derivative, such as tetracyanoquinodimethane (TCNQ) and/or 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ);

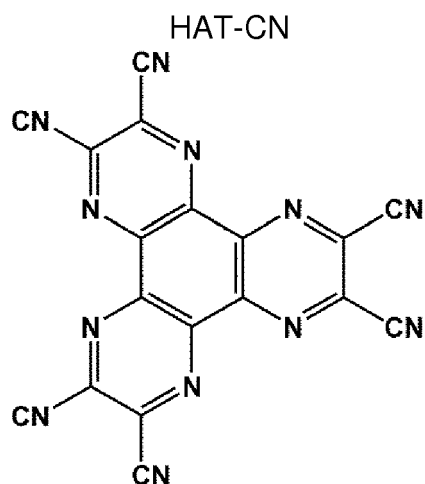
a metal oxide, such as tungsten oxide and/or molybdenum oxide;

1,4,5,8,9,11-hexaazatriphenylene-hexacarbonitrile (HAT-CN); and

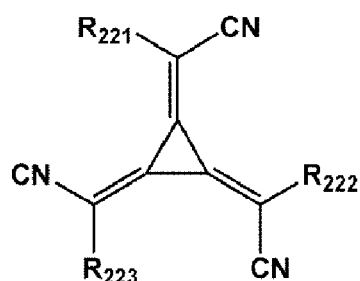
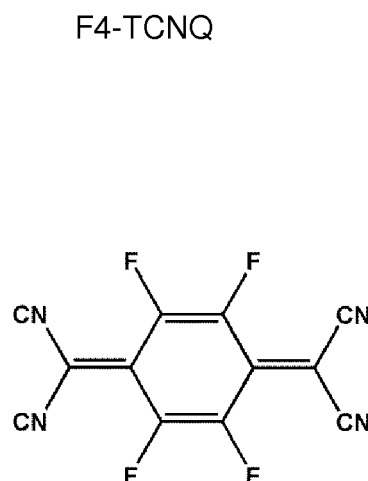
a compound represented by Formula 221,

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but embodiments of the present disclosure are not limited thereto:



Formula 221



30 **[0122]** In Formula 221,

$R_{221}$  to  $R_{223}$  may each independently be selected from a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkyl group, a substituted or unsubstituted  $C_1$ - $C_{16}$  heterocycloalkyl group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkenyl group, a substituted or unsubstituted  $C_1$ - $C_{16}$  heterocycloalkenyl group, a substituted or unsubstituted  $C_6$ - $C_{60}$  aryl group, a substituted or unsubstituted  $C_1$ - $C_{60}$  heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed

35 C8-C60 polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, and at least one selected from  $R_{221}$  to  $R_{223}$  may have at least one substituent selected from a cyano group, -F, -Cl, -Br, -I, a  $C_1$ - $C_{20}$  alkyl group substituted with -F, a  $C_1$ - $C_{20}$  alkyl group substituted with -Cl, a  $C_1$ - $C_{20}$  alkyl group substituted with -Br, and a  $C_1$ - $C_{20}$  alkyl group substituted with -I.

40 **Emission layer in organic layer 150**

**[0123]** When the organic light-emitting device 10 is a full-color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, or a blue emission layer, according to a sub-pixel. In one or more embodiments, the emission layer may have a stacked structure of two or more layers selected from a red

45 emission layer, a green emission layer, and a blue emission layer, in which the two or more layers contact each other or are separated from each other. In one or more embodiments, the emission layer may comprise two or more materials selected from a red light-emitting material, a green light-emitting material, and a blue light-emitting material, in which the two or more materials are mixed with each other in a single layer to emit white light.

**[0124]** A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, for example, about 200 Å to about 600 Å. When the thickness of the emission layer is within these ranges, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

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**Electron transport region in organic layer 150**

**[0125]** The electron transport region may have i) a single-layered structure comprising a single layer comprising a single material, ii) a single-layered structure comprising a single layer comprising a plurality of different materials, or iii) a multi-layered structure having a plurality of layers comprising a plurality of different materials.

**[0126]** The electron transport region may comprise at least one selected from a buffer layer, a hole blocking layer, an

electron control layer, an electron transport layer, and an electron injection layer, but embodiments of the present disclosure are not limited thereto.

**[0127]** For example, the electron transport region may have an electron transport layer/electron injection layer structure, a hole blocking layer/electron transport layer/electron injection layer structure, an electron control layer/electron transport layer/electron injection layer structure, or a buffer layer/electron transport layer/electron injection layer structure, wherein for each structure, constituting layers are sequentially stacked (e.g., laminated) from an emission layer. However, embodiments of the structure of the electron transport region are not limited thereto.

**[0128]** The electron transport region (for example, a buffer layer, a hole blocking layer, an electron control layer, and/or an electron transport layer in the electron transport region) may comprise a metal-free compound containing at least one  $\pi$  electron-depleted nitrogen-containing ring.

**[0129]** The term " $\pi$  electron-depleted nitrogen-containing ring" as used herein refers to a  $C_1$ - $C_{60}$  heterocyclic group having at least one  $*-N=*$  moiety as a ring-forming moiety.

**[0130]** For example, the " $\pi$  electron-depleted nitrogen-containing ring" may be i) a 5-membered to 7-membered heteromonocyclic group having at least one  $*-N=*$  moiety, ii) a heteropolycyclic group in which two or more 5-membered to 7-membered heteromonocyclic groups each having at least one  $*-N=*$  moiety are condensed with each other, or iii) a heteropolycyclic group in which at least one of 5-membered to 7-membered heteromonocyclic groups, each having at least one  $*-N=*$  moiety, is condensed with at least one  $C_5$ - $C_{60}$  carbocyclic group.

**[0131]** Examples of the  $\pi$  electron-depleted nitrogen-containing ring comprise an imidazole, a pyrazole, a thiazole, an isothiazole, an oxazole, an isoxazole, a pyridine, a pyrazine, a pyrimidine, a pyridazine, an indazole, a purine, a quinoline, an isoquinoline, a benzoquinoline, a phthalazine, a naphthyridine, a quinoxaline, a quinazoline, a cinnoline, a phenanthridine, an acridine, a phenanthroline, a phenazine, a benzimidazole, an isobenzothiazole, a benzoxazole, an isobenzoxazole, a triazole, a tetrazole, an oxadiazole, a triazine, thiadiazol, an imidazopyridine, an imidazopyrimidine, and an azacarbazole, but embodiments of the present disclosure are not limited thereto.

**[0132]** For example, the electron transport region may comprise a compound represented by Formula 601:



In Formula 601,

$Ar_{601}$  may be a substituted or unsubstituted  $C_5$ - $C_{60}$  carbocyclic group or a substituted or unsubstituted  $C_1$ - $C_{60}$  heterocyclic group,

$xe11$  may be 1, 2, or 3,

$L_{601}$  may be selected from a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkylene group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkylene group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkenylene group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkenylene group, a substituted or unsubstituted  $C_6$ - $C_{60}$  arylene group, a substituted or unsubstituted  $C_1$ - $C_{60}$  heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed  $C_8$ - $C_{60}$  polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed 8- to 60-membered heteropolycyclic group,

$xe1$  may be an integer of 0 to 5,

$R_{601}$  may be selected from a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkenyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  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  $C_1$ - $C_{60}$  heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed  $C_8$ - $C_{60}$  polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group,  $-Si(Q_{601})(Q_{602})(Q_{603})$ ,  $-C(=O)(Q_{601})$ ,  $-S(=O)(O_{601})$ , and  $-P(=O)(Q_{601})(Q_{602})$ ,

$Q_{601}$  to  $Q_{603}$  may each independently be a  $C_1$ - $C_{10}$  alkyl group, a  $C_1$ - $C_{10}$  alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group, and

$xe21$  may be an integer of 1 to 5.

**[0133]** In one embodiment, at least one of  $Ar_{601}(S)$  in the number of  $xe11$  and  $R_{601}(s)$  in the number of  $xe21$  may comprise the  $\pi$  electron-depleted nitrogen-containing ring.

**[0134]** In one embodiment, ring  $Ar_{601}$  in Formula 601 may be selected from:

a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group,

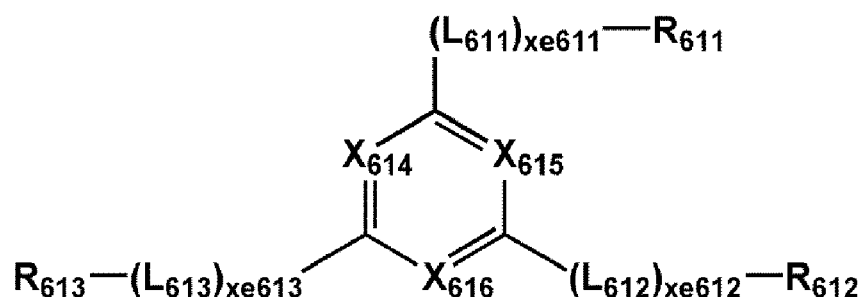
an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, an isobenzothiazole group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a thiadiazole group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group; and a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, an isobenzothiazole group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a thiadiazole group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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 biphenyl group, a terphenyl group, a naphthyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), -S(=O)<sub>2</sub>(Q<sub>31</sub>), and -P(=O)(Q<sub>31</sub>)(Q<sub>32</sub>), Q<sub>31</sub> to Q<sub>33</sub> may each independently be selected from a C<sub>1</sub>-C<sub>10</sub> alkyl group, a C<sub>1</sub>-C<sub>10</sub> alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0135] When xe11 in Formula 601 is two or more, two or more Ar<sub>601</sub> (s) may be linked via a single bond.

[0136] In one or more embodiments, Ar<sub>601</sub> in Formula 601 may be an anthracene group.

[0137] In one or more embodiments, a compound represented by Formula 601 may be represented by Formula 601-1:

Formula 601-1



[0138] In Formula 601-1,

X<sub>614</sub> may be N or C(R<sub>614</sub>), X<sub>615</sub> may be N or C(R<sub>615</sub>), X<sub>616</sub> may be N or C(R<sub>616</sub>), and at least one selected from X<sub>614</sub> to X<sub>616</sub> may be N,

L<sub>611</sub> to L<sub>613</sub> may each independently be the same as defined in connection with L<sub>601</sub>,

xe611 to xe613 may each independently be the same as defined in connection with xe1,

R<sub>611</sub> to R<sub>613</sub> may each independently be the same as defined in connection with R<sub>601</sub>,

R<sub>614</sub> to R<sub>616</sub> may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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 biphenyl group, a terphenyl group, and a naphthyl group.

[0139] In one embodiment, L<sub>601</sub> and L<sub>611</sub> to L<sub>613</sub> in Formulae 601 and 601-1 may each independently be selected from:

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group,

a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, a pyridinylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a thiadiazolylenylene group, an oxadiazolylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a triazinylenylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzimidazolylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an imidazopyridinylenylene group, an imidazopyrimidinylenylene group, and an azacarbazolylenylene group; and

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, a pyridinylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a thiadiazolylenylene group, an oxadiazolylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a triazinylenylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzimidazolylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an imidazopyridinylenylene group, an imidazopyrimidinylenylene group, and an azacarbazolylenylene group, each substituted with at least one selected from deuterium, - F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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 biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxaliny group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, but embodiments of the present disclosure are not limited thereto.

**[0140]** In one or more embodiments, xe1 and xe611 to xe613 in Formulae 601 and 601-1 may each independently be 0, 1, or 2.

**[0141]** In one or more embodiments, R<sub>601</sub> and R<sub>611</sub> to R<sub>613</sub> in Formula 601 and 601 - 1 may each independently be selected from:

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxaliny group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group.

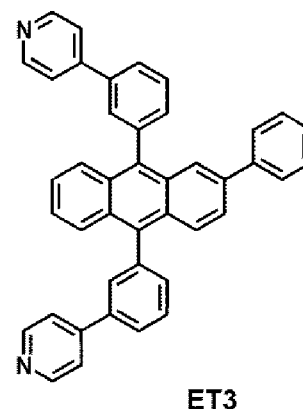
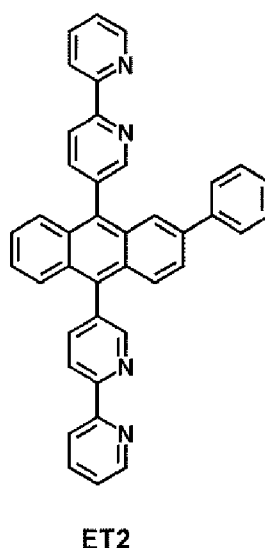
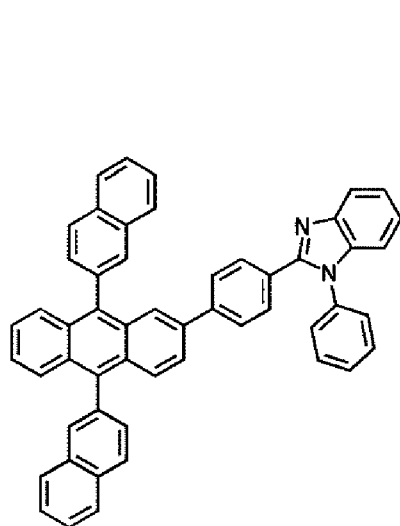
group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group;

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl 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 phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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 biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl 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 phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group; and

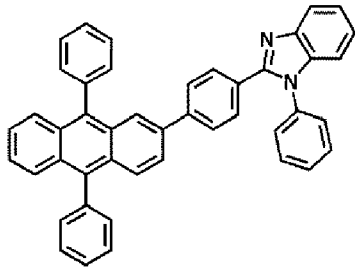
-S(=O)<sub>2</sub>(Q<sub>601</sub>) and -P(=O)(Q<sub>601</sub>)(Q<sub>602</sub>), and

Q<sub>601</sub> and Q<sub>602</sub> are the same as described above with respect to Formula 601.

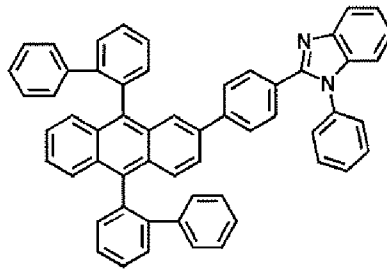
**[0142]** The electron transport region may comprise at least one compound selected from Compounds ET1 to ET36, but embodiments of the present disclosure are not limited thereto:



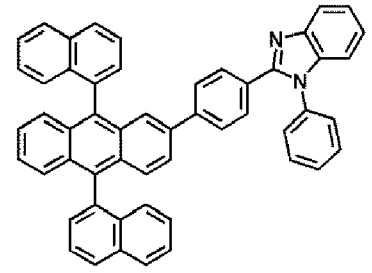
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ET4

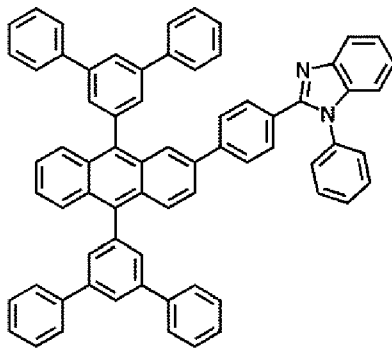


ET5

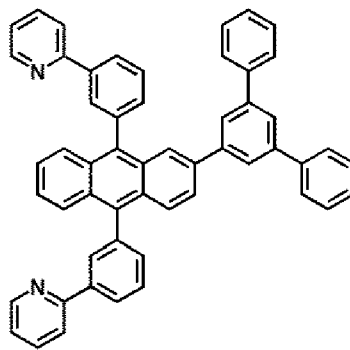


ET6

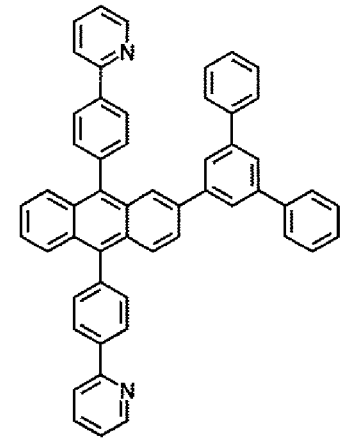
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ET7



ET8



ET9

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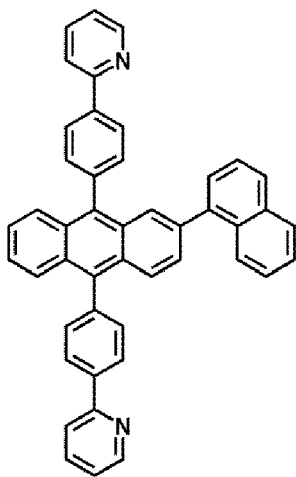
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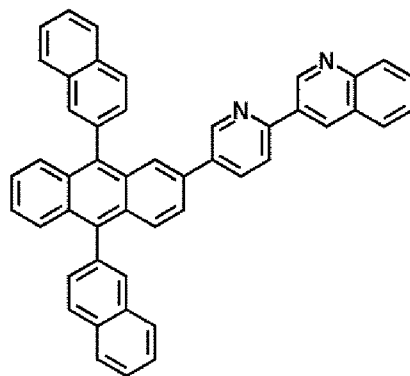
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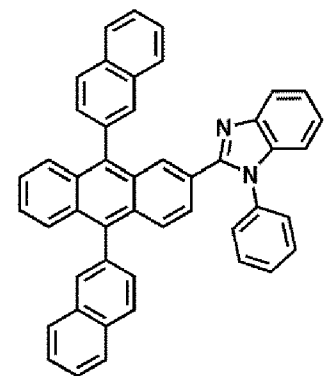
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ET10

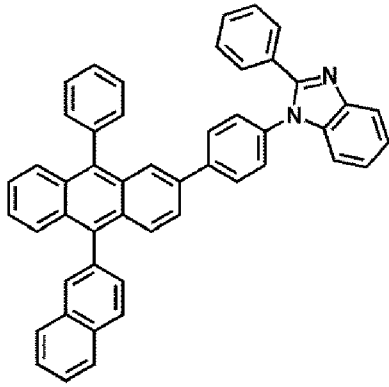


ET11

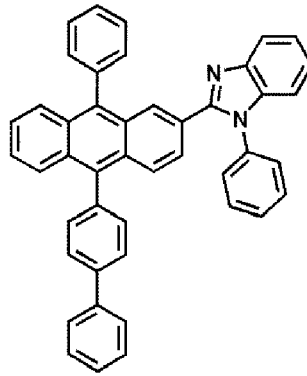


ET12

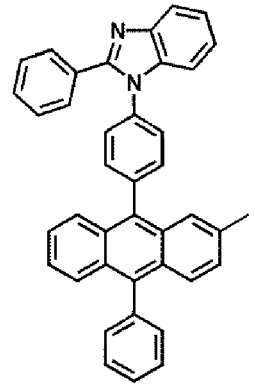
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ET13



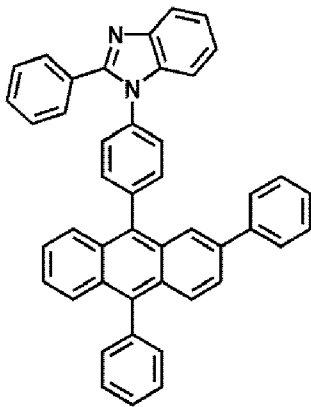
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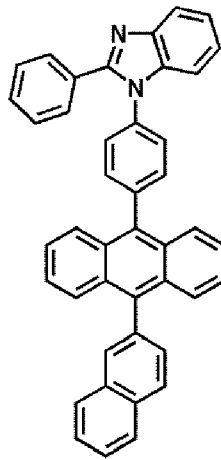
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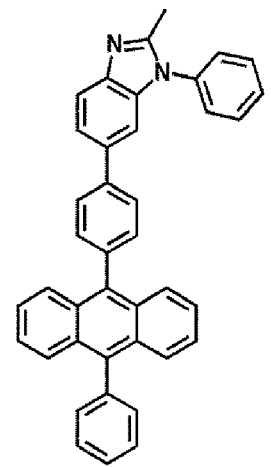
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ET16



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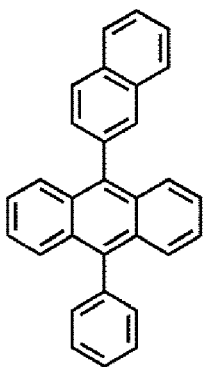
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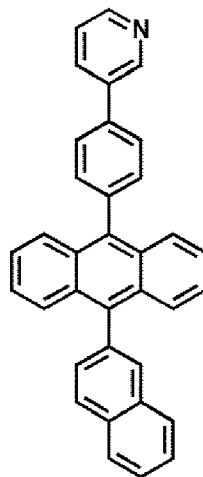
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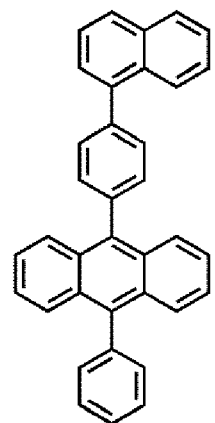
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ET19

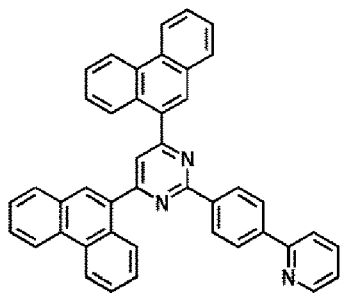


ET20

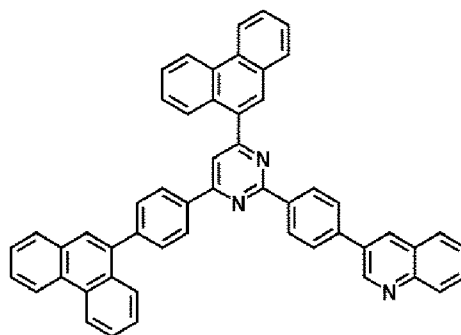


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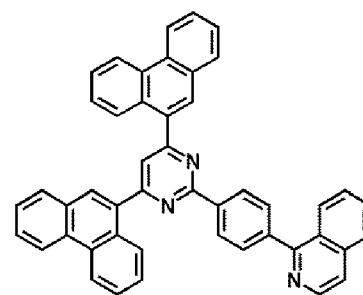
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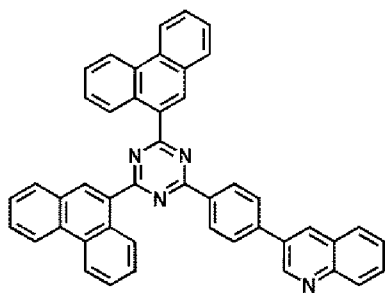


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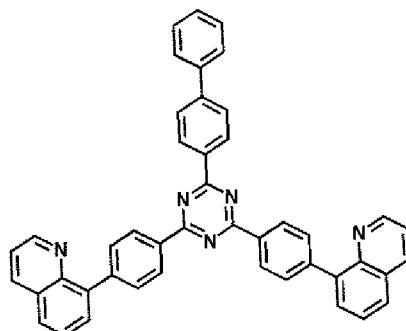


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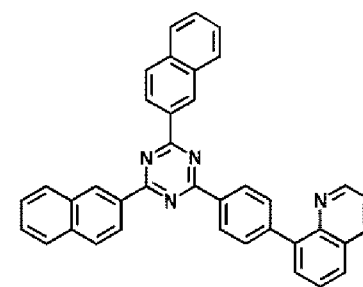
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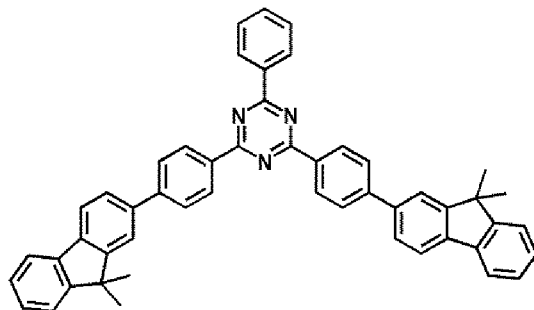


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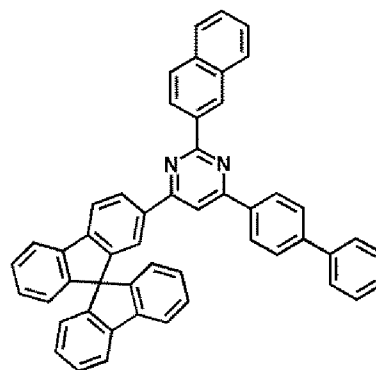


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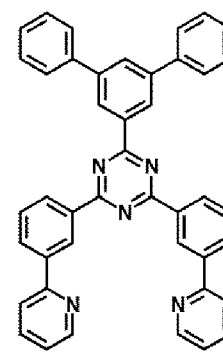
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ET28



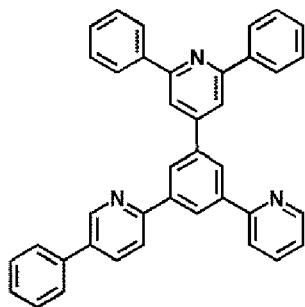
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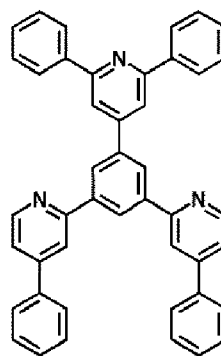
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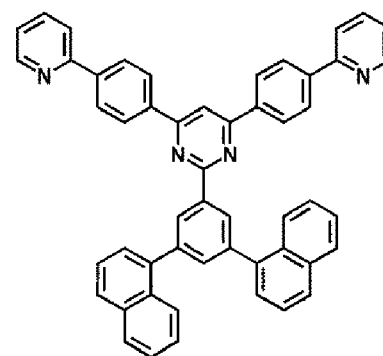
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ET31



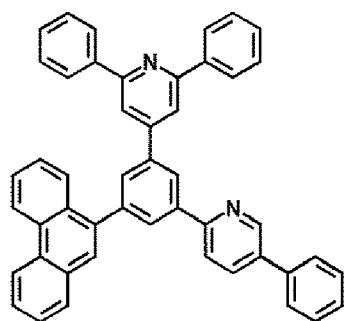
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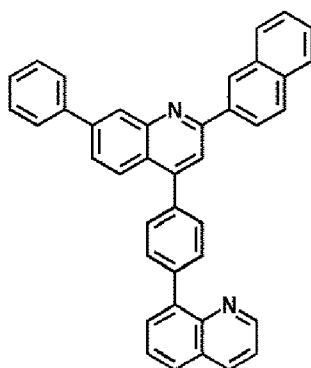
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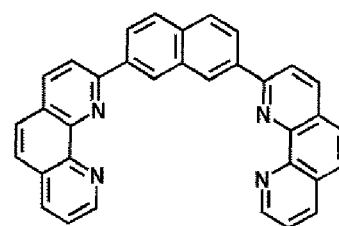
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ET34



ET35

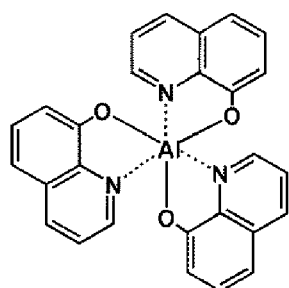
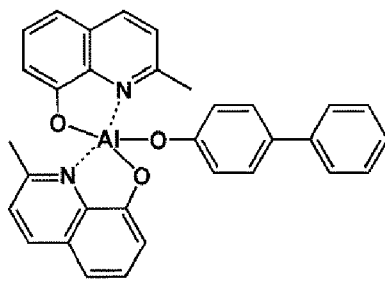


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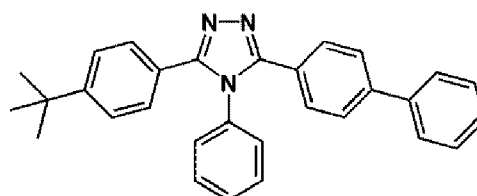
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**[0143]** In one embodiment, the electron transport region may comprise at least one compound selected from 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), Alq<sub>3</sub>, BAlq, 3-(biphenyl-4-yl)-5-(4-*tert*-butylphenyl)-4-phenyl-4*H*-1,2,4-triazole (TAZ), NTAZ, and diphenyl(4-(triphenylsilyl)phenyl)-phosphine oxide (TSPO1):

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Alq<sub>3</sub>

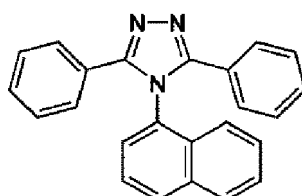
BAlq



TAZ

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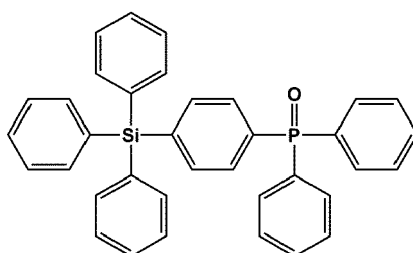
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NTAZ

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TSPO1

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**[0144]** A thickness of the buffer layer, the hole blocking layer, or the electron control layer may be in a range of about 20 Å to about 1,000 Å, for example, about 30 Å to about 300 Å. When the thicknesses of the buffer layer, the hole blocking layer, and the electron control layer are within these ranges, the electron blocking layer may have suitable (e.g., excellent) electron blocking characteristics or electron control characteristics without a substantial increase in driving

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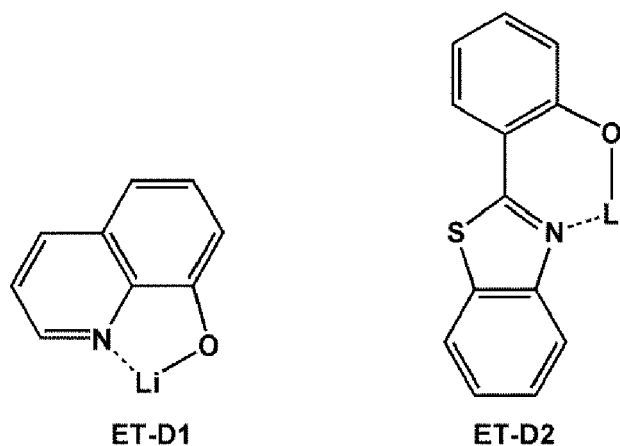
voltage.

[0145] A thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, for example, about 150 Å to about 500 Å. When the thickness of the electron transport layer is within the ranges described above, the electron transport layer may have satisfactory electron transport characteristics without a substantial increase in driving voltage.

[0146] The electron transport region (for example, the electron transport layer in the electron transport region) may further comprise, in addition to the materials described above, a metal-containing material.

[0147] The metal-containing material may comprise at least one selected from alkali metal complex and alkaline earth-metal complex. The alkali metal complex may comprise a metal ion selected from a Li ion, a Na ion, a K ion, a Rb ion, and a Cs ion, and the alkaline earth-metal complex may comprise a metal ion selected from a Be ion, a Mg ion, a Ca ion, a Sr ion, and a Ba ion. A ligand coordinated with the metal ion of the alkali metal complex or the alkaline earth-metal complex may be selected from a hydroxy quinoline, a hydroxy isoquinoline, a hydroxy benzoquinoline, a hydroxy acridine, a hydroxy phenanthridine, a hydroxy phenyloxazole, a hydroxy phenylthiazole, a hydroxy diphenyloxadiazole, a hydroxy diphenylthiadiazol, a hydroxy phenylpyridine, a hydroxy phenylbenzimidazole, a hydroxy phenylbenzothiazole, a bipyridine, a phenanthroline, and a cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

[0148] For example, the metal-containing material may comprise a Li complex. The Li complex may comprise, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2.



[0149] The electron transport region may comprise an electron injection layer that facilitates injection of electrons from the second electrode 190. The electron injection layer may directly contact the second electrode 190.

[0150] The electron injection layer may have i) a single-layered structure comprising a single layer comprising a single material, ii) a single-layered structure comprising a single layer comprising a plurality of different materials, or iii) a multi-layered structure having a plurality of layers comprising a plurality of different materials.

[0151] The electron injection layer may comprise an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare earth metal complex, or any combinations thereof.

[0152] The alkali metal may be selected from Li, Na, K, Rb, and Cs. In one embodiment, the alkali metal may be Li, Na, and/or Cs. In one or more embodiments, the alkali metal may be Li and/or Cs, but embodiments of the present disclosure are not limited thereto.

[0153] The alkaline earth metal may be selected from Mg, Ca, Sr, and Ba.

[0154] The rare earth metal may be selected from Sc, Y, Ce, Tb, Yb, and Gd.

[0155] The alkali metal compound, the alkaline earth-metal compound, and the rare earth metal compound may be selected from oxides and halides (for example, fluorides, chlorides, bromides, and/or iodides) of the alkali metal, the alkaline earth-metal, and the rare earth metal.

[0156] The alkali metal compound may be selected from alkali metal oxides, such as  $\text{Li}_2\text{O}$ ,  $\text{Cs}_2\text{O}$ , and/or  $\text{K}_2\text{O}$ , and alkali metal halides, such as LiF, NaF, CsF, KF, LiI, NaI, CsI, and/or KI. In one embodiment, the alkali metal compound may be selected from LiF,  $\text{Li}_2\text{O}$ , NaF, LiI, NaI, CsI, and KI, but embodiments of the present disclosure are not limited thereto.

[0157] The alkaline earth-metal compound may be selected from alkaline earth-metal oxides, such as BaO, SrO, CaO,  $\text{Ba}_x\text{Sr}_{1-x}\text{O}$  ( $0 < x < 1$ ), and  $\text{Ba}_x\text{Ca}_{1-x}\text{O}$  ( $0 < x < 1$ ). In one embodiment, the alkaline earth-metal compound may be selected from BaO, SrO, and CaO, but embodiments of the present disclosure are not limited thereto.

[0158] The rare earth metal compound may be selected from  $\text{YbF}_3$ ,  $\text{ScF}_3$ ,  $\text{ScO}_3$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{Ce}_2\text{O}_3$ ,  $\text{GdF}_3$ , and  $\text{TbF}_3$ . In

one embodiment, the rare earth metal compound may be selected from  $\text{YbF}_3$ ,  $\text{ScF}_3$ ,  $\text{TbF}_3$ ,  $\text{YbI}_3$ ,  $\text{ScI}_3$ , and  $\text{TbI}_3$ , but embodiments of the present disclosure are not limited thereto.

**[0159]** The alkali metal complex, the alkaline earth-metal complex, and the rare earth metal complex may comprise an ion of alkali metal, alkaline earth-metal, and rare earth metal as described above, and a ligand coordinated with a metal ion of the alkali metal complex, the alkaline earth-metal complex, or the rare earth metal complex may be selected from hydroxy quinoline, hydroxy isoquinoline, hydroxy benzoquinoline, hydroxy acridine, hydroxy phenanthridine, hydroxy phenyloxazole, hydroxy phenylthiazole, hydroxy diphenyloxadiazole, hydroxy diphenylthiadiazol, hydroxy phenylpyridine, hydroxy phenylbenzimidazole, hydroxy phenylbenzothiazole, bipyridine, phenanthroline, and cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

**[0160]** The electron injection layer may comprise or consist of (i.e., comprise only) an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare earth metal complex, or any combinations thereof, as described above. In one or more embodiments, the electron injection layer may further comprise an organic material. When the electron injection layer further comprises an organic material, an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare earth metal complex, or any combinations thereof may be homogeneously or non-homogeneously dispersed in a matrix comprising the organic material.

**[0161]** A thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, for example, about 3 Å to about 90 Å. When the thickness of the electron injection layer is within the ranges described above, the electron injection layer may have satisfactory electron injection characteristics without a substantial increase in driving voltage.

### Second electrode 190

**[0162]** The second electrode 190 may be disposed on the organic layer 150 having such a structure. The second electrode 190 may be a cathode which is an electron injection electrode, and in this regard, a material for forming the second electrode 190 may be selected from a metal, an alloy, an electrically conductive compound, and a combination thereof, which have a relatively low work function.

**[0163]** The second electrode 190 may comprise at least one selected from lithium (Li), silver (Ag), magnesium (Mg), aluminum (Al), aluminum-lithium (Al-Li), calcium (Ca), magnesium-indium (Mg-In), magnesium-silver (Mg-Ag), ITO, and IZO, but embodiments of the present disclosure are not limited thereto. The second electrode 190 may be a transmissive electrode, a semi-transmissive electrode, or a reflective electrode.

**[0164]** The second electrode 190 may have a single-layered structure, or a multi-layered structure comprising two or more layers.

### Description of FIGS. 2 to 4

**[0165]** An organic light-emitting device 20 of FIG. 2 comprises a first capping layer 210, a first electrode 110, an organic layer 150, and a second electrode 190, which are sequentially stacked in this stated order; an organic light-emitting device 30 of FIG. 3 comprises a first electrode 110, an organic layer 150, a second electrode 190, and a second capping layer 220, which are sequentially stacked in this stated order; and an organic light-emitting device 40 of FIG. 4 comprises a first capping layer 210, a first electrode 110, an organic layer 150, a second electrode 190, and a second capping layer 220, which are sequentially stacked in this stated order.

**[0166]** Regarding FIGS. 2 to 4, the first electrode 110, the organic layer 150, and the second electrode 190 may be understood by referring to the description presented in connection with FIG. 1.

**[0167]** In the organic layer 150 of each of the organic light-emitting devices 20 and 40, light generated in an emission layer may pass through the first electrode 110, which is a semi-transmissive electrode or a transmissive electrode, and the first capping layer 210 toward the outside, and in the organic layer 150 of each of the organic light-emitting devices 30 and 40, light generated in an emission layer may pass through the second electrode 190, which is a semi-transmissive electrode or a transmissive electrode, and the second capping layer 220 toward the outside.

**[0168]** The first capping layer 210 and the second capping layer 220 may increase external luminescent efficiency according to the principle of constructive interference.

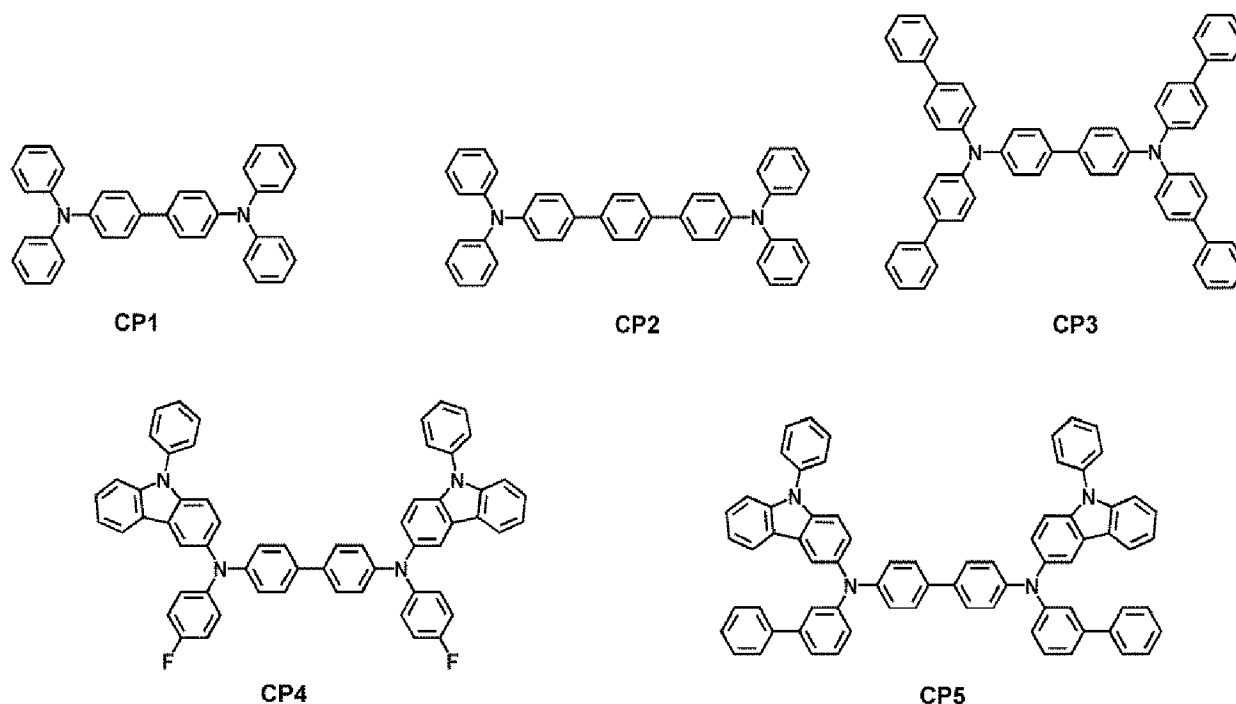
**[0169]** The first capping layer 210 and the second capping layer 220 may each independently be an organic capping layer comprising an organic material, an inorganic capping layer comprising an inorganic material, or a composite capping layer comprising an organic material and an inorganic material.

**[0170]** At least one selected from the first capping layer 210 and the second capping layer 220 may each independently comprise at least one material selected from carbocyclic compounds, heterocyclic compounds, amine-based compounds, porphyrine derivatives, phthalocyanine derivatives, naphthalocyanine derivatives, alkali metal complexes, and alkaline earth-based complexes. The carbocyclic compound, the heterocyclic compound, and the amine-based compound may

be optionally substituted with a substituent containing (e.g., comprising) at least one element selected from O, N, S, Se, Si, F, Cl, Br, and I. In one embodiment, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently comprise an amine-based compound.

[0171] In one embodiment, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently comprise the compound represented by Formula 201 or the compound represented by Formula 202.

[0172] In one or more embodiments, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently comprise a compound selected from Compounds HT28 to HT33 and Compounds CP1 to CP5, but embodiments of the present disclosure are not limited thereto.



[0173] Hereinbefore, the organic light-emitting device according to an embodiment has been described in connection with FIGS. 1 to 4. However, embodiments of the present disclosure are not limited thereto.

[0174] Layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region may be formed in a certain region by utilizing one or more suitable methods selected from vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, ink-jet printing, laser-printing, and laser-induced thermal imaging.

[0175] When layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region are formed by vacuum deposition, the deposition may be performed at a deposition temperature of about 100 °C to about 500 °C, a vacuum degree of about 10<sup>-8</sup> torr to about 10<sup>-3</sup> torr, and a deposition speed of about 0.01 Å/sec to about 100 Å/sec by taking into account a material to be comprised in a layer to be formed, and the structure of a layer to be formed.

[0176] When layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region are formed by spin coating, the spin coating may be performed at a coating speed of about 2000 rpm to about 5000 rpm and at a heat treatment temperature of about 80°C to 200°C by taking into account a material to be comprised in a layer to be formed, and the structure of a layer to be formed.

### Display apparatus

[0177] The organic light-emitting device according to an embodiment may be comprised in a display device comprising a thin film transistor. The thin film transistor may comprise a gate electrode, source and drain electrodes, a gate insulating film, and an active layer, and one of the source and drain electrodes may electrically contact a first electrode of the organic light-emitting device.

[0178] The active layer may comprise crystalline silicon, amorphous silicon, organic semiconductor, oxide semiconductor, and/or the like, but embodiments of the present disclosure are not limited thereto.

**[0179]** The display apparatus may further comprise a sealing member that seals the organic light-emitting device. The sealing member may enable the implementation of an image in the organic light-emitting device, and may reduce or prevent penetration of external air and moisture into the organic light-emitting device. The sealing member may be a sealing substrate made of glass and/or plastic. The sealing member may be a thin-film encapsulation layer comprising a plurality of organic layers and/or a plurality of inorganic layers. When the sealing member is a thin-film encapsulation layer, the whole flat display apparatus may be made flexible.

### General definition of substituents

**[0180]** The term " $\pi$  electron-depleted nitrogen-containing ring" as used herein refers to, for example, a cyclic group having at least one  $\text{*N=}$  moiety (e.g. a  $\text{C}_1\text{-C}_{60}$  heteroaryl group comprising one or more N atom), and examples thereof comprise an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyridazine group, a pyrimidine group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, an isobenzothiazole group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, s thiadiazol group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group, but embodiments of the present disclosure are not limited thereto.

**[0181]** The term " $\pi$  electron-depleted nitrogen-free ring" as used herein refers to, for example, a  $\text{C}_5\text{-C}_{60}$  carbocyclic group or a  $\text{C}_1\text{-C}_{60}$  heterocyclic group, as. The  $\pi$  electron-depleted nitrogen-free ring may be a  $\text{C}_5\text{-C}_{60}$  aryl group or a  $\text{C}_1\text{-C}_{60}$  heteraryl group.

**[0182]** Examples of the  $\pi$  electron-depleted nitrogen-free cyclic group comprise a benzene group, a heptalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, acenaphthylene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentacene group, a hexacene group, a pentacene group, a rubicene group, a corozen group, an ovalene group, a pyrrole group, an isoindole group, an indole group, a furan group, a thiophene group, a benzofuran group, a benzothiophene group, a benzocarbazole group, a dibenzocarbazole group, a dibenzofuran group, a dibenzothiophene group, a dibenzothiophene sulfone group, a carbazole group, a dibenzosilole group, an indenocarbazole group, an indolocarbazole group, a benzofurocarbazole group, a benzothienocarbazole group and a triindolobenzene group, but embodiments of the present disclosure are not limited thereto.

**[0183]** The term " $\text{C}_1\text{-C}_{60}$  alkyl group" as used herein refers to a linear or branched saturated aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms e.g. 1 to 30 carbon atoms, 1 to 20 carbon atoms, 1 to 10 carbon atoms, 1 to 6 carbon atoms or 1 to 4 carbon atoms. Examples thereof comprise a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an isoamyl group, and a hexyl group. The term " $\text{C}_1\text{-C}_{60}$  alkenylene group" as used herein refers to a divalent group having the same structure as the  $\text{C}_1\text{-C}_{60}$  alkyl group.

**[0184]** The term " $\text{C}_2\text{-C}_{60}$  alkenyl group" as used herein refers to a hydrocarbon group having at least one double bond in the middle or at the terminus of the  $\text{C}_2\text{-C}_{60}$  alkyl group, and examples thereof comprise an ethenyl group, a propenyl group, and a butenyl group. The term " $\text{C}_2\text{-C}_{60}$  alkenylene group" as used herein refers to a divalent group having the same structure as the  $\text{C}_2\text{-C}_{60}$  alkenyl group.

**[0185]** The term " $\text{C}_2\text{-C}_{60}$  alkynyl group" as used herein refers to a hydrocarbon group having at least one triple bond in the middle or at the terminus of the  $\text{C}_2\text{-C}_{60}$  alkyl group, and examples thereof comprise an ethynyl group, and a propynyl group. The term " $\text{C}_2\text{-C}_{60}$  alkynylene group" as used herein refers to a divalent group having the same structure as the  $\text{C}_2\text{-C}_{60}$  alkynyl group.

**[0186]** The term " $\text{C}_1\text{-C}_{60}$  alkoxy group" as used herein refers to a monovalent group represented by  $\text{-OA}_{101}$  (wherein  $\text{A}_{101}$  is the  $\text{C}_1\text{-C}_{60}$  alkyl group), and examples thereof comprise a methoxy group, an ethoxy group, and an isopropoxy group.

**[0187]** The term " $\text{C}_3\text{-C}_{10}$  cycloalkyl group" as used herein refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and examples thereof comprise a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term " $\text{C}_3\text{-C}_{10}$  cycloalkylene group" as used herein refers to a divalent group having the same structure as the  $\text{C}_3\text{-C}_{10}$  cycloalkyl group.

**[0188]** The term " $\text{C}_1\text{-C}_{10}$  heterocycloalkyl group" as used herein refers to a monovalent monocyclic group having at least one heteroatom (e.g. 1, 2, 3, 4 or 5 hereoatoms) selected from N, O, Si, P, and S as a ring-forming atom in addition to 1 to 10 carbon atoms e.g. 1, 2, 3, 4 or 5 ring carbon atoms. Examples thereof comprise a 1,2,3,4-oxatriazolidinyl group, a tetrahydrofuranyl group, and a tetrahydrothiophenyl group. The term " $\text{C}_1\text{-C}_{10}$  heterocycloalkylene group" as used herein refers to a divalent group having the same structure as the  $\text{C}_1\text{-C}_{10}$  heterocycloalkyl group.

**[0189]** The term " $\text{C}_3\text{-C}_{10}$  cycloalkenyl group" as used herein refers to a monovalent monocyclic group that has 3 to

10 carbon atoms and at least one double bond in the ring thereof and no aromaticity, and examples thereof comprise a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term "C<sub>3</sub>-C<sub>10</sub> cycloalkenylene group" as used herein refers to a divalent group having the same structure as the C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group.

5 [0190] The term "C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group" as used herein refers to a monovalent monocyclic group that has at least one heteroatom (e.g. 1, 2, 3, 4 or 5 hereoatoms) selected from N, O, Si, P, and S as a ring-forming atom, 1 to 10 carbon atoms e.g. 1, 2, 3, 4 or 5 ring carbon atoms, and at least one double bond in its ring. Non-limiting examples of the C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group comprise a 4,5-dihydro-1,2,3,4-oxatriazolyl group, a 2,3-dihydrofuranlyl group, and a 2,3-dihydrothiophenyl group. The term "C<sub>1</sub>-C<sub>10</sub> heterocycloalkenylene group" as used herein refers to a divalent group having the same structure as the C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group.

10 [0191] The term "C<sub>6</sub>-C<sub>60</sub> aryl group" as used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms, e.g. 6 to 20 ring carbon atoms, 6 to 14 ring carbon atoms or 6 to 10 ring carbon atoms. The term "C<sub>6</sub>-C<sub>60</sub> arylene group" as used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms e.g. 6 to 20 ring carbon atoms, 6 to 14 ring carbon atoms or 6 to 10 ring carbon atoms. 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 each comprise two or more rings, the rings may be fused to each other.

15 [0192] The term "C<sub>1</sub>-C<sub>60</sub> heteroaryl group" as used herein refers to a monovalent group having a carbocyclic aromatic system that has at least one heteroatom (e.g. 1, 2, 3, 4 or 5 hereoatoms) selected from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 60 carbon atoms e.g. 1 to 19 ring carbon atoms, 1 to 13 ring carbon atoms or 1 to 9 ring carbon atoms. The term "C<sub>1</sub>-C<sub>60</sub> heteroarylene group" as used herein refers to a divalent group having a carbocyclic aromatic system that has at least one heteroatom selected (e.g. 1, 2, 3, 4 or 5 hereoatoms) from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 60 carbon atoms e.g. 1 to 19 ring carbon atoms, 1 to 13 ring carbon atoms or 1 to 9 ring carbon atoms. Examples of the C<sub>1</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>1</sub>-C<sub>60</sub> heteroaryl group and the C<sub>1</sub>-C<sub>60</sub> heteroarylene group each comprise two or more rings, the rings may be fused to each other.

20 [0193] The term "C<sub>6</sub>-C<sub>60</sub> aryloxy group" as used herein refers to a group represented by -OA<sub>102</sub> (wherein A<sub>102</sub> is the C<sub>6</sub>-C<sub>60</sub> aryl group), and the term "C<sub>6</sub>-C<sub>60</sub> arylthio group" refers to a group represented by -SA<sub>103</sub> (wherein A<sub>103</sub> is the C<sub>6</sub>-C<sub>60</sub> aryl group).

25 [0194] The term "C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group" as used herein refers to a group represented by -OA<sub>104</sub> (wherein A<sub>104</sub> is the C<sub>1</sub>-C<sub>60</sub> heteroaryl group), and the term "C<sub>6</sub>-C<sub>60</sub> heteroarylthio group" as used herein refers to a group represented by -SA<sub>105</sub> (wherein A<sub>105</sub> is the C<sub>1</sub>-C<sub>60</sub> heteroaryl group).

30 [0195] The term "monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group" as used herein refers to a monovalent group, having 8 to 60 carbon atoms having two or more rings condensed with each other, only carbon atoms as ring-forming atoms (for example 8 to 20, 8 to 14 or 8 to 10 ring carbon atoms), and no aromaticity in its entire molecular structure. An example of the monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group is a fluorenyl group. The term "divalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group" as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group.

35 [0196] The term "monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group" as used herein refers to a monovalent group having 8- to 60-ring-forming atoms, two or more rings condensed to each other, at least one heteroatom (e.g. 1, 2, 3, 4 or 5 hereoatoms) selected from N, O, Si, P, and S, in addition to carbon atoms (for example, having 1 to 59, 2 to 59, 2 to 19, 2 to 13 or 2 to 9 ring carbon atoms), as a ring-forming atom, and no aromaticity in its entire molecular structure. An example of the monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group is a carbazolyl group. The term "divalent non-aromatic condensed 8- to 60-membered heteropolycyclic group" as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group.

40 [0197] The term "C<sub>5</sub>-C<sub>60</sub> carbocyclic group" as used herein refers to a monocyclic or polycyclic group having 5 to 60 carbon atoms e.g. 5 to 20 ring carbon atoms, 5 to 14 ring carbon atoms or 5 to 10 ring carbon atoms, in which the ring-forming atoms comprise only carbon atoms. The C<sub>5</sub>-C<sub>60</sub> carbocyclic group may be an aromatic carbocyclic group or a non-aromatic carbocyclic group. The C<sub>5</sub>-C<sub>60</sub> carbocyclic group may be a ring (such as benzene), a monovalent group (such as a phenyl group), or a divalent group (such as a phenylene group). In one or more embodiments, depending on the number of substituents connected to the C<sub>5</sub>-C<sub>60</sub> carbocyclic group, the C<sub>5</sub>-C<sub>60</sub> carbocyclic group may be a trivalent group or a quadrivalent group.

45 [0198] The term "C<sub>1</sub>-C<sub>60</sub> heterocyclic group" as used herein refers to a group having the same structure as the C<sub>5</sub>-C<sub>60</sub> carbocyclic group, except that as a ring-forming atom, at least one heteroatom (e.g. 1, 2, 3, 4 or 5 hereoatoms) selected from N, O, Si, P, and S is utilized in addition to 1 to 60 carbon atoms (e.g. 1 to 20 ring carbon atoms, 1 to 14 ring carbon atoms or 1 to 10 ring carbon atoms).

50 [0199] Certain groups are specified herein as being substituted or unsubstituted. Unless otherwise specified, when a group is substituted it is typically substituted with 1, 2, 3 or 4 substituents. For example, when a group is substituted it

may substituted with 1, 2 or 3 substituents; 1 or 2 substituents; or 1 substituent. Groups which are not specified as being substituted or unsubstituted are typically unsubstituted.

**[0200]** Unless otherwise specified, when a group is substituted it is typically substituted with at least one substituent (e.g. 1, 2, 3 or 4 substituents) selected from:

5 deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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, 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, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> hetero aryloxy group, a C<sub>1</sub>-C<sub>60</sub> hetero arylthio group, a monovalent non-aromatic condensed C8-C60 polycyclic group, a monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, -Si(Q<sub>11</sub>)(Q<sub>12</sub>)(Q<sub>13</sub>), -N(Q<sub>11</sub>)(Q<sub>12</sub>), -B(Q<sub>11</sub>)(Q<sub>12</sub>), -C(=O)(Q<sub>11</sub>), -S(=O)<sub>2</sub>(Q<sub>11</sub>), and -P(=O)(Q<sub>11</sub>)(Q<sub>12</sub>);

10 a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> hetero aryloxy group, a C<sub>1</sub>-C<sub>60</sub> hetero arylthio group, a monovalent non-aromatic condensed C8-C60 polycyclic group, and a monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group;

20 a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> hetero aryloxy group, a C<sub>1</sub>-C<sub>60</sub> hetero arylthio group, a monovalent non-aromatic condensed C8-C60 polycyclic group, and a monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> hetero aryloxy group, a C<sub>1</sub>-C<sub>60</sub> hetero arylthio group, a monovalent non-aromatic condensed C8-C60 polycyclic group, a monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group,

30 -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>), -N(Q<sub>21</sub>)(Q<sub>22</sub>), -B(Q<sub>21</sub>)(Q<sub>22</sub>), -C(=O)(Q<sub>21</sub>), -S(=O)<sub>2</sub>(Q<sub>21</sub>), and -P(=O)(Q<sub>21</sub>)(Q<sub>22</sub>); and -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), -N(Q<sub>31</sub>)(Q<sub>32</sub>), -B(Q<sub>31</sub>)(Q<sub>32</sub>), -C(=O)(Q<sub>31</sub>), -S(=O)<sub>2</sub>(Q<sub>31</sub>), and -P(=O)(Q<sub>31</sub>)(Q<sub>32</sub>), and

35 Q<sub>11</sub> to Q<sub>13</sub>, Q<sub>21</sub> to Q<sub>23</sub>, and Q<sub>31</sub> to Q<sub>33</sub> may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> hetero aryloxy group, a C<sub>1</sub>-C<sub>60</sub> hetero arylthio group, a monovalent non-aromatic condensed C8-C60 polycyclic group, a monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, a C<sub>1</sub>-C<sub>60</sub> alkyl group substituted with at least one selected from deuterium, -F, and a cyano group, a C<sub>6</sub>-C<sub>60</sub> aryl group substituted with at least one selected from deuterium, -F, and a cyano group, a biphenyl group, and a terphenyl group.

**[0201]** The term "Ph" as used herein refers to a phenyl group, the term "Me" as used herein refers to a methyl group, the term "Et" as used herein refers to an ethyl group, the term "ter-Bu" or "But" as used herein refers to a tert-butyl group, and the term "OMe" as used herein refers to a methoxy group.

45 **[0202]** The term "biphenyl group" as used herein refers to "a phenyl group substituted with a phenyl group." In other words, the "biphenyl group" is a substituted phenyl group having a C<sub>6</sub>-C<sub>60</sub> aryl group as a substituent.

**[0203]** The term "terphenyl group" as used herein refers to "a phenyl group substituted with a biphenyl group." In other words, the "terphenyl group" is a phenyl group having, as a substituent, a C<sub>6</sub>-C<sub>60</sub> aryl group substituted with a C<sub>6</sub>-C<sub>60</sub> aryl group.

50 \* and \*\* as used herein, unless defined otherwise, each refer to a binding site to a neighboring atom in a corresponding formula.

**[0204]** Hereinafter, a compound according to embodiments and an organic light-emitting device according to embodiments will be described in more detail with reference to Synthesis Examples and Examples. The wording "B was utilized instead of A" used in describing Synthesis Examples refers to that an identical molar equivalent of B was utilized in place of A.

## Examples

## Example 1

5 [0205] As an anode, an ITO substrate, on which ITO/Ag/ITO were deposited, was cut to a size of 50 mm x 50 mm x 0.7 mm, sonicated with isopropyl alcohol and pure water for 5 minutes each, and then cleaned by exposure to ultraviolet rays and ozone for 30 minutes. Then, the ITO substrate was provided to a vacuum deposition apparatus.

10 [0206] Compound HT3 and F4-TCNQ were vacuum-deposited on the ITO substrate at a weight ratio of 98:2 to form a hole injection layer having a thickness of 100 Å, Compound HT3 was vacuum-deposited on the hole injection layer to form a hole transport layer having a thickness of 1,200 Å, and Compounds H001, T001, and D001 were co-deposited on the hole transport layer at a weight ratio of 70:29.5:0.5 to form an emission layer having a thickness of 300 Å. Compound ET-1 and LiQ were co-deposited on the emission layer at a weight ratio of 50:50 to form an electron transport layer having a thickness of 310 Å. LiQ was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and Mg and Ag (at a weight ratio of 130:10) were co-deposited on the electron injection layer to form a cathode having a thickness of 130 Å, thereby completing the manufacture of an organic light-emitting device.

## Examples 2 to 11 and Comparative Examples 1 to 5

20 [0207] Organic light-emitting devices were manufactured in the same manner as in Example 1, except that Compounds shown in Table 1 were each utilized in forming an emission layer.

## Evaluation Example

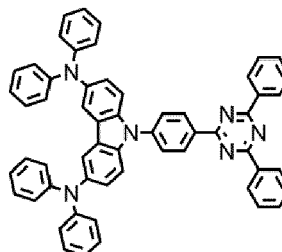
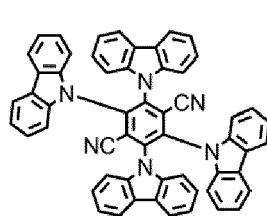
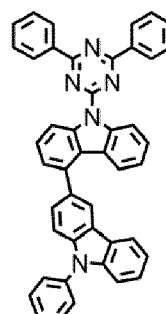
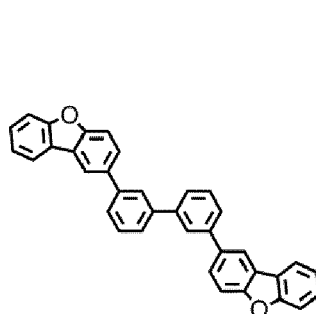
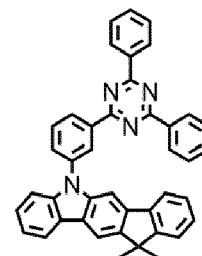
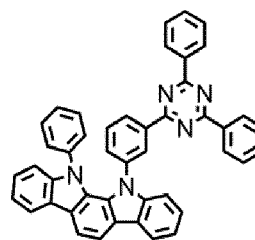
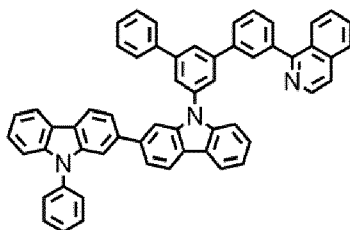
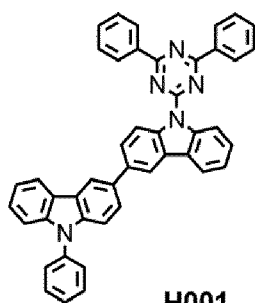
25 [0208] The current efficiency and lifespan of the organic light-emitting devices manufactured according to Examples 1 to 11 and Comparative Examples 1 to 5 were measured at 10 mA/cm<sup>2</sup> by utilizing Keithley SMU 236 and a luminance meter PR650, and results thereof are shown in Table 1. The lifespan represents an amount of time that lapsed when luminance was 95 % of the initial luminance (100 %). In addition, the lifespan was expressed with a relative value with respect to Comparative Example 1. That is, the lifespan was a relative value calculated utilizing the lifespan value of Comparative Example 1 as 100%.

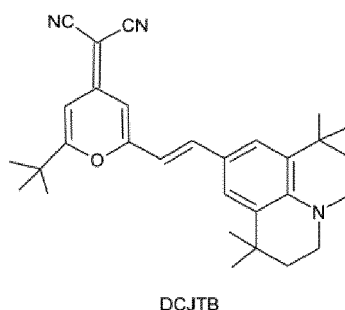
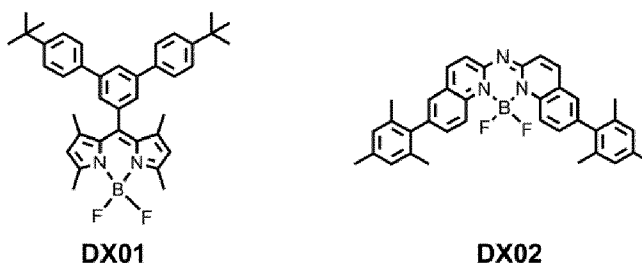
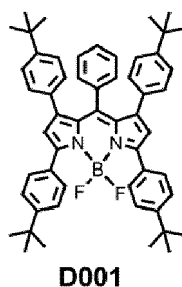
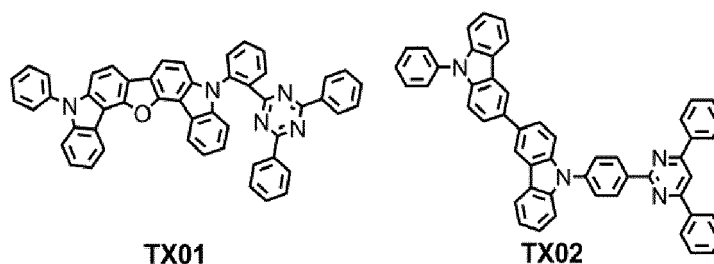
Table 1

|    | Emission layer        |                 |                |  | Emission color | Efficiency (cd/A) | Lifespan (%) |     |
|----|-----------------------|-----------------|----------------|--|----------------|-------------------|--------------|-----|
|    | First compound        | Second compound | Third compound | Weight ratio (first compound: second compound: third compound) |                |                   |              |     |
| 35 | Example 1             | H001            | T001           | D001   | 70:29.5:0.5    | Red               | 20.2         | 180 |
| 40 | Example 2             | H001            | T001           | D001   | 80:19.5:0.5    | Red               | 21.3         | 165 |
|    | Example 3             | H001            | T001           | D001   | 70:29:1        | Red               | 19.0         | 170 |
|    | Example 4             | H002            | T001           | D001   | 70:29.5:0.5    | Red               | 19.5         | 180 |
| 45 | Example 5             | H002            | T001           | D001   | 80:19.5:0.5    | Red               | 20.1         | 170 |
|    | Example 6             | H003            | T001           | D001   | 70:29.5:0.5    | Red               | 21.0         | 195 |
|    | Example 7             | H003            | T001           | D001   | 80:19.5:0.5    | Red               | 22.7         | 170 |
|    | Example 8             | H004            | T001           | D001   | 70:29.5:0.5    | Red               | 21.3         | 190 |
| 50 | Example 9             | H004            | T001           | D001   | 80:19.5:0.5    | Red               | 22.0         | 185 |
|    | Example 10            | H001            | T002           | D001   | 70:29.5:0.5    | Red               | 22.5         | 165 |
|    | Example 11            | H001            | T002           | D001   | 80:19.5:0.5    | Red               | 23.6         | 150 |
| 55 | Comparative Example 1 | H001            | T001           | DCJTB  | 70:29.5:0.5    | Red               | 7.1          | 100 |

(continued)

|                       | Emission layer |                 |                |  | Emission color  | Efficiency (cd/A) | Lifespan (%) |
|-----------------------|----------------|-----------------|----------------|--|-----------------|-------------------|--------------|
|                       | First compound | Second compound | Third compound | Weight ratio (first compound: second compound: third compound) |                 |                   |              |
| Comparative Example 2 | H001           | T001            | -              | 70:30  | yellowish green | 28                | 30           |
| Comparative Example 3 | H001           | -               | DCJTB          | 95:5   | Red             | 2.8               | 110          |
| Comparative Example 4 | HX01           | TX01            | DX01           | 70:29.5:0.5  | Green           | 32                | 70           |
| Comparative Example 5 | HX02           | TX02            | DX02           | 70:29.5:0.5  | Blue            | 5.2               | 7            |





[0209] Referring to Table 1, it is confirmed that the current efficiency and lifespan of the organic light-emitting devices of Examples 1 to 11 are better (e.g., more excellent) than those of the organic light-emitting devices of Comparative Examples 1 to 5. For example, it is confirmed that the organic light-emitting devices of Examples 1 to 3 have significantly improved lifespan while maintaining a similar or improved current efficiency.

[0210] An organic light-emitting device according to an embodiment may have high efficiency and a long lifespan.

[0211] Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list. Further, the use of "may" when describing embodiments of the present invention refers to "one or more embodiments of the present invention." Also, the term "exemplary" is intended to refer to an example or illustration.

[0212] It will be understood that when an element or layer is referred to as being "on," "connected to," or "coupled to" another element or layer, it can be directly on, connected to, or coupled to the other element or layer, or one or more intervening elements or layers may be present.

[0213] As used herein, the terms "substantially," "about," and similar terms are used as terms of approximation and not as terms of degree, and are intended to account for the inherent deviations in measured or calculated values that would be recognized by those of ordinary skill in the art. Further, the use of "may" when describing embodiments of the present disclosure refers to "one or more embodiments of the present disclosure." Also, the term "exemplary" is intended

to refer to an example or illustration.

[0214] Also, any numerical range recited herein is intended to comprise all subranges of the same numerical precision subsumed within the recited range. For example, a range of "1.0 to 10.0" is intended to comprise all subranges between (and comprising) the recited minimum value of 1.0 and the recited maximum value of 10.0, that is, having a minimum value equal to or greater than 1.0 and a maximum value equal to or less than 10.0, such as, for example, 2.4 to 7.6. Any maximum numerical limitation recited herein is intended to comprise all lower numerical limitations subsumed therein, and any minimum numerical limitation recited in this specification is intended to comprise all higher numerical limitations subsumed therein. Accordingly, Applicant reserves the right to amend this specification, comprising the claims, to expressly recite any sub-range subsumed within the ranges expressly recited herein.

[0215] It should be understood that embodiments described herein 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.

[0216] While one or more embodiments 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 scope as defined by the following claims, with due account being taken of any equivalents thereof.

## Claims

1. An organic light-emitting device comprising:

a first electrode;

a second electrode; and

an organic layer between the first electrode and the second electrode,

wherein the organic layer comprises an emission layer,

the emission layer comprises a first compound, a second compound, and a third compound,

the first compound is represented by Formula 1,

the second compound is represented by Formula 2,

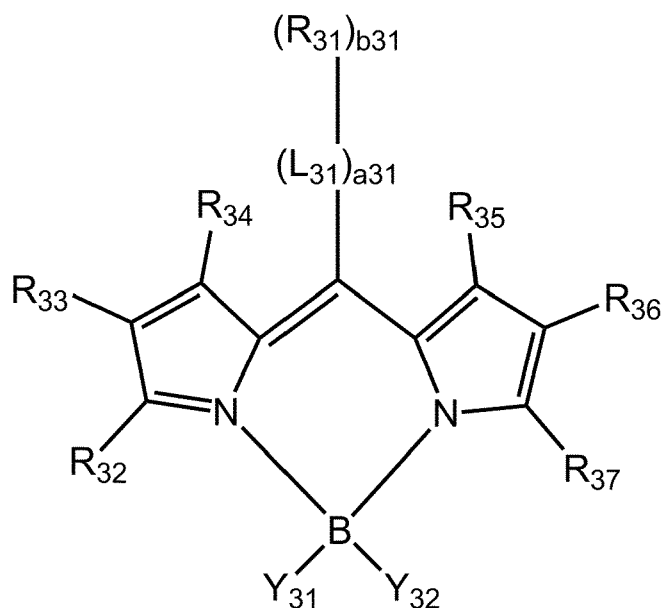
the third compound is represented by Formula 3, and

the first compound and the second compound are different from each other:

Formula 1  $(Y_{11})_{c11}-(L_{11})_{a11}-(Y_{12})_{c12}$

Formula 2  $(Y_{21})_{c21}-(L_{21})_{a21}-(Y_{22})_{c22}$

Formula 3



wherein, in Formulae 1 to 3,

$L_{11}$  is selected from:

a  $\pi$  electron-depleted nitrogen-free cyclic group; and

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$ ,

$a_{11}$  is selected from 0, 1, 2, and 3,

$Y_{12}$  is selected from:

-F, a cyano group, and a  $\pi$  electron-depleted nitrogen-containing cyclic group;

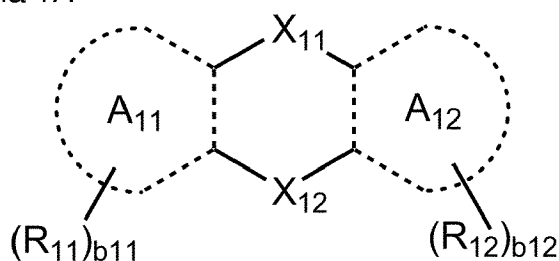
a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic group, each substituted with at least one selected from -F and a cyano group; and

a  $\pi$  electron-depleted nitrogen-containing cyclic group substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic group,

$c_{11}$  and  $c_{12}$  are each independently selected from 1, 2, and 3,

$Y_{11}$  is a group represented by Formula 1A,

Formula 1A



$X_{11}$  is selected from a single bond,  $\text{N}(\text{R}_{13})$ , O, and S,

$X_{12}$  is selected from a single bond,  $\text{N}(\text{R}_{14})$ , O, and S,

$X_{11}$  and  $X_{12}$  are not a single bond at the same time,

$A_{11}$  and  $A_{12}$  are each independently a  $\pi$  electron-depleted nitrogen-free cyclic group,

$R_{11}$  to  $R_{14}$  are each independently selected from:

a binding site, hydrogen, deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$ ;

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$ ; and

a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with a  $\pi$  electron-depleted nitrogen-free cyclic group that is substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ , wherein one selected from  $R_{11}$  to  $R_{14}$  is a binding site,

$b_{11}$  and  $b_{12}$  are each independently selected from 1, 2, 3, 4, 5, and 6,

$L_{21}$  is selected from a substituted or unsubstituted  $C_5$ - $C_{60}$  carbocyclic group and a substituted or unsubstituted  $C_1$ - $C_{60}$  heterocyclic group,

$a_{21}$  is selected from 0, 1, 2, and 3,

$Y_{22}$  is selected from:

-F, a cyano group, and a  $\pi$  electron-depleted nitrogen-containing cyclic group;

a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic group, each substituted with at least one selected from -F and a cyano group; and

a  $\pi$  electron-depleted nitrogen-containing cyclic group substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-depleted nitrogen-free cyclic group,

$c_{21}$  and  $c_{22}$  are each independently selected from 1, 2, 3, 4, 5, and 6,

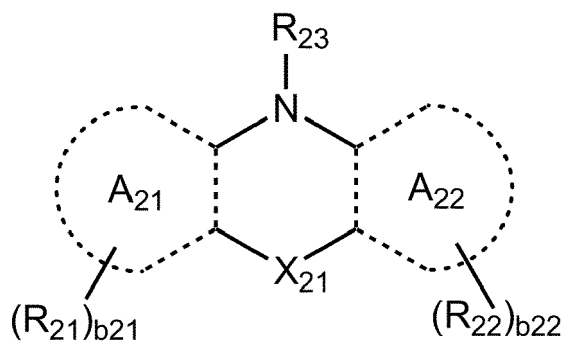
$Y_{21}$  is a group represented by one selected from Formulae 2A to 2C,

Formula 2A

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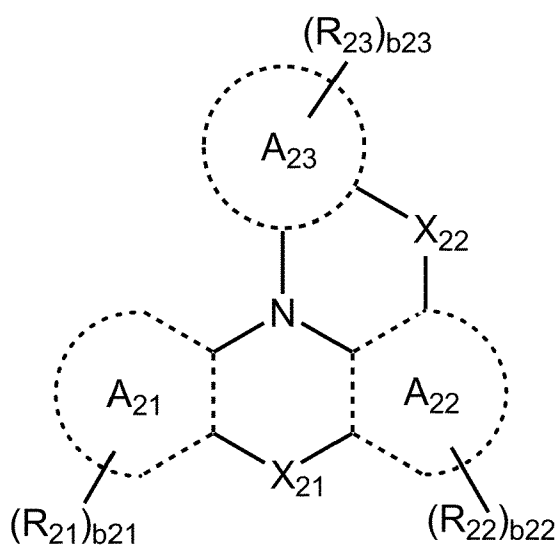
Formula 2B

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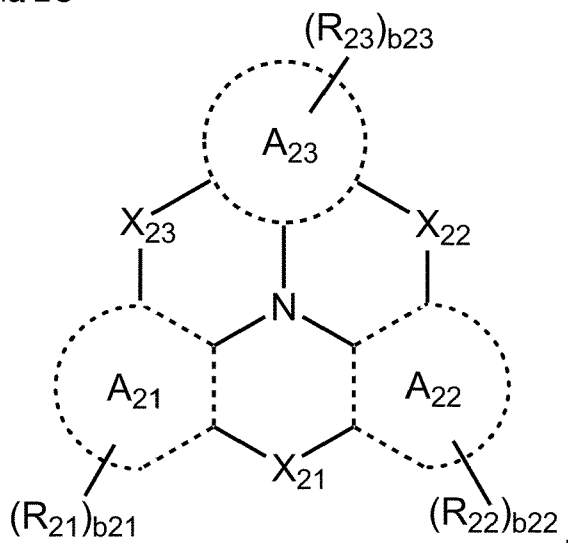
Formula 2C

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$X_{21}$  is selected from a single bond, N( $R_{24}$ ), O, and S,  
 $X_{22}$  is selected from a single bond, N( $R_{25}$ ), O, and S,

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$X_{23}$  is selected from a single bond,  $N(R_{26})$ , O, and S,  
 $A_{21}$  to  $A_{23}$  are each independently a  $\pi$  electron-depleted nitrogen-free cyclic group,  
 $R_{21}$  to  $R_{26}$  are each independently selected from:

5 a binding site, hydrogen, deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group,  $-N(Q_1)(Q_2)$ , and  $-Si(Q_1)(Q_2)(Q_3)$ ;  
a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group,  $-N(Q_{31})(Q_{32})$ , and  $-Si(Q_{31})(Q_{32})(Q_{33})$ ; and  
10 a  $\pi$  electron-depleted nitrogen-free cyclic group substituted with a  $\pi$  electron-depleted nitrogen-free cyclic group that is substituted with at least one selected from deuterium, a  $C_1$ - $C_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group,  $-N(Q_{21})(Q_{22})$ , and  $-Si(Q_{21})(Q_{22})(Q_{23})$ , wherein one selected from  $R_{21}$  to  $R_{24}$  in Formula 2A is a binding site, one selected from  $R_{21}$  to  $R_{25}$  in Formula 2B is a binding site, and one selected from  $R_{21}$  to  $R_{26}$  in Formula 2C is a binding site,  
15  $b_{21}$  to  $b_{23}$  are each independently selected from 1, 2, 3, 4, 5, and 6,  
 $L_{31}$  is selected from a substituted or unsubstituted  $C_5$ - $C_{60}$  carbocyclic group and a substituted or unsubstituted  $C_1$ - $C_{60}$  heterocyclic group,  
 $a_{31}$  is selected from 0, 1, 2, and 3,  
20  $R_{31}$  to  $R_{37}$  are each independently selected from hydrogen, 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 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 substituted or unsubstituted  $C_1$ - $C_{60}$  alkoxy group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkenyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  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  $C_1$ - $C_{60}$  heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed C8-C60 polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group,  $-Si(Q_1)(Q_2)(Q_3)$ ,  $-B(Q_1)(Q_2)$ ,  $-N(Q_1)(Q_2)$ ,  $-P(Q_1)(Q_2)$ ,  $-C(=O)(Q_1)$ ,  $-S(=O)(Q_1)$ ,  $-S(=O)_2(Q_1)$ ,  $-P(=O)(Q_1)(Q_2)$ , and  $-P(=S)(Q_1)(Q_2)$ , wherein  $R_{31}$  to  $R_{37}$  are optionally linked to form a substituted or unsubstituted  $C_5$ - $C_{60}$  carbocyclic group or a substituted or unsubstituted  $C_1$ - $C_{60}$  heterocyclic group,  
25  $b_{31}$  is selected from 1, 2, 3, 4, 5, and 6,  
 $Y_{31}$  and  $Y_{32}$  are each independently selected from -F, -Cl, -Br, -I, a substituted or unsubstituted  $C_1$ - $C_{60}$  alkyl group, a substituted or unsubstituted  $C_1$ - $C_{60}$  alkoxy group, a substituted or unsubstituted  $C_6$ - $C_{60}$  aryl group, and a substituted or unsubstituted  $C_6$ - $C_{60}$  aryloxy group, wherein  $Y_{31}$  and  $Y_{32}$  are optionally linked to form a substituted or unsubstituted  $C_5$ - $C_{60}$  carbocyclic group or a substituted or unsubstituted  $C_1$ - $C_{60}$  heterocyclic group, and  
30  $Q_1$  to  $Q_3$ ,  $Q_{21}$  to  $Q_{23}$ , and  $Q_{31}$  to  $Q_{33}$  are each independently selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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  $C_1$ - $C_{10}$  heterocycloalkyl group, a  $C_3$ - $C_{10}$  cycloalkenyl group, a  $C_1$ - $C_{10}$  heterocycloalkenyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_6$ - $C_{60}$  aryloxy group, a  $C_6$ - $C_{60}$  arylthio group, a  $C_1$ - $C_{60}$  heteroaryl group, a  $C_1$ - $C_{60}$  hetero aryloxy group, a  $C_1$ - $C_{60}$  hetero arylthio group, a monovalent non-aromatic condensed C8-C60 polycyclic group, a monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, a biphenyl group, and a terphenyl group.  
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### 2. The organic light-emitting device of claim 1, wherein

$L_{11}$  is selected from:

55 a benzene group, a naphthalene group, a phenalene group, an anthracene group, a fluoranthene group, a triphenylene group, a phenanthrene group, a pyrene group, a chrysene group, a perylene group, a fluorene group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group; and

a benzene group, a naphthalene group, a phenalene group, an anthracene group, a fluoranthene group, a triphenylene group, a phenanthrene group, a pyrene group, a chrysene group, a perylene group, a fluorene group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group, each substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, and L<sub>21</sub> and L<sub>31</sub> are each independently selected from:

a benzene group, a naphthalene group, a phenalene group, an anthracene group, a fluoranthene group, a triphenylene group, a phenanthrene group, a pyrene group, a chrysene group, a perylene group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a benzoisoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a benzoquinoxaline group, a quinazoline group, a benzoquinazoline group, a fluorene group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group; and a benzene group, a naphthalene group, a phenalene group, an anthracene group, a fluoranthene group, a triphenylene group, a phenanthrene group, a pyrene group, a chrysene group, a perylene group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a benzoisoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a benzoquinoxaline group, a quinazoline group, a benzoquinazoline group, a fluorene group, a carbazole group, a dibenzofuran group, and a dibenzothiophene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono 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 biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group.

3. The organic light-emitting device of claim 1 or 2, wherein R<sub>11</sub> to R<sub>14</sub> are each independently selected from:

a binding site, hydrogen, deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>); a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, each substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, and -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>); and a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, each substituted with at least one selected from a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group,

a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group that are each substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>),  
 one selected from R<sub>11</sub> to R<sub>14</sub> is a binding site, and  
 Q<sub>1</sub> to Q<sub>3</sub>, Q<sub>21</sub> to Q<sub>23</sub>, and Q<sub>31</sub> to Q<sub>33</sub> are each independently selected from a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group.

4. The organic light-emitting device of any one of claims 1 to 3, wherein  
 Y<sub>12</sub> is selected from:

-F, a cyano group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group;

a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from -F and a cyano group; and

a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group.

5. The organic light-emitting device of any one of the preceding claims, wherein:

(i) c<sub>11</sub> and c<sub>12</sub> are each 1; and/or

(ii) X<sub>21</sub> is a single bond, X<sub>22</sub> is a single bond, and X<sub>23</sub> is a single bond; and/or

(iii) Y<sub>21</sub> is a group represented by Formula 2A; and/or

(iv) X<sub>11</sub> is selected from N(R<sub>13</sub>), O, and S, and X<sub>12</sub> is a single bond; and/or

(v) c<sub>21</sub> and c<sub>22</sub> are each independently selected from 1, 2, and 3.



group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group; and

$-B(Q_1)(Q_2)$  and  $-N(Q_1)(Q_2)$ , and

$Q_1$  and  $Q_2$  are each independently selected from:

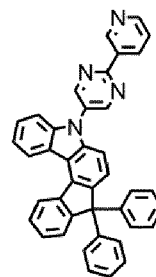
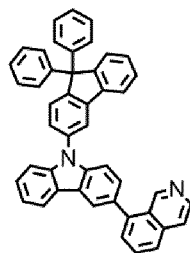
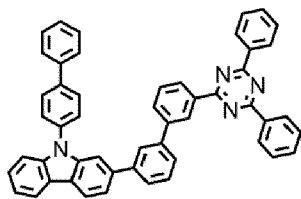
hydrogen, deuterium, and a  $C_1$ - $C_{20}$  alkyl group;

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group; and a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from deuterium, a  $C_1$ - $C_{20}$  alkyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinolinyl group, an isoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazolyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group.

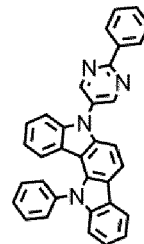
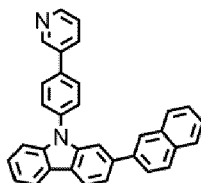
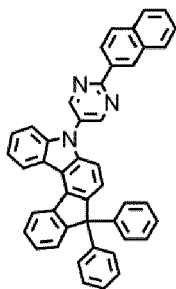
8. The organic light-emitting device of any one of the preceding claims, wherein  $Y_{31}$  and  $Y_{32}$  are each independently selected from -F, -Cl, -Br, -I, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group.
9. The organic light-emitting device of any one of the preceding claims, wherein the first compound is selected from compounds of Group I, the second compound is selected from compounds of Group II, and the third compound is selected from compounds of Group III:

<Group I>

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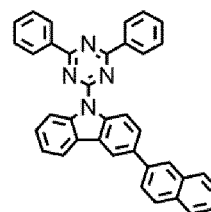
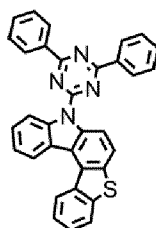
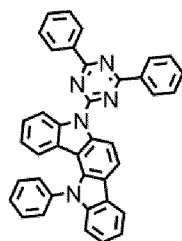


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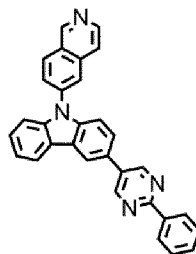
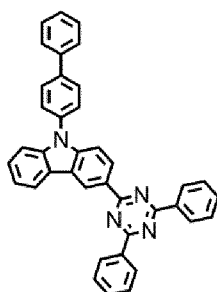
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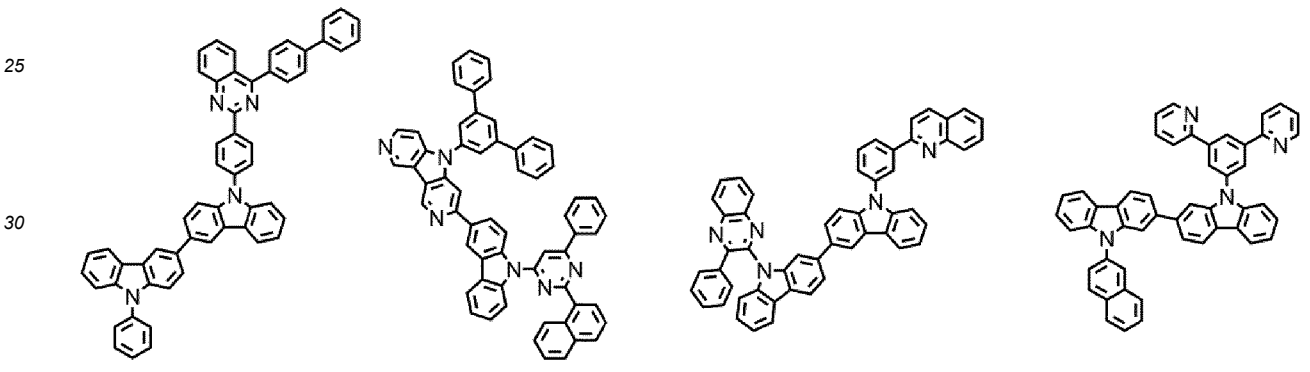
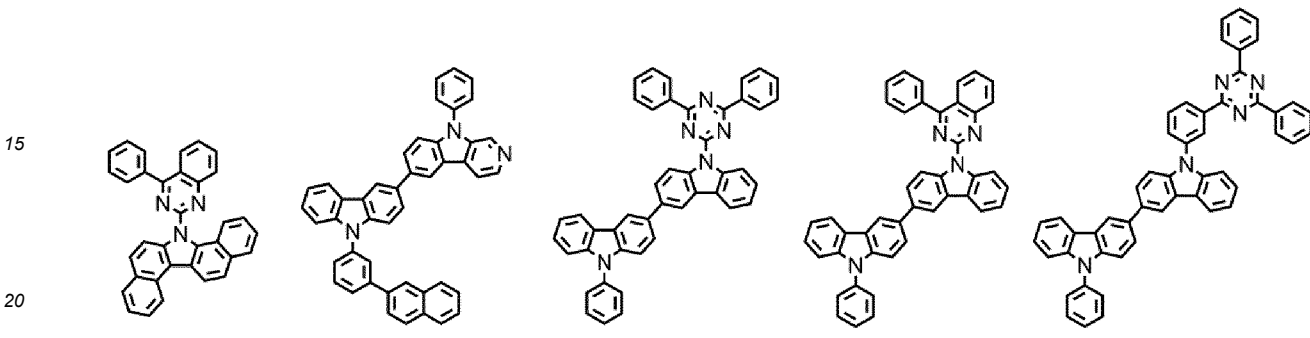
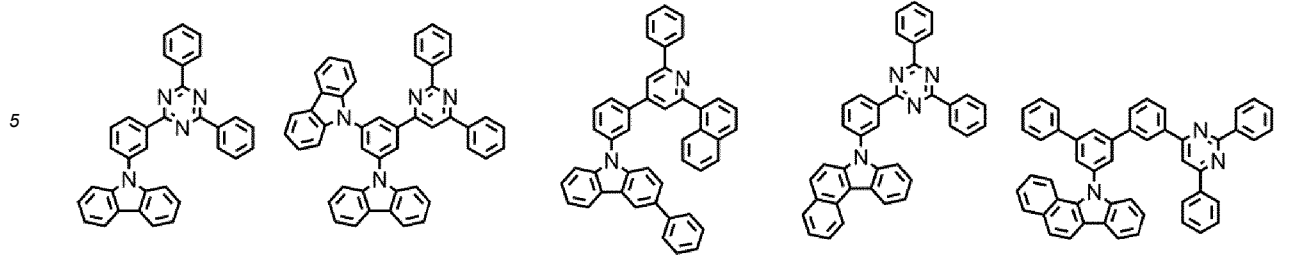


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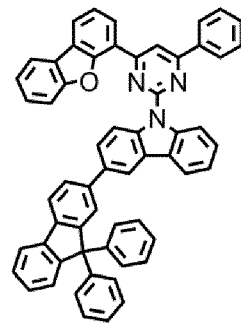
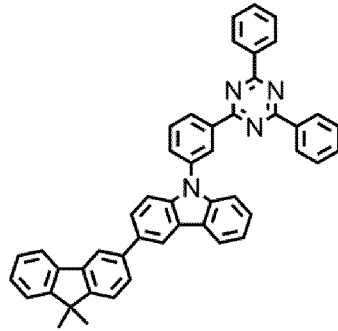
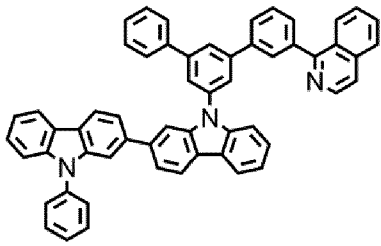
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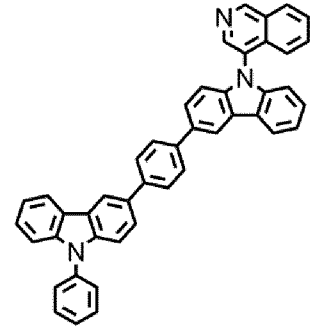
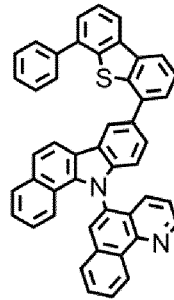
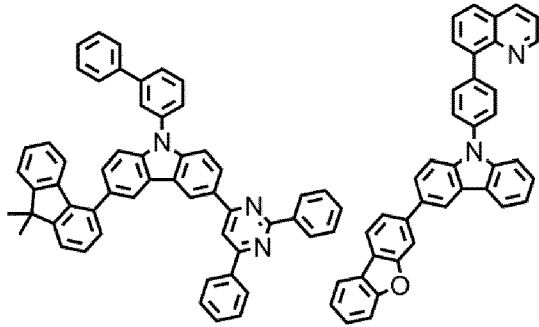


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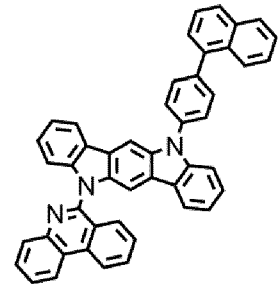
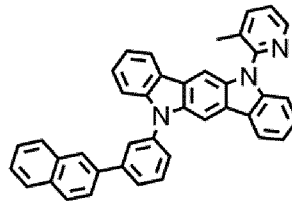
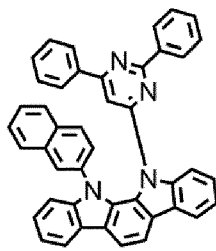
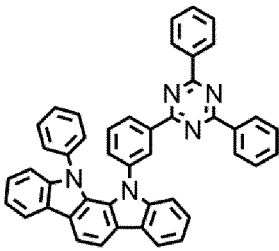
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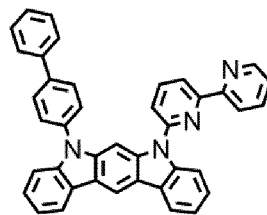
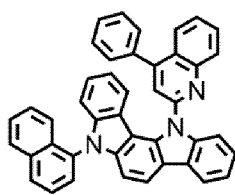
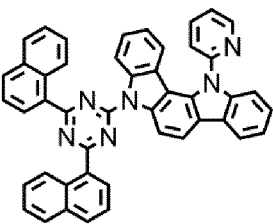
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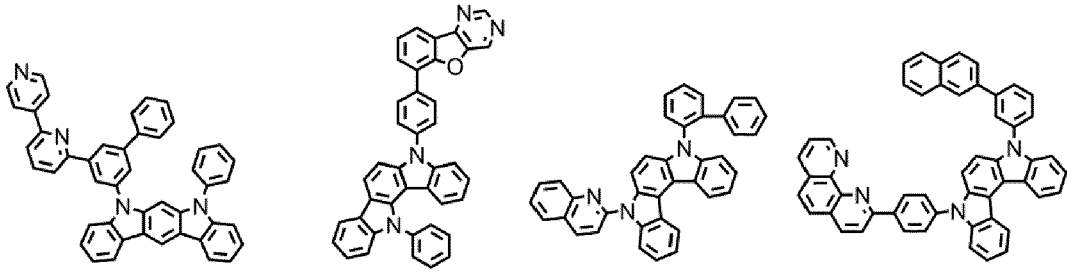
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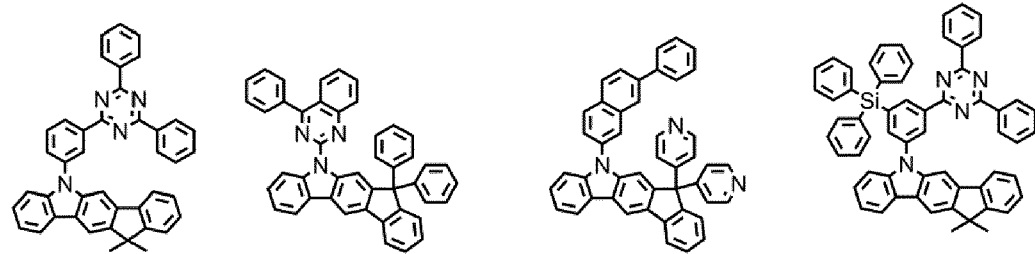
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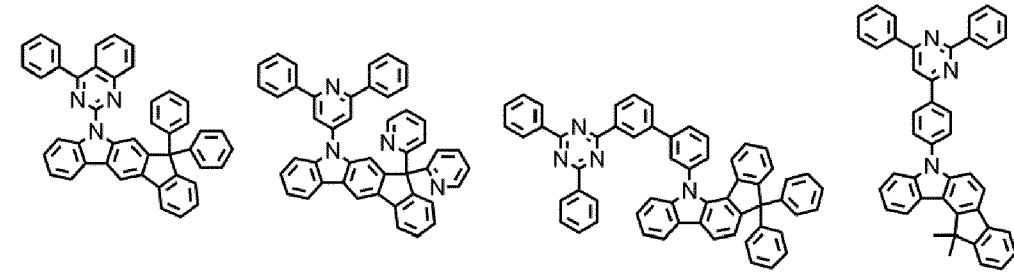


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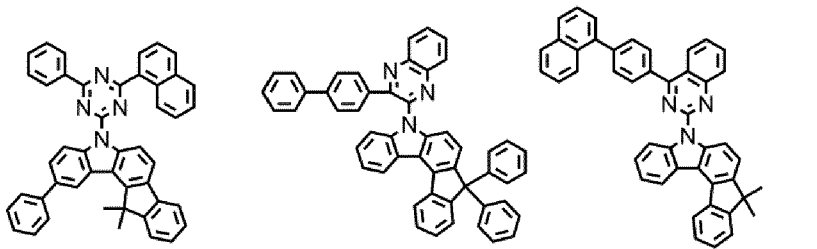
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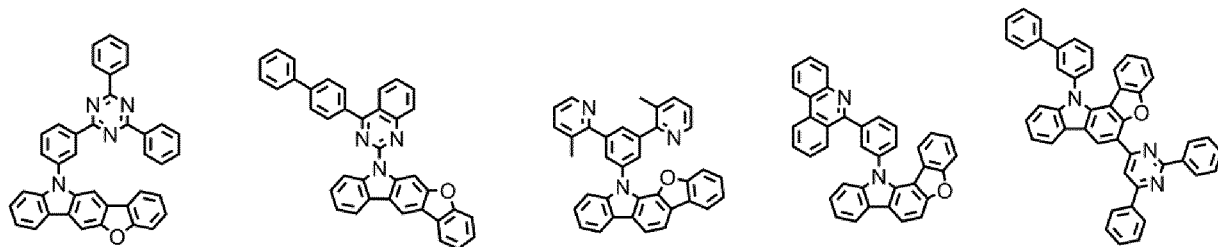
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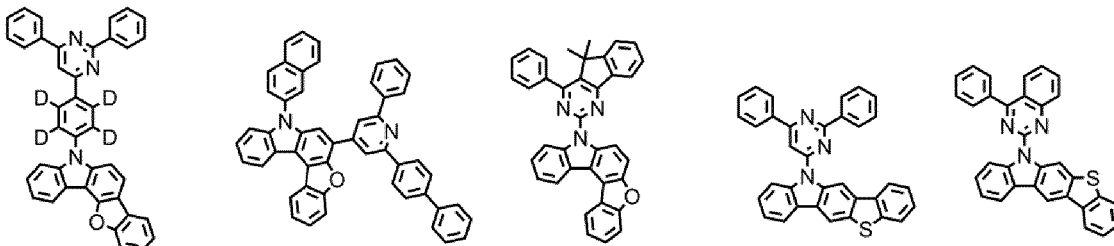
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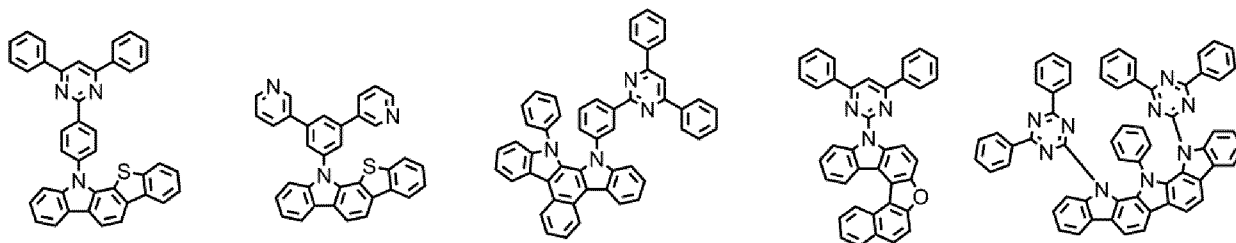
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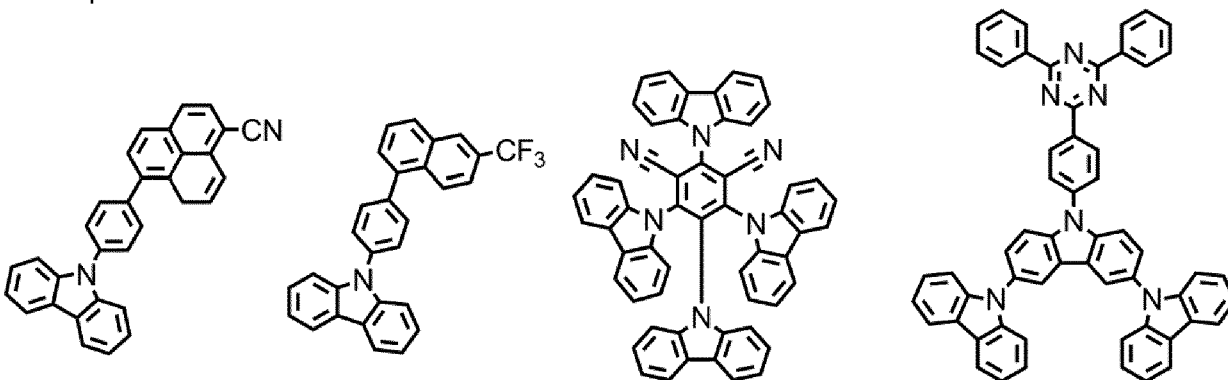
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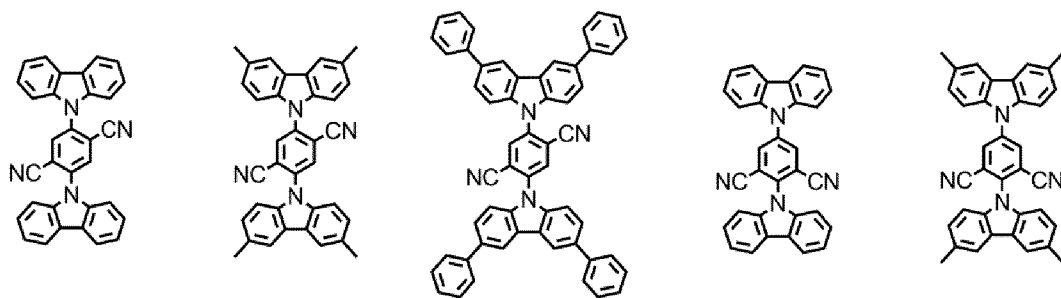
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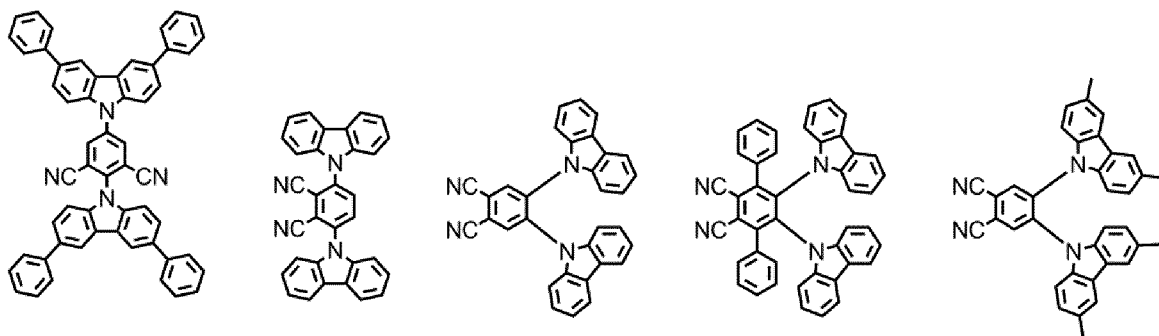
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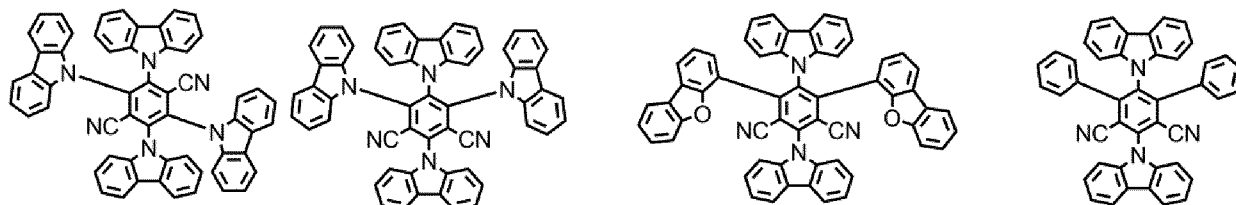


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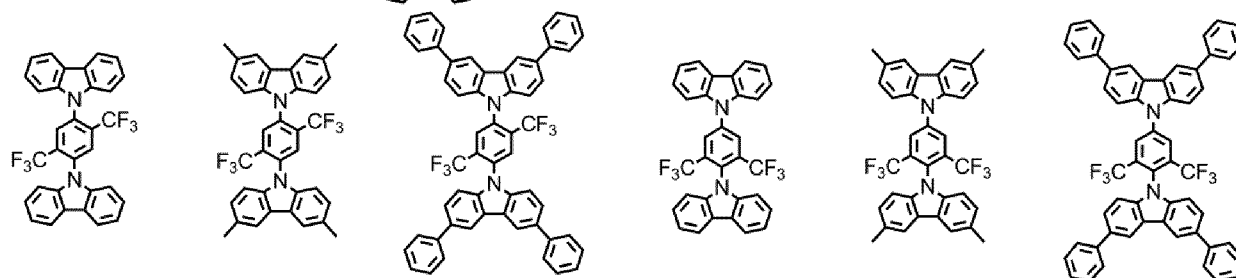
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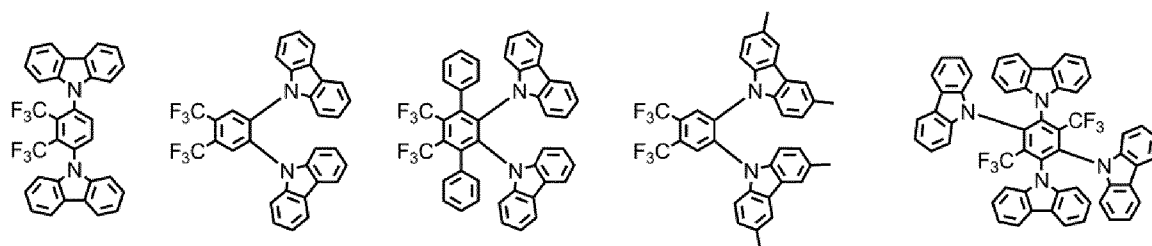
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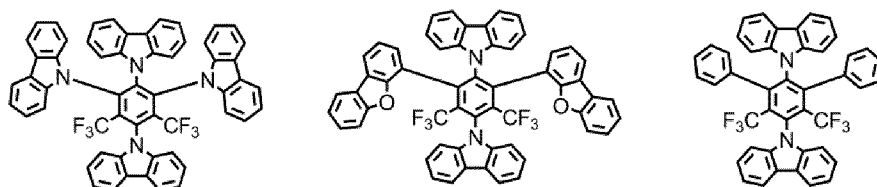
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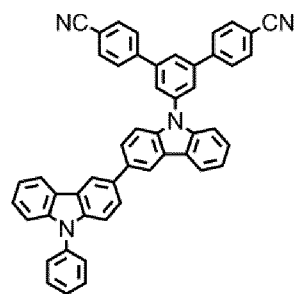
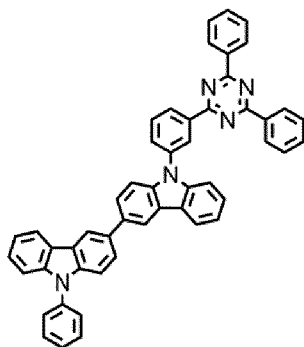
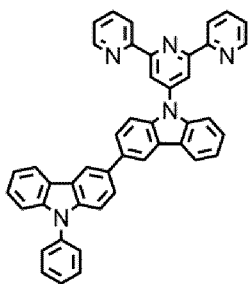
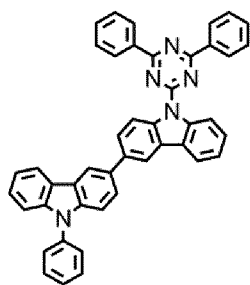
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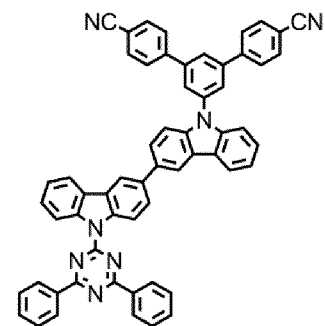
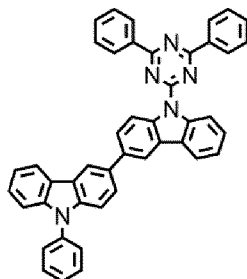
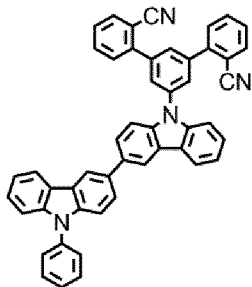
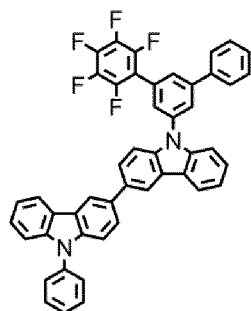
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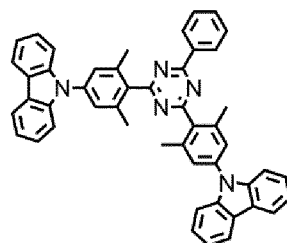
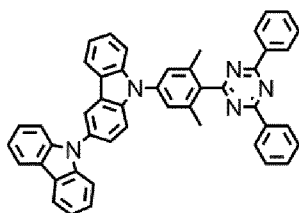
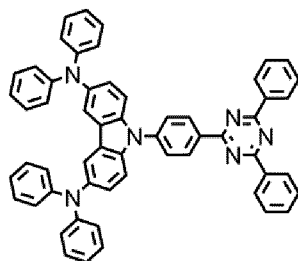
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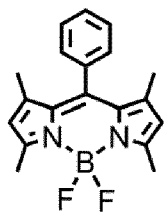
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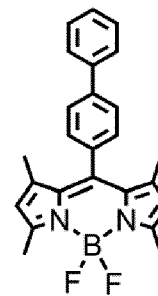
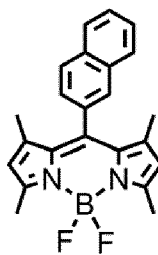
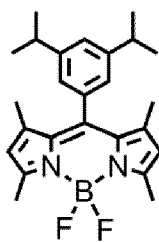
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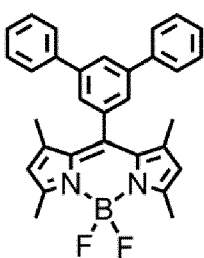
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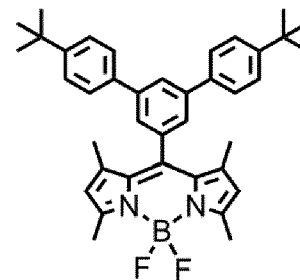
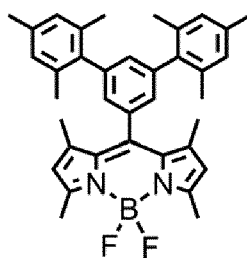
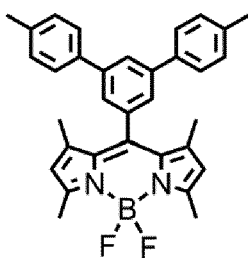
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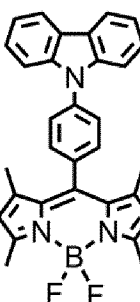
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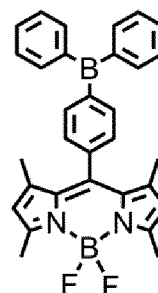
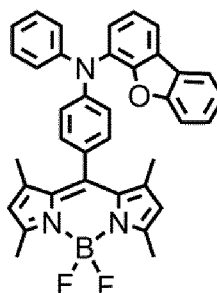
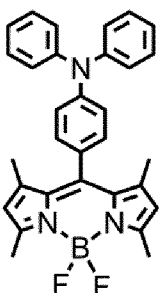
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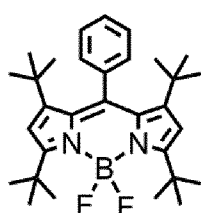


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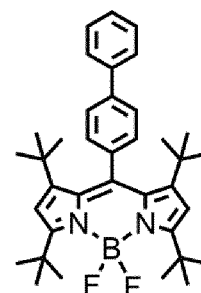
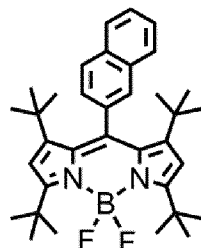
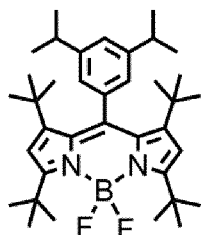


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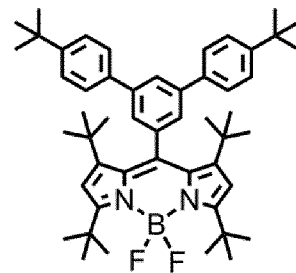
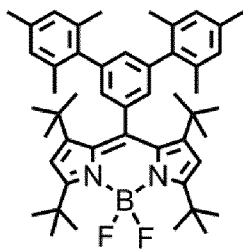
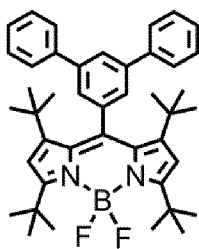
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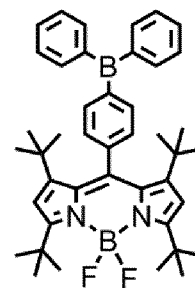
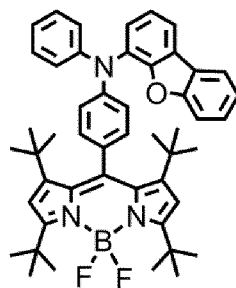
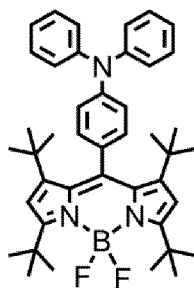
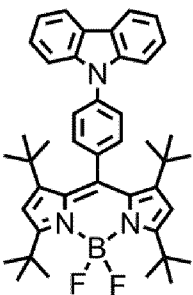
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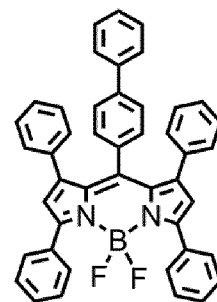
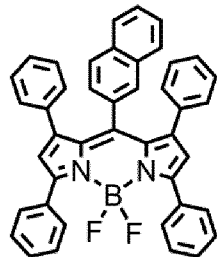
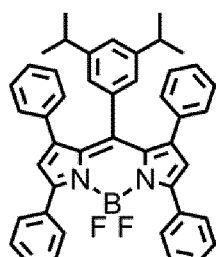
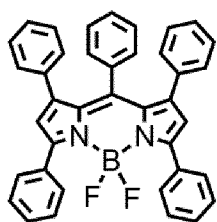
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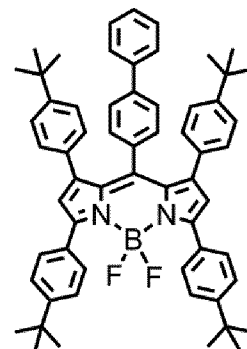
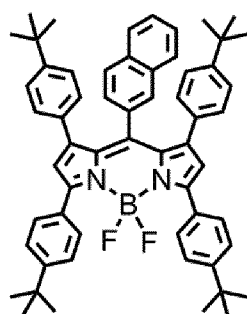
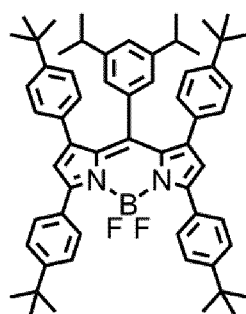
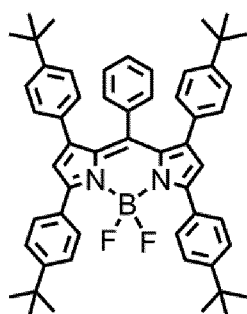
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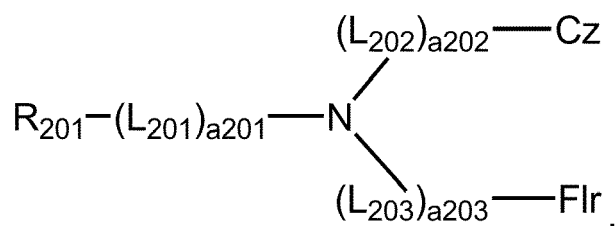
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wherein, in Condition 1,  $\Delta E_{ST}(C2)$  is a difference between a lowest excitation singlet energy level of the second compound ( $E_{S1}(C2)$ ) and a lowest excitation triplet energy level of the second compound ( $E_{T1}(C2)$ ); and/or  
 (ii) the third compound has a maximum emission wavelength in a range of about 520 nm to about 780 nm.

- 5 **11.** The organic light-emitting device of any one of the preceding claims, wherein  
 the organic layer further comprises a hole transport region,  
 the hole transport region is between the first electrode and the emission layer, the hole transport region comprises  
 a first hole transport layer and a second hole transport layer,  
 the first hole transport layer comprises a first hole transport material,  
 10 the second hole transport layer comprises a second hole transport material, and the first hole transport material and  
 the second hole transport material are different from each other.
- 12.** The organic light-emitting device of claim 11, wherein  
 the first hole transport material is represented by Formula 201:

Formula 201

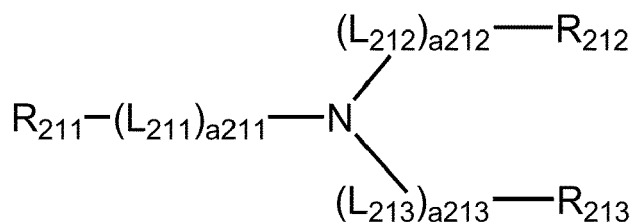


wherein, in Formula 201,

$L_{201}$  to  $L_{203}$  are each independently selected from a substituted or unsubstituted  $C_5-C_{60}$  carbocyclic group and  
 a substituted or unsubstituted  $C_1-C_{60}$  heterocyclic group,  
 30  $a_{201}$  to  $a_{203}$  are each independently selected from 0, 1, 2, and 3,  
 $Cz$  is a substituted or unsubstituted carbazolyl group,  
 $Flr$  is a substituted or unsubstituted fluorenyl group, and  
 $R_{201}$  is selected from a substituted or unsubstituted  $C_3-C_{10}$  cycloalkyl group, a substituted or unsubstituted  
 35  $C_1-C_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $C_3-C_{10}$  cycloalkenyl group, a substituted or un-  
 substituted  $C_1-C_{10}$  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 un-  
 substituted  $C_1-C_{60}$  heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed C8-  
 C60 polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-mem-  
 40 bered heteropolycyclic group.

- 13.** The organic light-emitting device of claim 11 or 12, wherein  
 the second hole transport material is represented by Formula 202:

Formula 202

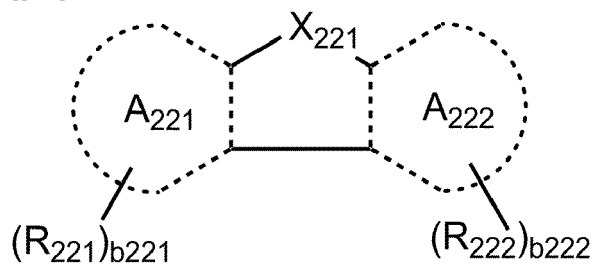


wherein, in Formula 202,

$L_{211}$  to  $L_{213}$  are each independently selected from a substituted or unsubstituted  $C_5-C_{60}$  carbocyclic group and  
 a substituted or unsubstituted  $C_1-C_{60}$  heterocyclic group,  
 55  $a_{211}$  to  $a_{213}$  are each independently selected from 0, 1, 2, and 3,

R<sub>211</sub> to R<sub>213</sub> are each independently selected from a group represented by Formula 202A, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>1</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>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, wherein at least one selected from R<sub>211</sub> to R<sub>213</sub> is a group represented by Formula 202A,

Formula 202A



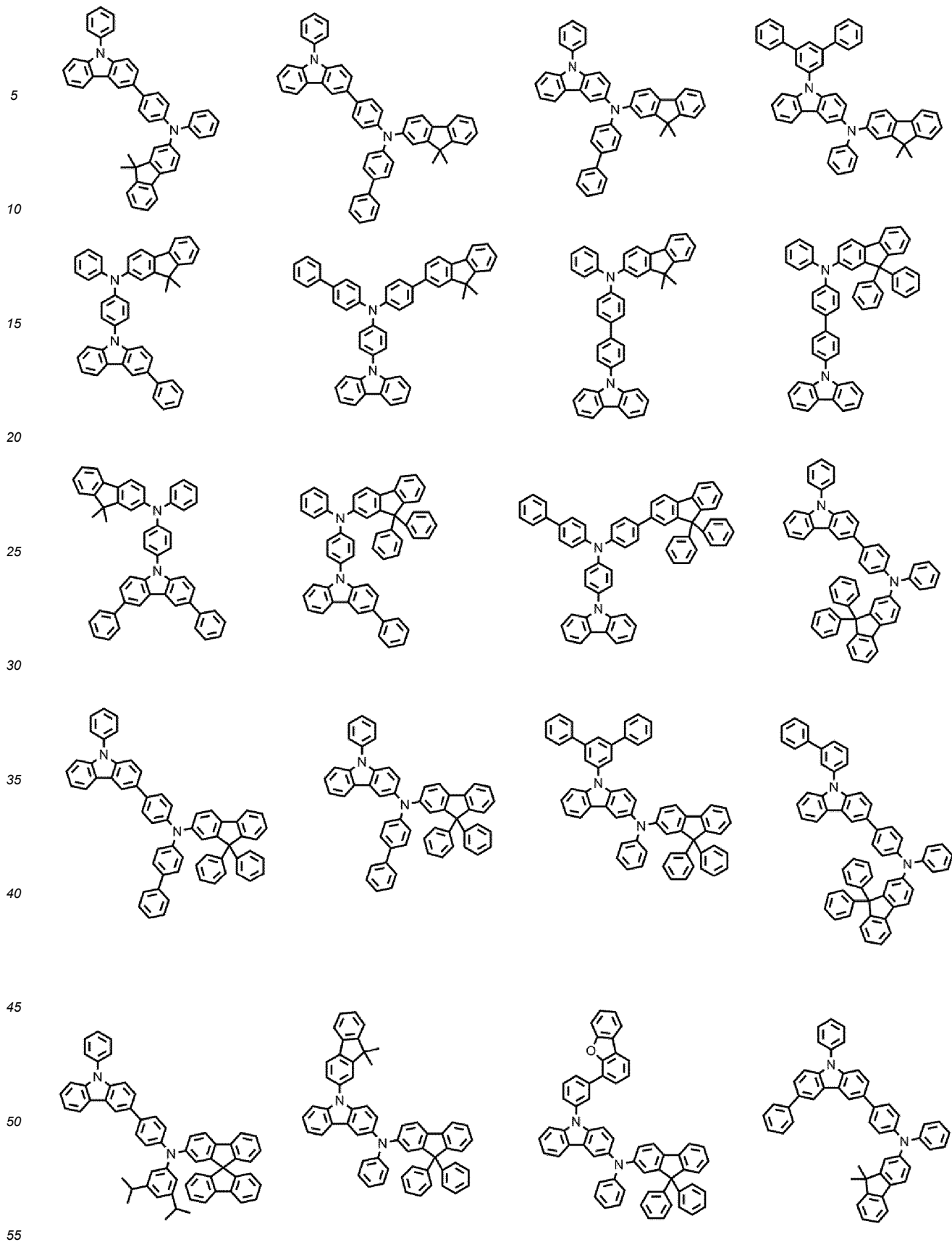
X<sub>221</sub> is selected from N(R<sub>223</sub>), C(R<sub>223</sub>)(R<sub>224</sub>), O, and S,

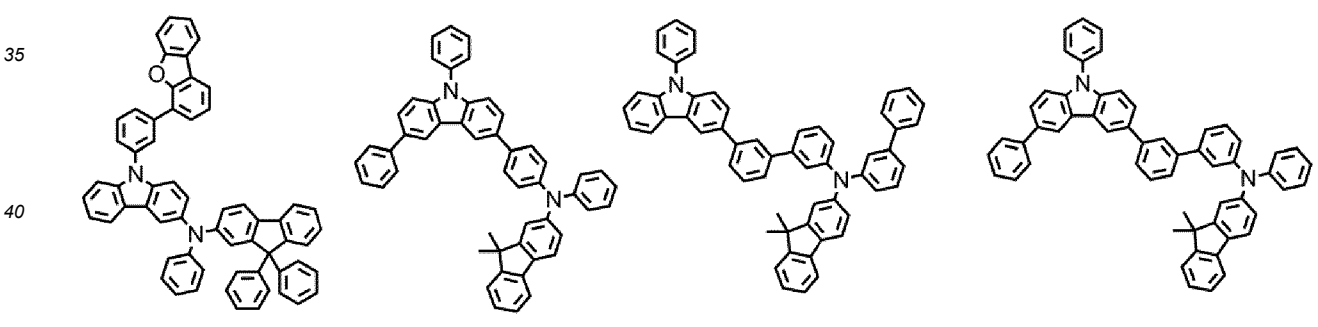
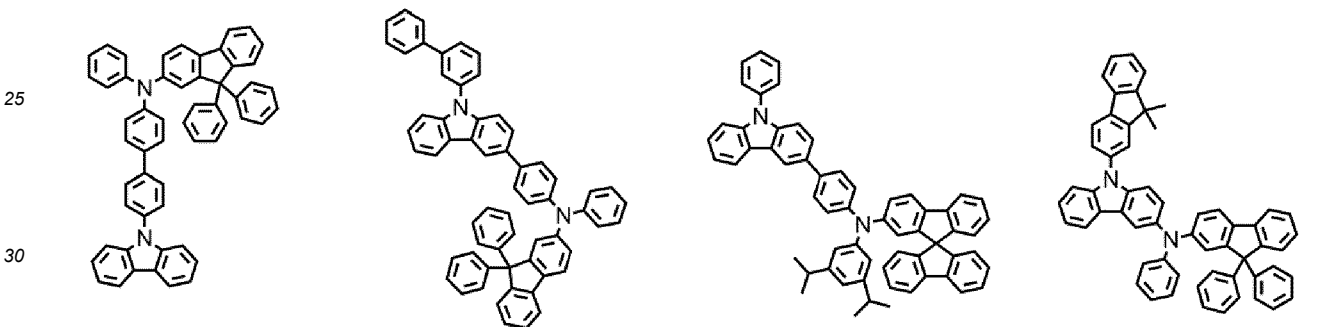
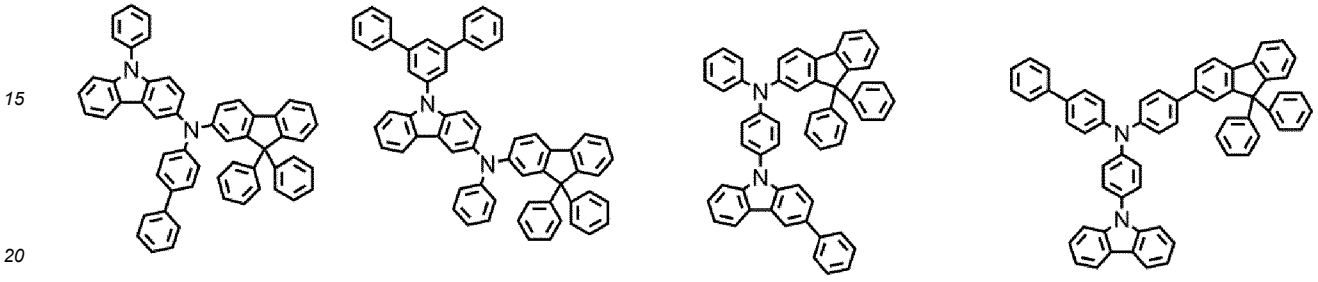
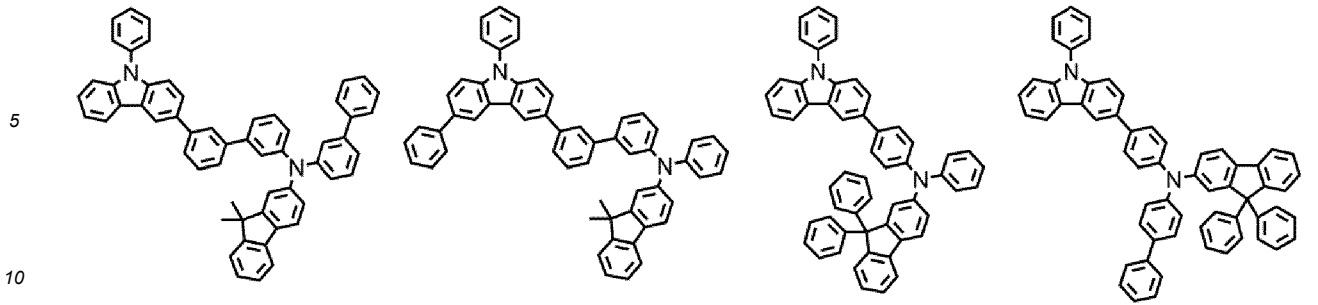
A<sub>221</sub> and A<sub>222</sub> are each independently selected from i) a 6-membered ring, ii) a condensed ring in which two or more 6-membered rings are condensed with each other, and iii) a condensed ring in which at least one 6-membered ring and at least one 5-membered ring are condensed with each other,

R<sub>221</sub> to R<sub>224</sub> are each independently selected from a binding site, hydrogen, 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 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>1</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>1</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>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed C<sub>8</sub>-C<sub>60</sub> polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed 8- to 60-membered heteropolycyclic group, wherein one selected from R<sub>221</sub> to R<sub>224</sub> is a binding site, and b<sub>221</sub> and b<sub>222</sub> are each independently selected from 1, 2, 3, 4, 5, and 6.

14. The organic light-emitting device of any one of claims 11 to 13, wherein the first hole transport material is selected from compounds of Group IV, and the second hole transport material is selected from compounds of Group V:

<Group IV>





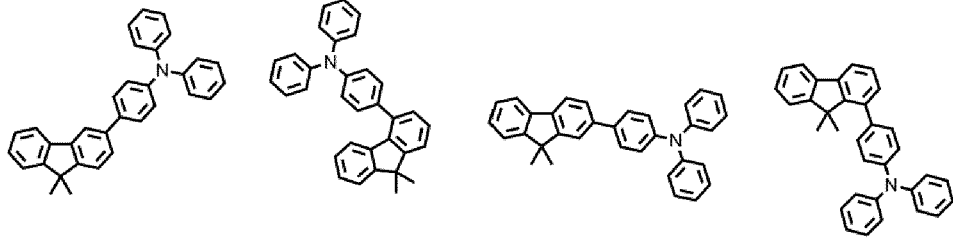
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<Group V>

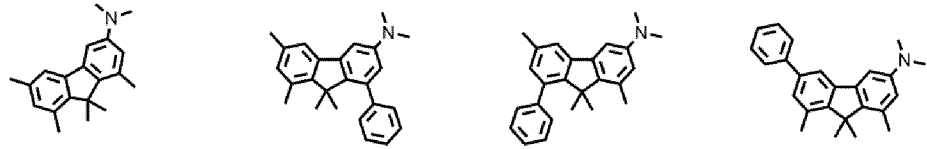
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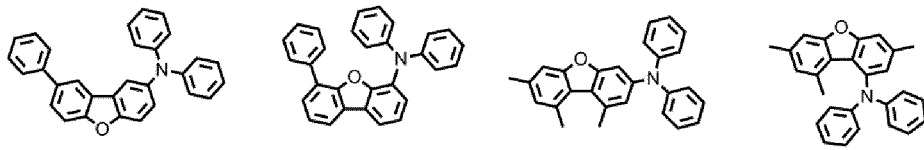
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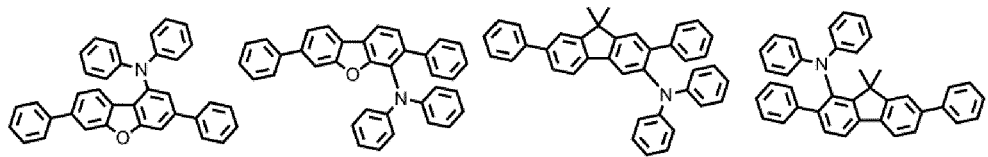
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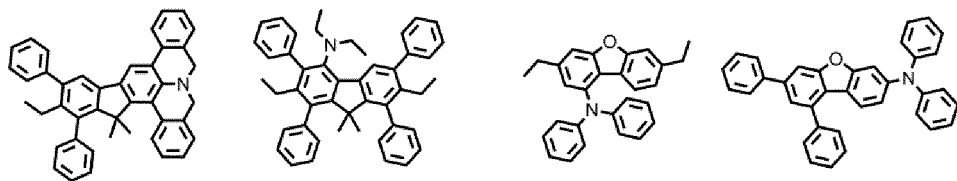


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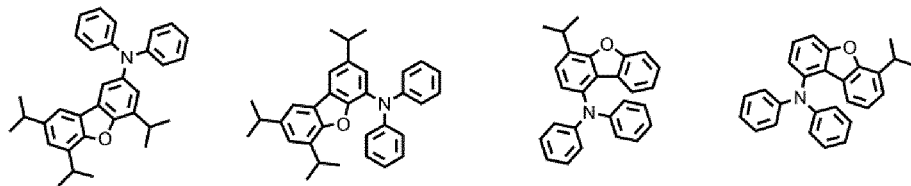
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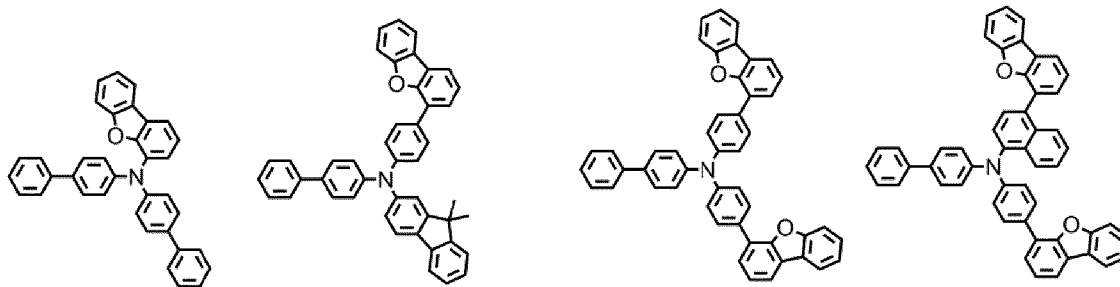


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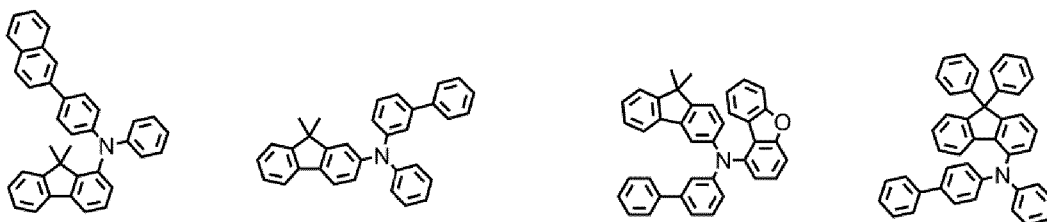
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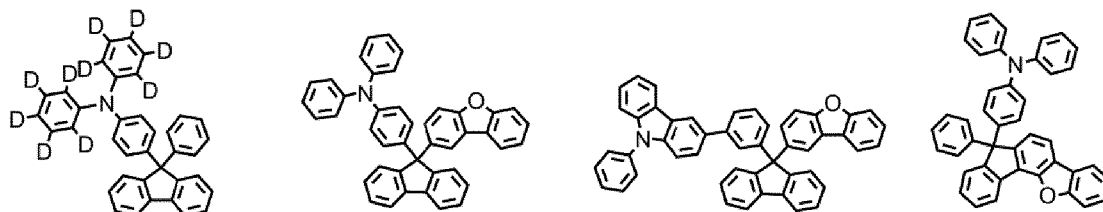
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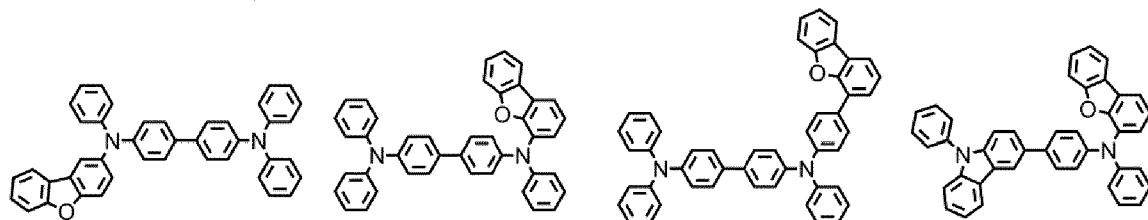
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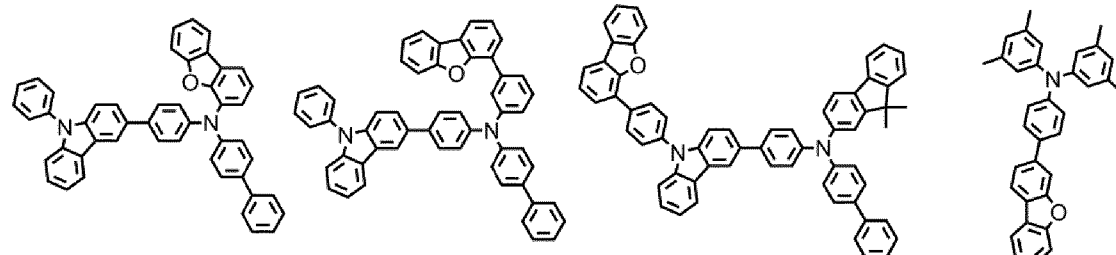


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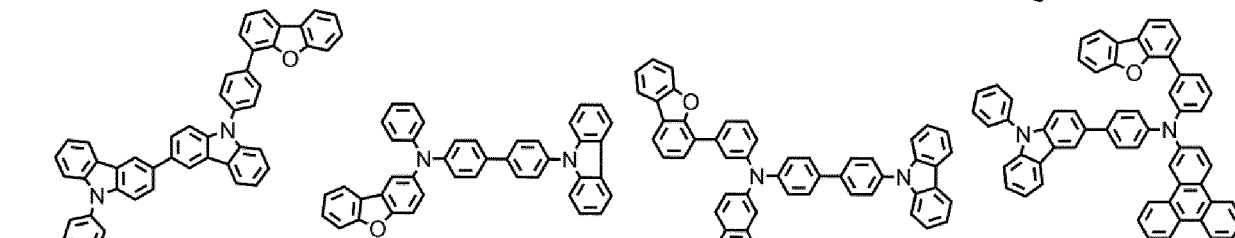


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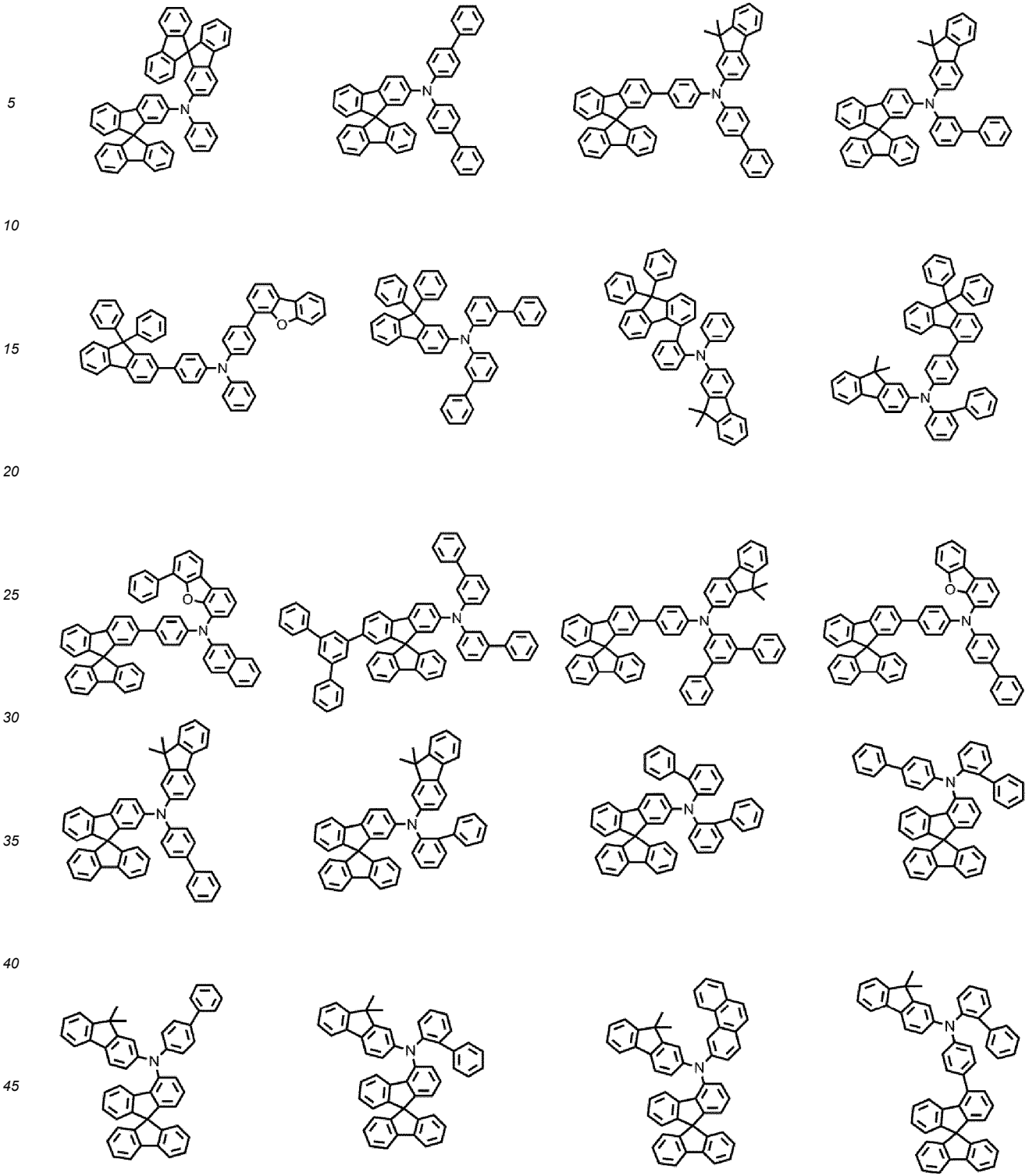


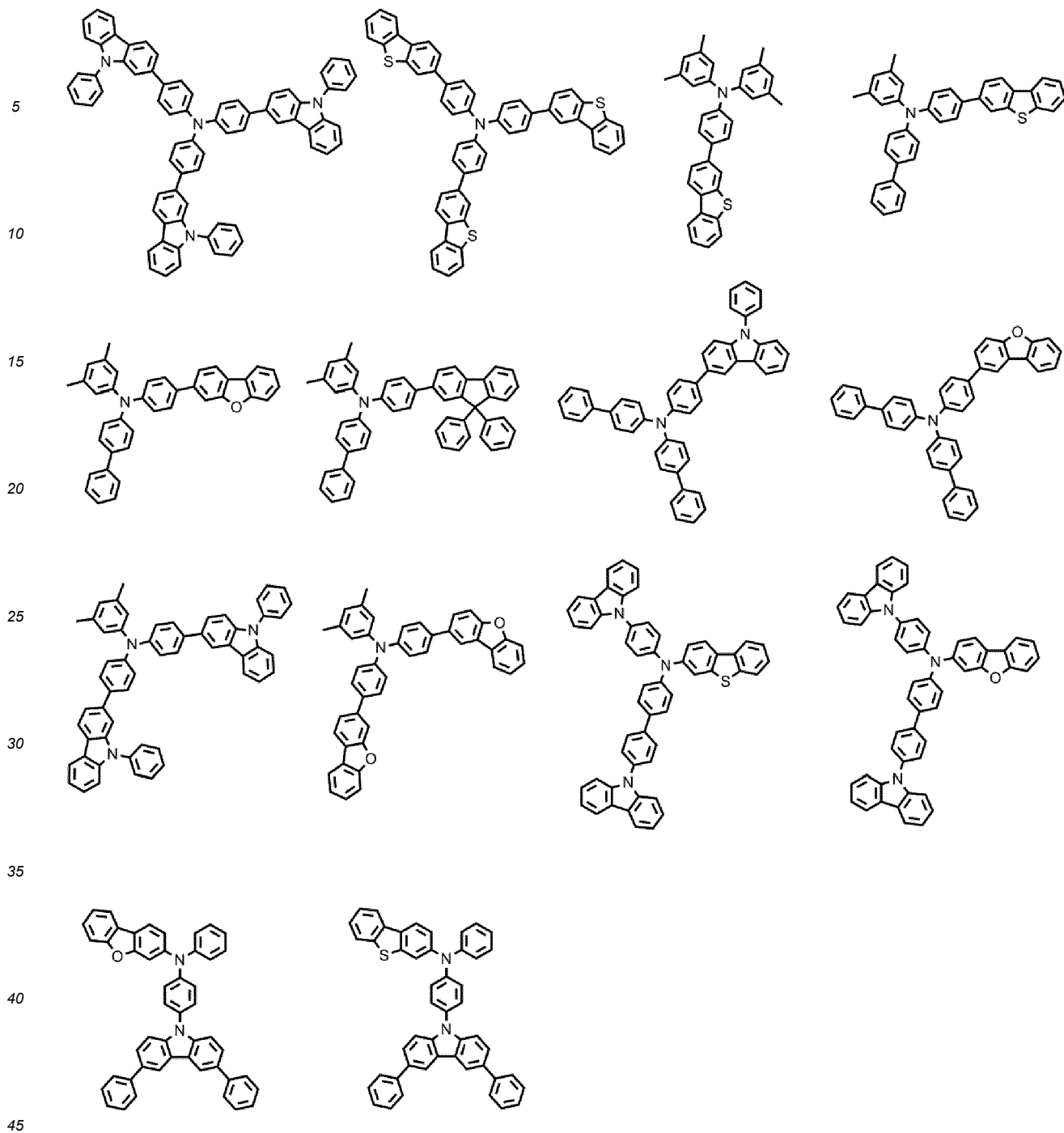
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15. A display apparatus comprising:

50 a thin film transistor comprising a source electrode, a drain electrode, and an active layer; and  
 the organic light-emitting device of any one of claims 1 to 14,  
 wherein the first electrode of the organic light-emitting device is electrically connected to one selected from the  
 source electrode and the drain electrode of the thin film transistor.

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FIG. 1

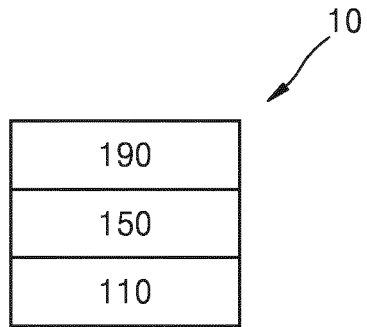


FIG. 2

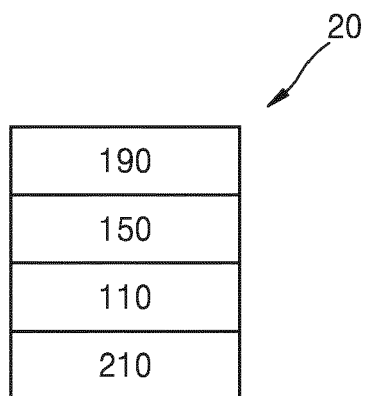


FIG. 3

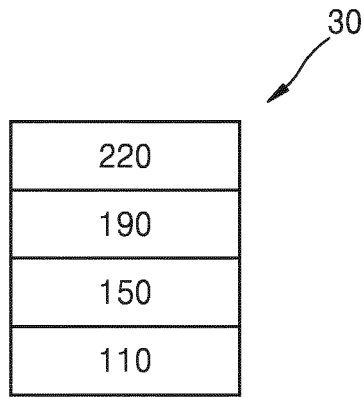
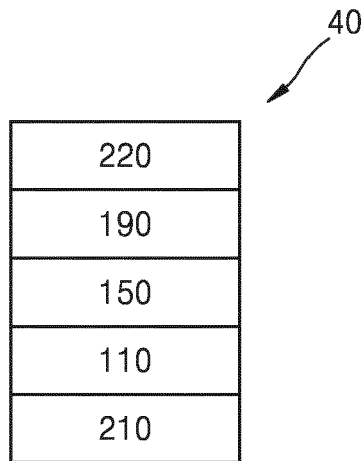


FIG. 4





EUROPEAN SEARCH REPORT

Application Number  
EP 19 20 0643

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| DOCUMENTS CONSIDERED TO BE RELEVANT  |   |  |   |
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| Category   | Citation of document with indication, where appropriate, of relevant passages   | Relevant to claim  | CLASSIFICATION OF THE APPLICATION (IPC) |
| A  | US 2018/151810 A1 (ADACHI CHIHAYA [JP] ET AL) 31 May 2018 (2018-05-31)<br>* paragraph [0095] - paragraph [0106] *<br>-----  | 1-15   | INV.<br>H01L51/54                       |
| A  | EP 2 402 351 A1 (IDEMITSU KOSAN CO [JP]; MITSUI CHEMICALS INC [JP])<br>4 January 2012 (2012-01-04)<br>* paragraph [0069] - paragraph [0104];<br>tables 1-4 *<br>----- | 1-15   |   |
|  |   |  | TECHNICAL FIELDS SEARCHED (IPC)         |
|  |   |  | H01L                                    |
| The present search report has been drawn up for all claims   |   |  |   |
| Place of search<br><b>The Hague</b>  |   | Date of completion of the search<br><b>15 April 2020</b> | Examiner<br><b>Konráðsson, Ásgeir</b>   |
| <b>CATEGORY OF CITED DOCUMENTS</b><br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |   |  |   |

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 19 20 0643

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15-04-2020

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

**REFERENCES CITED IN THE DESCRIPTION**

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|                |   |         |            |
|----------------|---|---------|------------|
| 专利名称(译)        | 包含相同的有机电致发光装置和显示装置  |         |            |
| 公开(公告)号        | <a href="#">EP3671884A1</a>   | 公开(公告)日 | 2020-06-24 |
| 申请号            | EP2019200643  | 申请日     | 2019-09-30 |
| [标]申请(专利权)人(译) | 三星显示有限公司  |         |            |
| 申请(专利权)人(译)    | 三星DISPLAY CO. , LTD.  |         |            |
| 当前申请(专利权)人(译)  | 三星DISPLAY CO. , LTD.  |         |            |
| [标]发明人         | KIM KYUNGSIK<br>KIM SEULONG<br>BAE SUNGSOO<br>HUR JAEWEON   |         |            |
| 发明人            | KIM, KYUNGSIK<br>KIM, SEULONG<br>BAE, SUNGSOO<br>LEE, DONGCHAN<br>HUR, JAEWEON  |         |            |
| IPC分类号         | H01L51/54   |         |            |
| CPC分类号         | H01L51/0067 H01L51/0072 H01L51/008 H01L51/5024 H01L2251/5384 C07D209/86 C07D401/14 C07D403/10 C07D403/14 C07D487/04 C07F5/022 C09K11/06 C09K2211/1018 H01L27/3248 H01L51/0061 H01L51/5012 H01L51/5056 |         |            |
| 优先权            | 1020180165469 2018-12-19 KR   |         |            |
| 外部链接           | <a href="#">Espacenet</a>   |         |            |

摘要(译)

一种有机发光器件，包括第一电极；和第二电极。第二电极；第一电极和第二电极之间的有机层。有机层包括发射层。发射层包括第一化合物，第二化合物和第三化合物。第一化合物由式1表示，第二化合物由式2表示，第三化合物由式3表示，并且第一化合物和第二化合物彼此不同。公式1 (Y11) c11- (L11) a11- (Y12) c12公式2 (Y21) c21- (L21) a21- (Y22) c22

Formula 3

