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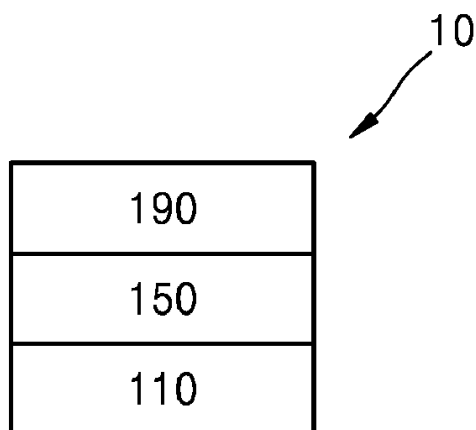
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(54) **ORGANIC LIGHT-EMITTING DEVICE AND DISPLAY APPARATUS INCLUDING THE SAME**

(57) Provided are an organic light-emitting device and a display apparatus including the same. The organic light-emitting device includes: a first electrode; a second electrode; and an organic layer between the first electrode and the second electrode, wherein the organic layer includes an emission layer, the emission layer includes 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.

**FIG. 1**



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**Description****BACKGROUND****1. Field**

[0001] One or more embodiments relate to an organic light-emitting device and a display apparatus including the same.

**2. Description of the Related Art**

[0002] Organic light-emitting devices are self-emission devices that have wide viewing angles, high contrast ratios, short response times, as well as excellent characteristics in terms of brightness, driving voltage, and response speed, and produce full-color images.

[0003] An example of such organic light-emitting devices may include a first electrode on a substrate, and a hole transport region, an emission layer, an electron transport region, and a second electrode, which are sequentially on the first electrode. Holes provided from the first electrode may move toward the emission layer through the hole transport region, and electrons provided from the second electrode may move toward the emission layer through the electron transport region. Carriers, such as holes and electrons, recombine in the emission layer to produce excitons. These excitons transit (e.g., transition or relax) from an excited state to a ground state, thereby generating light.

**SUMMARY**

[0004] One or more embodiments include an organic light-emitting device and a display apparatus including the same.

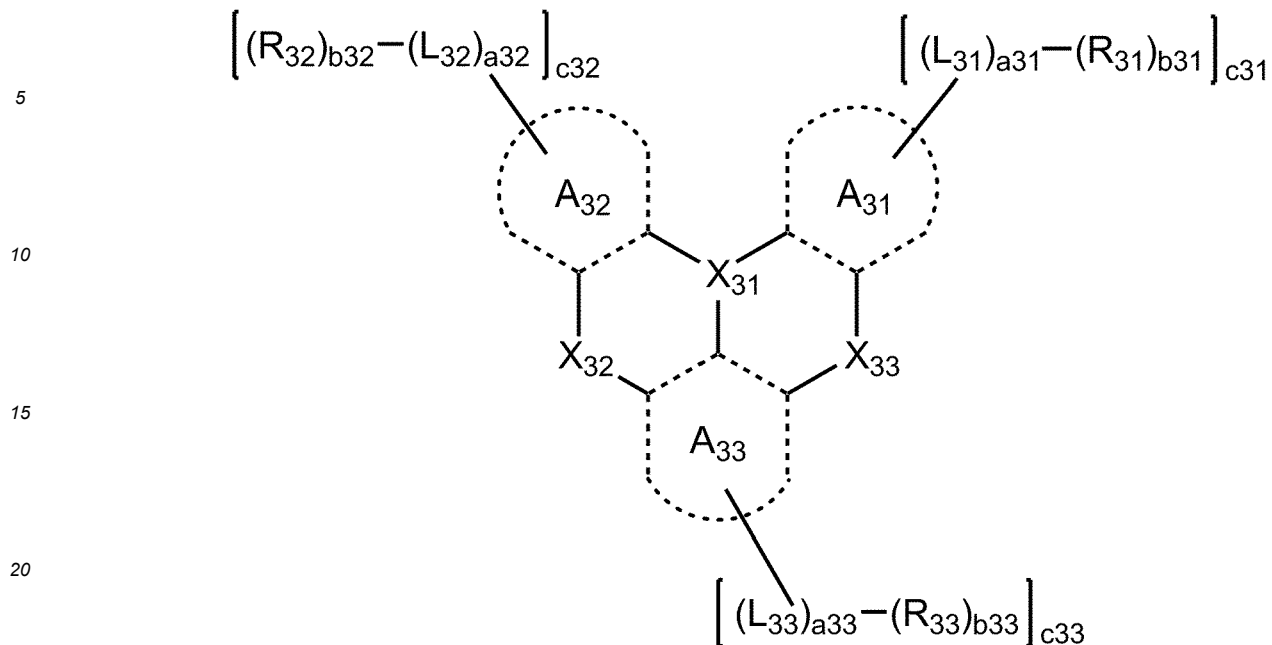
[0005] Additional aspects of embodiments will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

[0006] An aspect of an embodiment of the present disclosure provides an organic light-emitting device including: a first electrode; a second electrode; and an organic layer between the first electrode and the second electrode, wherein the organic layer includes an emission layer, the emission layer includes 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:

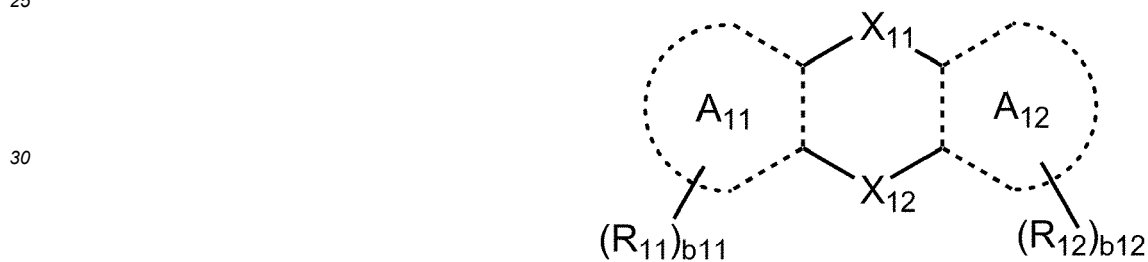
Formula 1  $(Y_{11})_{c11}-(L_{11})_{a11}-(Y_{12})_{c12}$

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

Formula 3

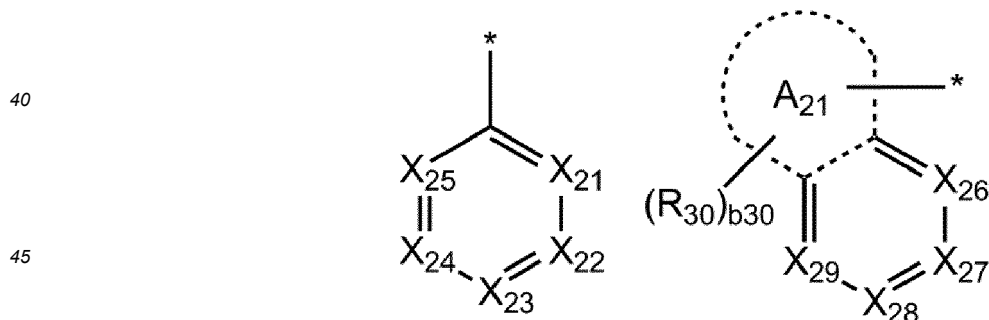


Formula 1A



Formula 2A

Formula 2B



[0007] In Formulae 1 to 3, 1A, 2A, and 2B,

50  $L_{11}$  is selected from:

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

55 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  $-\text{Si}(Q_{31})(Q_{32})(Q_{33})$ ,

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

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

Y<sub>12</sub> is selected from:

a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, 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, 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>),  
 c<sub>11</sub> and c<sub>12</sub> are each independently selected from 1, 2, and 3,  
 X<sub>11</sub> is selected from a single bond, C(R<sub>13</sub>)(R<sub>14</sub>), N(R<sub>13</sub>), O, and S,  
 X<sub>12</sub> is selected from a single bond, C(R<sub>15</sub>)(R<sub>16</sub>), N(R<sub>15</sub>), O, and S,  
 X<sub>11</sub> and X<sub>12</sub> are not a single bond simultaneously (e.g., X<sub>11</sub> and X<sub>12</sub> are not both a single bond),  
 A<sub>11</sub> and A<sub>12</sub> are each independently a  $\pi$  electron-depleted nitrogen-free cyclic group,

R<sub>11</sub> to R<sub>16</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, 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, 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>13</sub> and R<sub>15</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  $\pi$  electron-depleted nitrogen-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group; and  
 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 deuterium, -F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-  
 depleted nitrogen-containing cyclic group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and -  
 Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>),  
 a<sub>21</sub> is selected from 0, 1, 2, and 3,  
 Y<sub>21</sub> is a group represented by Formula 2A or 2B,

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

-F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, a  $\pi$  electron-  
 depleted nitrogen-free cyclic group, and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>);  
 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 deuterium, -F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl  
 group, a  $\pi$  electron-depleted nitrogen-containing cyclic 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-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group,  
 each substituted with at least one selected from a  $\pi$  electron-depleted nitrogen-containing cyclic group and a  
 $\pi$  electron-depleted nitrogen-free cyclic group that are each 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, a  $\pi$  electron-depleted nitrogen-  
 free cyclic group, and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>),  
 c<sub>21</sub> and c<sub>22</sub> are each independently selected from 1, 2, 3, 4, 5, and 6,  
 A<sub>21</sub> is selected from a C<sub>5</sub>-C<sub>60</sub> carbocyclic group and a C<sub>1</sub>-C<sub>60</sub> heterocyclic group,  
 X<sub>21</sub> is selected from C(R<sub>21</sub>) and N, X<sub>22</sub> is selected from C(R<sub>22</sub>) and N, X<sub>23</sub> is selected from C(R<sub>23</sub>) and N, X<sub>24</sub>  
 is selected from C(R<sub>24</sub>) and N, X<sub>25</sub> is selected from C(R<sub>25</sub>) and N, X<sub>26</sub> is selected from C(R<sub>26</sub>) and N, X<sub>27</sub> is  
 selected from C(R<sub>27</sub>) and N, X<sub>28</sub> is selected from C(R<sub>28</sub>) and N, X<sub>29</sub> is selected from C(R<sub>29</sub>) and N, wherein at  
 least one selected from X<sub>21</sub> to X<sub>25</sub> is N, and at least one selected from X<sub>26</sub> to X<sub>29</sub> is N,

R<sub>21</sub> to R<sub>30</sub> are each independently selected from:

hydrogen, deuterium, -F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic

group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$ ;  
 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 deuterium,  $-\text{F}$ , a cyano group, a  $\text{C}_1\text{-C}_{60}$  alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic 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-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group, each substituted with at least one selected from a  $\pi$  electron-depleted nitrogen-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group that are each 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, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ , wherein  $\text{R}_{21}$  to  $\text{R}_{25}$  are optionally linked to form a substituted or unsubstituted  $\text{C}_5\text{-C}_{60}$  carbocyclic group or a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  heterocyclic group, and  $\text{R}_{26}$  to  $\text{R}_{30}$  are optionally linked to form a substituted or unsubstituted  $\text{C}_5\text{-C}_{60}$  carbocyclic group or a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  heterocyclic group,  
 $\text{b}_{30}$  is selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10,  
 $\text{X}_{31}$  is selected from B and N, and  $\text{X}_{32}$  and  $\text{X}_{33}$  are each independently selected from B( $\text{R}_{34}$ ), N( $\text{R}_{34}$ ), O, S, C( $\text{R}_{34}$ )( $\text{R}_{35}$ ), and Si( $\text{R}_{34}$ )( $\text{R}_{35}$ ), wherein, when  $\text{X}_{31}$  is B,  $\text{X}_{32}$  and  $\text{X}_{33}$  are each independently selected from N( $\text{R}_{34}$ ), O, S, C( $\text{R}_{34}$ )( $\text{R}_{35}$ ), and Si( $\text{R}_{34}$ )( $\text{R}_{35}$ ), and when  $\text{X}_{31}$  is N,  $\text{X}_{32}$  and  $\text{X}_{33}$  are each independently selected from B( $\text{R}_{34}$ ), O, S, C( $\text{R}_{34}$ )( $\text{R}_{35}$ ), and Si( $\text{R}_{34}$ )( $\text{R}_{35}$ ),  
 $\text{A}_{31}$  to  $\text{A}_{33}$  are each independently selected from a  $\text{C}_5\text{-C}_{60}$  carbocyclic group and a  $\text{C}_1\text{-C}_{60}$  heterocyclic group,  
 $\text{L}_{31}$  to  $\text{L}_{33}$  are each independently 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,  
 $\text{a}_{31}$  to  $\text{a}_{33}$  are each independently selected from 0, 1, 2, and 3,  
 $\text{R}_{31}$  to  $\text{R}_{35}$  are each independently selected from hydrogen, deuterium,  $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ , 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  $\text{C}_1\text{-C}_{60}$  alkyl group, a substituted or unsubstituted  $\text{C}_2\text{-C}_{60}$  alkenyl group, a substituted or unsubstituted  $\text{C}_2\text{-C}_{60}$  alkynyl group, a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  alkoxy group, a substituted or unsubstituted  $\text{C}_3\text{-C}_{10}$  cycloalkyl group, a substituted or unsubstituted  $\text{C}_1\text{-C}_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $\text{C}_3\text{-C}_{10}$  cycloalkenyl group, a substituted or unsubstituted  $\text{C}_1\text{-C}_{10}$  heterocycloalkenyl group, a substituted or unsubstituted  $\text{C}_6\text{-C}_{60}$  aryl group, a substituted or unsubstituted  $\text{C}_6\text{-C}_{60}$  aryloxy group, a substituted or unsubstituted  $\text{C}_6\text{-C}_{60}$  arylthio group, a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,  $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$ ,  $-\text{B}(\text{Q}_1)(\text{Q}_2)$ ,  $-\text{N}(\text{Q}_1)(\text{Q}_2)$ ,  $-\text{P}(\text{Q}_1)(\text{Q}_2)$ ,  $-\text{C}(=\text{O})(\text{Q}_1)$ ,  $-\text{S}(=\text{O})(\text{Q}_1)$ ,  $-\text{S}(=\text{O})_2(\text{Q}_1)$ ,  $-\text{P}(=\text{O})(\text{Q}_1)(\text{Q}_2)$ , and  $-\text{P}(=\text{S})(\text{Q}_1)(\text{Q}_2)$ , and  $\text{R}_{31}$  to  $\text{R}_{33}$  are optionally linked to form a substituted or unsubstituted  $\text{C}_5\text{-C}_{60}$  carbocyclic group or a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  heterocyclic group,  
 $\text{b}_{31}$  to  $\text{b}_{33}$  are each independently selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10,  
 $\text{c}_{31}$  to  $\text{c}_{33}$  are each independently selected from 1, 2, 3, 4, 5, and 6,  
 $\text{Q}_1$  to  $\text{Q}_3$ ,  $\text{Q}_{21}$  to  $\text{Q}_{23}$ , and  $\text{Q}_{31}$  to  $\text{Q}_{33}$  are each independently selected from hydrogen, deuterium,  $-\text{F}$ ,  $-\text{Cl}$ ,  $-\text{Br}$ ,  $-\text{I}$ , a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $\text{C}_1\text{-C}_{60}$  alkyl group, a  $\text{C}_2\text{-C}_{60}$  alkenyl group, a  $\text{C}_2\text{-C}_{60}$  alkynyl group, a  $\text{C}_1\text{-C}_{60}$  alkoxy group, a  $\text{C}_3\text{-C}_{10}$  cycloalkyl group, a  $\text{C}_1\text{-C}_{10}$  heterocycloalkyl group, a  $\text{C}_3\text{-C}_{10}$  cycloalkenyl group, a  $\text{C}_1\text{-C}_{10}$  heterocycloalkenyl group, a  $\text{C}_6\text{-C}_{60}$  aryl group, a  $\text{C}_6\text{-C}_{60}$  aryloxy group, a  $\text{C}_6\text{-C}_{60}$  arylthio group, a  $\text{C}_1\text{-C}_{60}$  heteroaryl group, a  $\text{C}_1\text{-C}_{60}$  heteroaryloxy group, a  $\text{C}_1\text{-C}_{60}$  heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, and  
 \* indicates a binding site to a neighboring atom.

**[0008]** Another aspect of an embodiment of the present disclosure provides a display apparatus including: a thin-film transistor including a source electrode, a drain electrode, and an active layer; and the organic light-emitting device described above, wherein the first electrode of the organic light-emitting device is electrically coupled to one selected from the source electrode and the drain electrode of the thin-film transistor.

**[0009]** At least some of the above and other features of the invention are set out in the claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0010]** These and/or other aspects of embodiments 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

**[0011]** The subject matter of the present disclosure will now be described more fully with reference to embodiments. The subject matter of the present 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. Features of embodiments of the disclosure, and how to achieve them, will become apparent by reference to the embodiments that will be described herein below in more detail, together with the accompanying drawings. The subject matter of this disclosure may, however, be embodied in many different forms and should not be limited to the embodiments.

**[0012]** 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 may not be repeated herein.

**[0013]** As used herein, the singular forms "a," "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise.

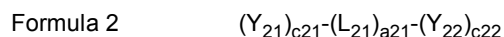
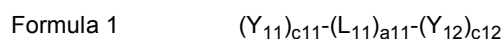
**[0014]** It will be further understood that the terms "comprises" and/or "comprising," as used herein, specify the presence of stated features or components, but do not preclude the presence or addition of one or more other features or components.

**[0015]** 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. For example, intervening layers, regions, or components may be present. In addition, it will also be understood that when an element or layer is referred to as being "between" two elements or layers, it can be the only element or layer between the two elements or layers, or one or more intervening elements or layers may also be present.

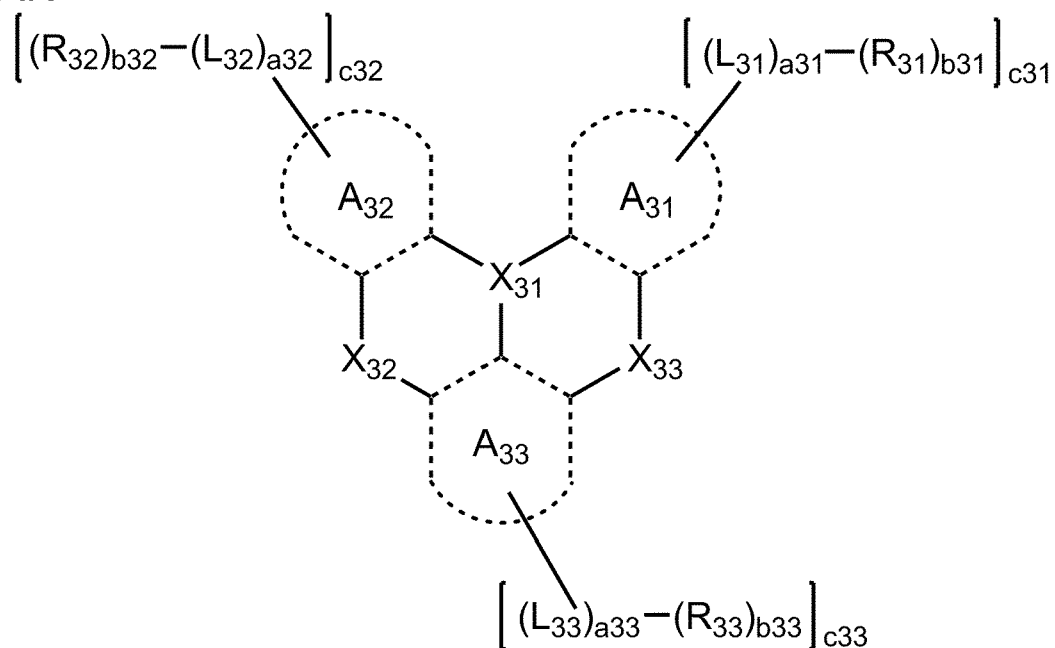
**[0016]** Sizes of components in the drawings may be exaggerated for convenience of explanation. In other words, because sizes and thicknesses of components in the drawings may be arbitrarily illustrated for convenience of explanation, the following embodiments of the present disclosure are not limited thereto.

**[0017]** The term "organic layer," as used herein, refers to a single layer and/or a plurality of layers between the first electrode and the second electrode of the organic light-emitting device. A material included in the "organic layer" is not limited to an organic material. For example, the "organic layer" may include an inorganic material.

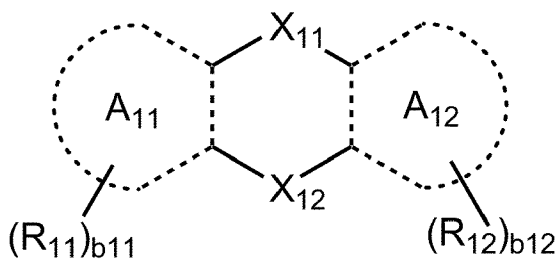
**[0018]** An organic light-emitting device according to an embodiment includes: a first electrode; a second electrode; and an organic layer between the first electrode and the second electrode, wherein the organic layer includes an emission layer, the emission layer includes a first compound, a second 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:



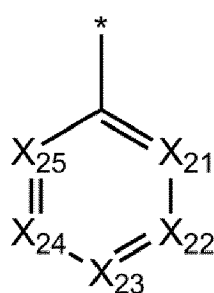
Formula 3



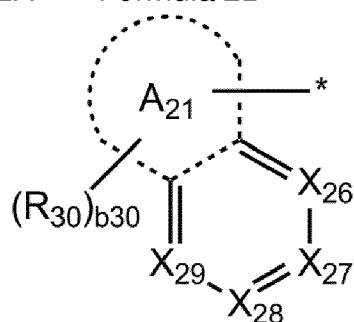
Formula 1A



Formula 2A



Formula 2B



**[0019]** In Formulae 1 to 3, 1A, 2A, and 2B,

$L_{11}$  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  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) 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 (e.g.  $a_{11}$  may be 0 or 1),
- $Y_{11}$  is a group represented by Formula 1A,

$Y_{12}$  is selected from:

a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a  $\pi$  electron-depleted nitrogen-free cyclic group, 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>  
 (e.g. C<sub>1</sub>-C<sub>20</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  
 5 that is substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</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>),  
 c<sub>11</sub> and c<sub>12</sub> are each independently selected from 1, 2, and 3 (e.g. c<sub>11</sub> and c<sub>12</sub> may be 1),  
 X<sub>11</sub> is selected from a single bond, C(R<sub>13</sub>)(R<sub>14</sub>), N(R<sub>13</sub>), O, and S,  
 X<sub>12</sub> is selected from a single bond, C(R<sub>15</sub>)(R<sub>16</sub>), N(R<sub>15</sub>), O, and S,  
 10 X<sub>11</sub> and X<sub>12</sub> are not a single bond simultaneously (e.g., X<sub>11</sub> and X<sub>12</sub> are not both a single bond),  
 A<sub>11</sub> and A<sub>12</sub> are each independently a  $\pi$  electron-depleted nitrogen-free cyclic group,

R<sub>11</sub> to R<sub>16</sub> are each independently selected from:

15 a binding site, hydrogen, deuterium, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a  $\pi$  electron-depleted nitrogen-free  
 cyclic group, 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>  
 (e.g. C<sub>1</sub>-C<sub>20</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  
 20 that is substituted with at least one selected from deuterium, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</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>13</sub> and R<sub>15</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,

25 L<sub>21</sub> is selected from:

a  $\pi$  electron-depleted nitrogen-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group; and  
 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 deuterium, -F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl  
 30 group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, a  $\pi$  electron-depleted nitrogen-free cyclic group,  
 and -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>),  
 a<sub>21</sub> is selected from 0, 1, 2, and 3 (e.g. a<sub>21</sub> may be 0 or 1),  
 Y<sub>21</sub> is a group represented by Formula 2A or 2B,

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

-F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group,  
 a  $\pi$  electron-depleted nitrogen-free cyclic group, and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>);  
 a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, and a  $\pi$  electron-  
 40 depleted nitrogen-free cyclic group, each substituted with at least one selected from deuterium, -F, a cyano  
 group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic 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-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group,  
 each substituted with at least one selected from a  $\pi$  electron-depleted nitrogen-containing cyclic group and a  
 45  $\pi$  electron-depleted nitrogen-free cyclic group that are each substituted with at least one selected from deuterium,  
 a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, a  $\pi$  electron-depleted  
 nitrogen-free cyclic group, and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>),  
 c<sub>21</sub> and c<sub>22</sub> are each independently selected from 1, 2, 3, 4, 5, and 6 (e.g. c<sub>21</sub> and c<sub>22</sub> may each independently  
 be selected from 1 or 2),  
 50 A<sub>21</sub> is selected from a C<sub>5</sub>-C<sub>60</sub> (e.g. C<sub>5</sub>-C<sub>30</sub>) carbocyclic group and a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heterocyclic group,  
 X<sub>21</sub> is selected from C(R<sub>21</sub>) and N, X<sub>22</sub> is selected from C(R<sub>22</sub>) and N, X<sub>23</sub> is selected from C(R<sub>23</sub>) and N, X<sub>24</sub>  
 is selected from C(R<sub>24</sub>) and N, X<sub>25</sub> is selected from C(R<sub>25</sub>) and N, X<sub>26</sub> is selected from C(R<sub>26</sub>) and N, X<sub>27</sub> is  
 selected from C(R<sub>27</sub>) and N, X<sub>28</sub> is selected from C(R<sub>28</sub>) and N, and X<sub>29</sub> is selected from C(R<sub>29</sub>) and N, wherein  
 at least one selected from X<sub>21</sub> to X<sub>25</sub> is N, and at least one selected from X<sub>26</sub> to X<sub>29</sub> is N,  
 55

R<sub>21</sub> to R<sub>30</sub> are each independently selected from:

hydrogen, deuterium, -F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a  $\pi$  electron-depleted nitrogen-



containing cyclic group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$ ;  
 a  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) 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 deuterium, -F, a cyano group, a  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic 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-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group, each substituted with at least one selected from a  $\pi$  electron-depleted nitrogen-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group that are each substituted with at least one selected from deuterium, a  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ ,  
 wherein  $\text{R}_{21}$  to  $\text{R}_{25}$  are optionally linked to form a substituted or unsubstituted  $\text{C}_5\text{-C}_{60}$  (e.g.  $\text{C}_5\text{-C}_{30}$ ) carbocyclic group or a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) heterocyclic group, and  
 $\text{R}_{26}$  to  $\text{R}_{30}$  are optionally linked to form a substituted or unsubstituted  $\text{C}_5\text{-C}_{60}$  (e.g.  $\text{C}_5\text{-C}_{30}$ ) carbocyclic group or a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) heterocyclic group,  
 $\text{b}_{30}$  is selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10,  
 $\text{X}_{31}$  is selected from B and N, and  $\text{X}_{32}$  and  $\text{X}_{33}$  are each independently selected from  $\text{B}(\text{R}_{34})$ ,  $\text{N}(\text{R}_{34})$ , O, S,  $\text{C}(\text{R}_{34})(\text{R}_{35})$ , and  $\text{Si}(\text{R}_{34})(\text{R}_{35})$ ,  
 wherein, when  $\text{X}_{31}$  is B,  $\text{X}_{32}$  and  $\text{X}_{33}$  are each independently selected from  $\text{N}(\text{R}_{34})$ , O, S,  $\text{C}(\text{R}_{34})(\text{R}_{35})$ , and  $\text{Si}(\text{R}_{34})(\text{R}_{35})$ , and when  $\text{X}_{31}$  is N,  $\text{X}_{32}$  and  $\text{X}_{33}$  are each independently selected from  $\text{B}(\text{R}_{34})$ , O, S,  $\text{C}(\text{R}_{34})(\text{R}_{35})$ , and  $\text{Si}(\text{R}_{34})(\text{R}_{35})$ ,  
 $\text{A}_{31}$  to  $\text{A}_{33}$  are each independently selected from a  $\text{C}_5\text{-C}_{60}$  (e.g.  $\text{C}_5\text{-C}_{30}$ ) carbocyclic group and a  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) heterocyclic group,  
 $\text{L}_{31}$  to  $\text{L}_{33}$  are each independently selected from a substituted or unsubstituted  $\text{C}_5\text{-C}_{60}$  (e.g.  $\text{C}_5\text{-C}_{30}$ ) carbocyclic group, and a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) heterocyclic group,  
 $\text{a}_{31}$  to  $\text{a}_{33}$  are each independently selected from 0, 1, 2, and 3 (e.g.  $\text{a}_{31}$  to  $\text{a}_{33}$  may each independently be selected from 0 or 1),  
 $\text{R}_{31}$  to  $\text{R}_{35}$  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  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) alkyl group, a substituted or unsubstituted  $\text{C}_2\text{-C}_{60}$  (e.g.  $\text{C}_2\text{-C}_{20}$ ) alkenyl group, a substituted or unsubstituted  $\text{C}_2\text{-C}_{60}$  (e.g.  $\text{C}_2\text{-C}_{20}$ ) alkynyl group, a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) alkoxy group, a substituted or unsubstituted  $\text{C}_3\text{-C}_{10}$  cycloalkyl group, a substituted or unsubstituted  $\text{C}_1\text{-C}_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $\text{C}_3\text{-C}_{10}$  cycloalkenyl group, a substituted or unsubstituted  $\text{C}_1\text{-C}_{10}$  heterocycloalkenyl group, a substituted or unsubstituted  $\text{C}_6\text{-C}_{60}$  (e.g.  $\text{C}_6\text{-C}_{30}$ ) aryl group, a substituted or unsubstituted  $\text{C}_6\text{-C}_{60}$  (e.g.  $\text{C}_6\text{-C}_{30}$ ) aryloxy group, a substituted or unsubstituted  $\text{C}_6\text{-C}_{60}$  (e.g.  $\text{C}_6\text{-C}_{30}$ ) arylthio group, a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,  $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$ ,  $-\text{B}(\text{Q}_1)(\text{Q}_2)$ ,  $-\text{N}(\text{Q}_1)(\text{Q}_2)$ ,  $-\text{P}(\text{Q}_1)(\text{Q}_2)$ ,  $-\text{C}(=\text{O})(\text{Q}_1)$ ,  $-\text{S}(=\text{O})(\text{Q}_1)$ ,  $-\text{S}(=\text{O})_2(\text{Q}_1)$ ,  $-\text{P}(=\text{O})(\text{Q}_1)(\text{Q}_2)$ , and  $-\text{P}(=\text{S})(\text{Q}_1)(\text{Q}_2)$ ,  
 $\text{R}_{31}$  to  $\text{R}_{33}$  are optionally linked to form a substituted or unsubstituted  $\text{C}_5\text{-C}_{60}$  (e.g.  $\text{C}_5\text{-C}_{30}$ ) carbocyclic group or a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) heterocyclic group,  
 $\text{b}_{31}$  to  $\text{b}_{33}$  are each independently selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10,  
 $\text{c}_{31}$  to  $\text{c}_{33}$  are each independently selected from 1, 2, 3, 4, 5, and 6,  
 $\text{Q}_1$  to  $\text{Q}_3$ ,  $\text{Q}_{21}$  to  $\text{Q}_{23}$ , and  $\text{Q}_{31}$  to  $\text{Q}_{33}$  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  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) alkyl group, a  $\text{C}_2\text{-C}_{60}$  (e.g.  $\text{C}_2\text{-C}_{20}$ ) alkenyl group, a  $\text{C}_2\text{-C}_{60}$  (e.g.  $\text{C}_2\text{-C}_{20}$ ) alkynyl group, a  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) alkoxy group, a  $\text{C}_3\text{-C}_{10}$  cycloalkyl group, a  $\text{C}_1\text{-C}_{10}$  heterocycloalkyl group, a  $\text{C}_3\text{-C}_{10}$  cycloalkenyl group, a  $\text{C}_1\text{-C}_{10}$  heterocycloalkenyl group, a  $\text{C}_6\text{-C}_{60}$  (e.g.  $\text{C}_6\text{-C}_{30}$ ) aryl group, a  $\text{C}_6\text{-C}_{60}$  (e.g.  $\text{C}_6\text{-C}_{30}$ ) aryloxy group, a  $\text{C}_6\text{-C}_{60}$  (e.g.  $\text{C}_6\text{-C}_{30}$ ) arylthio group, a  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) heteroaryl group, a  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) heteroaryloxy group, a  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, and  
 \* indicates a binding site to a neighboring atom.

**[0020]** For example,  $\text{L}_{11}$  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.

**[0021]** For example, L<sub>21</sub> and L<sub>31</sub> to L<sub>33</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 benzoquinolinyl group, a benzoisoquinolinyl 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.

**[0022]** For example, in Formulae 1 to 3, a<sub>11</sub>, a<sub>21</sub>, and a<sub>31</sub> to a<sub>33</sub> may each independently be selected from 0 and 1, but embodiments of the present disclosure are not limited thereto.

**[0023]** For example, in Formula 1A, X<sub>11</sub> may be selected from N(R<sub>13</sub>), O, and S, and 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, 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.

**[0025]** In one embodiment, 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, and a dibenzothiophene group, but embodiments of the present disclosure are not limited thereto.

**[0026]** For example, in Formula 1A, R<sub>11</sub> to R<sub>16</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, and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</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 benzonaph-

thothiophenyl 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 fluoranthrenyl 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 fluoranthrenyl 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 fluoranthrenyl 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 fluoranthrenyl 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 benzocarbazolyl 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>13</sub> and R<sub>15</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> may each independently be 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 fluoranthrenyl 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 benzocarbazolyl group, a dinaphthofuranyl group, and a dinaphthothiophenyl group, but embodiments of the present disclosure are not limited thereto.

**[0027]** In one embodiment, in Formula 1A, R<sub>11</sub> to R<sub>16</sub> may each independently be selected from:

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<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>); 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 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<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 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, and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>),

one selected from R<sub>11</sub> to R<sub>13</sub> and R<sub>15</sub> is a binding site,

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> may each independently be 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 fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

**[0028]** For example, in Formula 1, Y<sub>12</sub> may be 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,



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.

5 **[0029]** In one embodiment, in Formula 1,  $Y_{12}$  may be selected from:

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, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, and  $-Si(Q_1)(Q_2)(Q_3)$ ; and

15 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, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, and a benzothienodibenzothiophenyl 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, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, and  $-Si(Q_{31})(Q_{32})(Q_{33})$ ; and

30 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, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, and a benzothienodibenzothiophenyl 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, a dibenzothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, and a benzothienodibenzothiophenyl 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, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, and  $-Si(Q_{21})(Q_{22})(Q_{23})$ , 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.

55 **[0030]** For example, in Formula 1,  $c_{11}$  and  $c_{12}$  may be 1, but embodiments of the present disclosure are not limited thereto.

**[0031]** For example, in Formula 2,  $Y_{22}$  may be selected from:



a benzofluorenyl group, a benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl 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 that are each substituted with at least one 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 spiro-bifluorenyl 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, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl 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, a diazadibenzothiophenyl group, and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>), 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> may each independently be 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, 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 benzoquinolinyl group, a benzoisoquinolinyl 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.

**[0032]** In one embodiment, in Formula 2, Y<sub>22</sub> may be selected from:

-F, 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 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 spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>);  
 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 spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>);

quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl group, each substituted with at least one selected from deuterium, -F, 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 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 spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl 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 triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl 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 spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl 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 triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, and  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ , and  $\text{Q}_1$  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 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 spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, and  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ , and  $\text{Q}_1$  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 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 spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl group, but embodiments of the present disclosure are not limited thereto.

**[0033]** For example, in Formula 2, c21 and c22 may each independently be 1 and 2, but embodiments of the present disclosure are not limited thereto.

**[0034]** For example, in Formula 2B,  $\text{A}_{21}$  may be selected from a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a perylene group, a thiophene group, a furan group, a silole group, a carbazole group, an indole group, an isoindole group, a benzofuran group, a benzothiophene group, a benzosilole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, a dibenzocarbazole group, a dibenzosilole 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, a triazine 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, and a



phenanthroline group, but embodiments of the present disclosure are not limited thereto.

**[0035]** In one embodiment, in Formula 2B, A<sub>21</sub> may be selected from a benzene group, a naphthalene group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a quinoline group, and an isoquinoline group, but embodiments of the present disclosure are not limited thereto.

**[0036]** For example, in Formula 2A, X<sub>21</sub> may be N, X<sub>22</sub> may be C(R<sub>22</sub>), X<sub>23</sub> may be C(R<sub>23</sub>), X<sub>24</sub> may be C(R<sub>24</sub>), and X<sub>25</sub> may be C(R<sub>25</sub>);

X<sub>21</sub> may be C(R<sub>21</sub>), X<sub>22</sub> may be N, X<sub>23</sub> may be C(R<sub>23</sub>), X<sub>24</sub> may be C(R<sub>24</sub>), and X<sub>25</sub> may be C(R<sub>25</sub>);

X<sub>21</sub> may be C(R<sub>21</sub>), X<sub>22</sub> may be C(R<sub>22</sub>), X<sub>23</sub> may be N, X<sub>24</sub> may be C(R<sub>24</sub>), and X<sub>25</sub> may be C(R<sub>25</sub>);

X<sub>21</sub> may be N, X<sub>22</sub> may be C(R<sub>22</sub>), X<sub>23</sub> may be N, X<sub>24</sub> may be C(R<sub>24</sub>), and X<sub>25</sub> may be C(R<sub>25</sub>);

X<sub>21</sub> may be C(R<sub>21</sub>), X<sub>22</sub> may be N, X<sub>23</sub> may be C(R<sub>23</sub>), X<sub>24</sub> may be N, and X<sub>25</sub> may be C(R<sub>25</sub>);

X<sub>21</sub> may be N, X<sub>22</sub> may be C(R<sub>22</sub>), X<sub>23</sub> may be C(R<sub>23</sub>), X<sub>24</sub> may be N, and X<sub>25</sub> may be C(R<sub>25</sub>); or

X<sub>21</sub> may be N, X<sub>22</sub> may be C(R<sub>22</sub>), X<sub>23</sub> may be N, X<sub>24</sub> may be C(R<sub>24</sub>), and X<sub>25</sub> may be N, but embodiments of the present disclosure are not limited thereto.

**[0037]** For example, in Formula 2B, X<sub>26</sub> may be N, X<sub>27</sub> may be C(R<sub>27</sub>), X<sub>28</sub> may be C(R<sub>28</sub>), and X<sub>29</sub> may be C(R<sub>29</sub>);

X<sub>26</sub> may be C(R<sub>26</sub>), X<sub>27</sub> may be N, X<sub>28</sub> may be C(R<sub>28</sub>), and X<sub>29</sub> may be C(R<sub>29</sub>);

X<sub>26</sub> may be N, X<sub>27</sub> may be C(R<sub>27</sub>), X<sub>28</sub> may be N, and X<sub>29</sub> may be C(R<sub>29</sub>); or

X<sub>26</sub> may be N, X<sub>27</sub> may be C(R<sub>27</sub>), X<sub>28</sub> may be C(R<sub>28</sub>), and X<sub>29</sub> may be N, but embodiments of the present disclosure are not limited thereto.

**[0038]** For example, in Formulae 2A and 2B, R<sub>21</sub> to R<sub>30</sub> may each independently be selected from:

hydrogen, deuterium, -F, a cyano 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 benzo-carbazolyl 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 benzoquinolinyl group, a benzoisoquinolinyl 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, a diazadibenzothiophenyl group, and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>);

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 benzoquinolinyl group, a benzoisoquinolinyl 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, a cyano 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 benzoquinolinyl group, a benzoisoquinolinyl 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, a diazadibenzothiophenyl 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, 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 benzoquinolinyl group, a benzoisoquinolinyl 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 benzoquinolinyl group, a benzoisoquinolinyl 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, a diazadibenzothiophenyl group, and  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ , and

$\text{Q}_1$  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 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 benzoquinolinyl group, a benzoisoquinolinyl 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.

**[0039]** For example, in Formula 3,  $\text{X}_{31}$  may be B, and  $\text{X}_{32}$  and  $\text{X}_{33}$  may be  $\text{N}(\text{R}_{34})$ ; or  $\text{X}_{31}$  may be N, and  $\text{X}_{32}$  and  $\text{X}_{33}$  may be  $\text{B}(\text{R}_{34})$ , but embodiments of the present disclosure are not limited thereto.

**[0040]** For example, in Formula 3,  $\text{A}_{31}$  to  $\text{A}_{33}$  may each independently be selected from a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a perylene group, a thiophene group, a furan group, a silole group, a carbazole group, an indole group, an isoindole group, a benzofuran group, a benzothiophene group, a benzosilole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, a dibenzocarbazole group, and a dibenzosilole group, but embodiments of the present disclosure are not limited thereto.

**[0041]** In one embodiment, in Formula 3,  $\text{A}_{31}$  to  $\text{A}_{33}$  may be a benzene group, but embodiments of the present disclosure are not limited thereto.

**[0042]** For example, in Formula 3,  $\text{a}_{31}$  to  $\text{a}_{33}$  may each independently be selected from 0 and 1, but embodiments of the present disclosure are not limited thereto.

**[0043]** For example, in Formula 3,  $\text{R}_{31}$  to  $\text{R}_{35}$  may each independently be selected from:

hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano group, a  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, and a  $\text{C}_1$ - $\text{C}_{20}$  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 benzoquinolinyl group, a benzoisoquinolinyl 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 benzoquinolinyl group, a benzoisoquinolinyl 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  $\text{C}_1$ - $\text{C}_{20}$  alkyl group, a  $\text{C}_1$ - $\text{C}_{20}$  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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group;

and

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

$Q_1$  and  $Q_2$  may each independently be 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

In one embodiment, in Formula 3,  $R_{31}$  to  $R_{35}$  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 carbazoyl 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 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

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

$Q_1$  and  $Q_2$  may each independently be selected from:

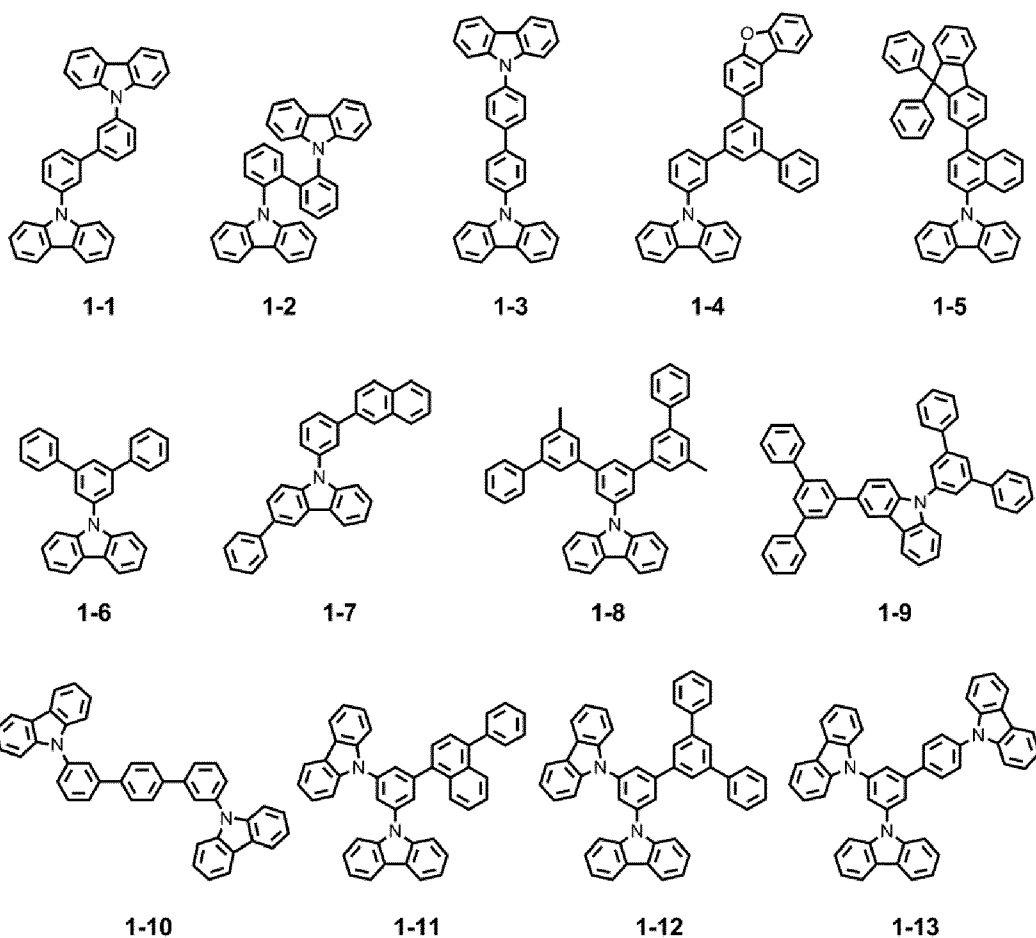
hydrogen, deuterium, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, and a tert-butyl group;

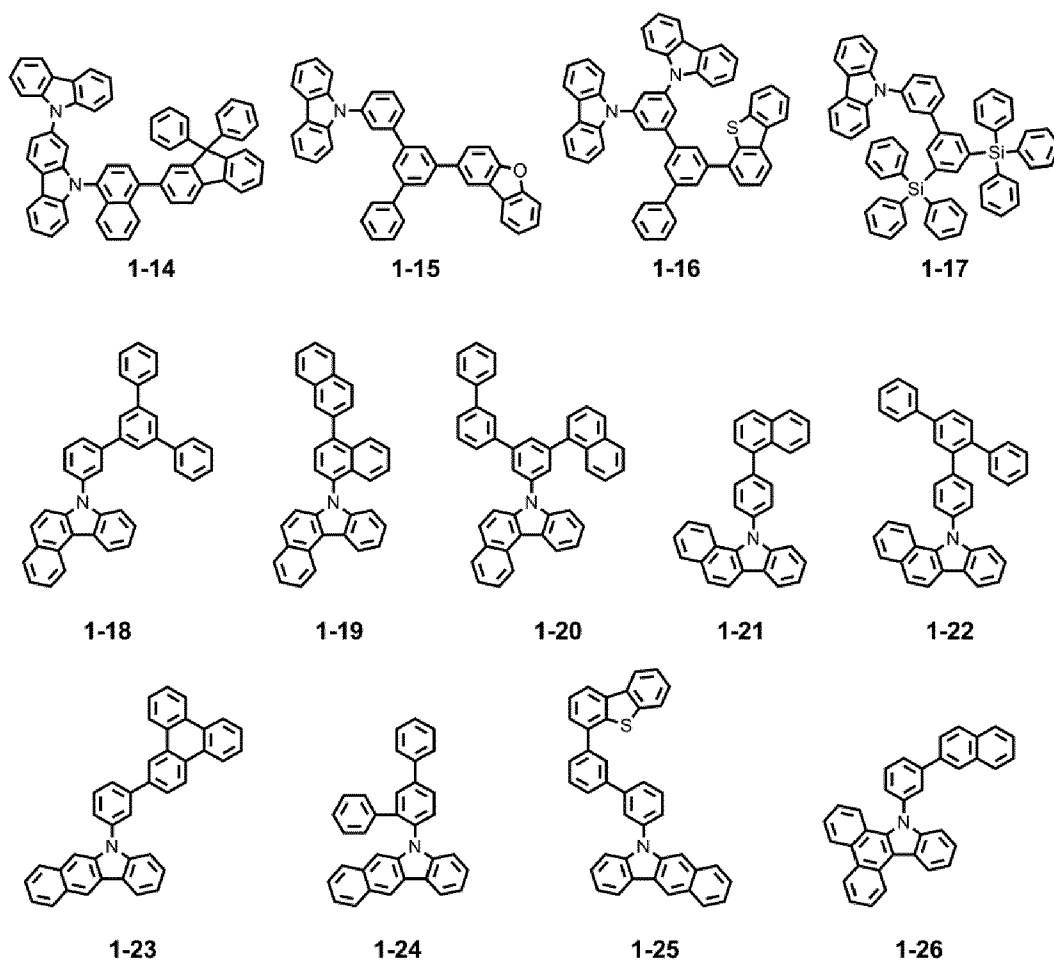
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

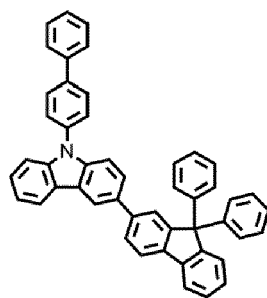
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from 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.

**[0044]** In one embodiment, the first compound may be selected from compounds of Group I:

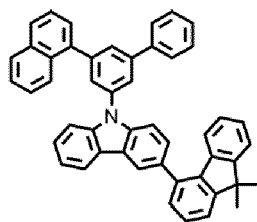
### Group I



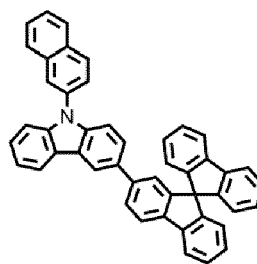




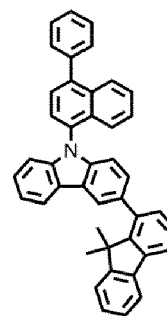
1-27



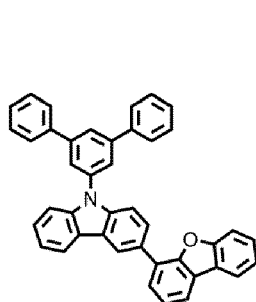
1-28



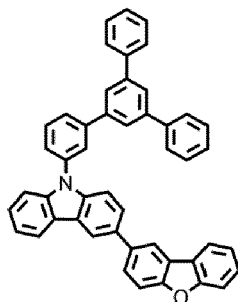
1-29



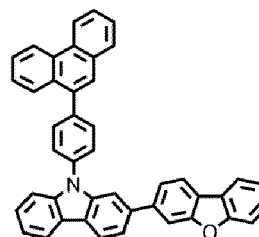
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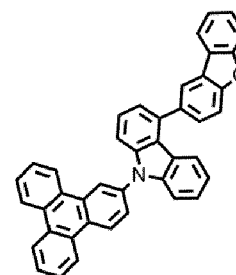
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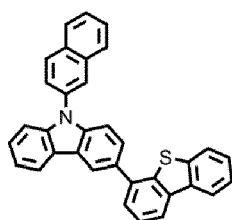
1-31'



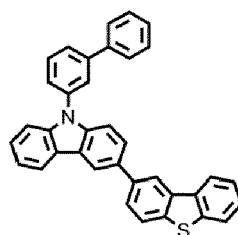
1-32



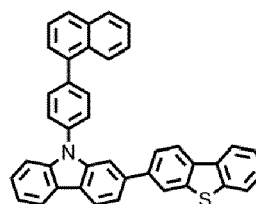
1-33



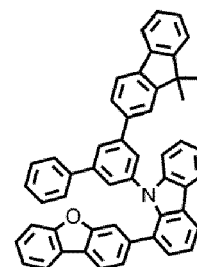
1-34



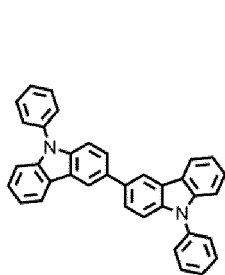
1-35



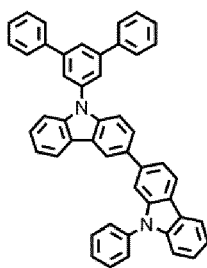
1-36



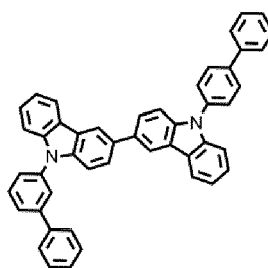
1-37



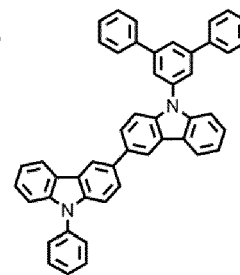
1-38



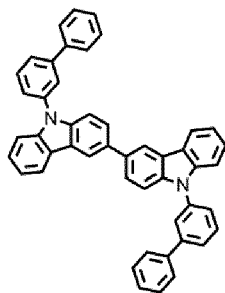
1-39



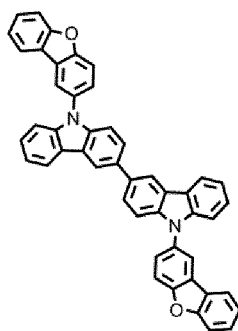
1-40



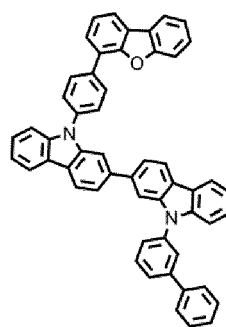
1-41



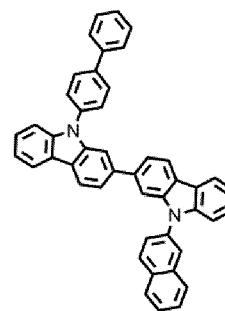
1-42



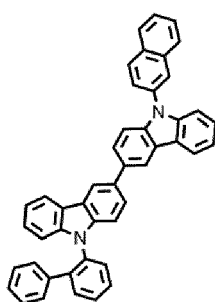
1-43



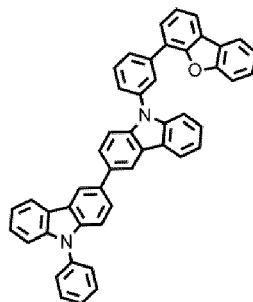
1-44



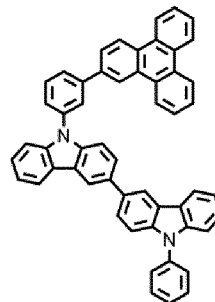
1-45



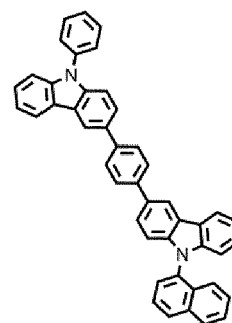
1-46



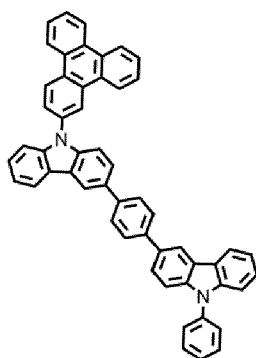
1-47



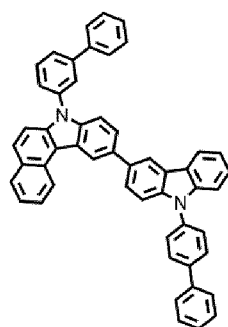
1-48



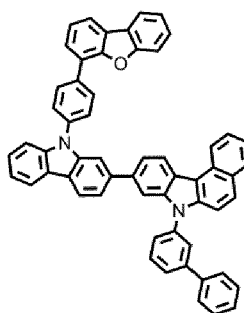
1-49



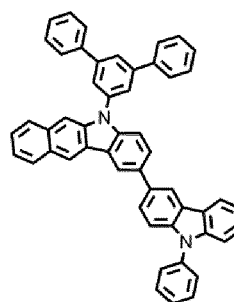
1-50



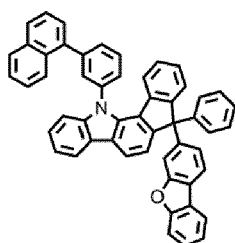
1-51



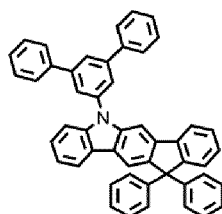
1-52



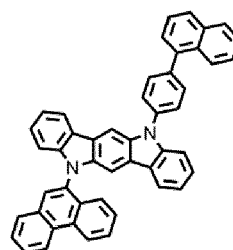
1-53



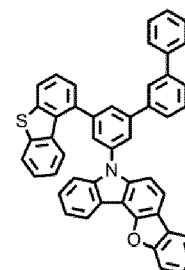
1-54



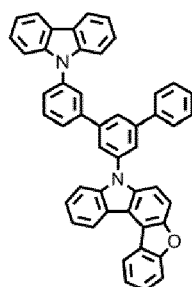
1-55



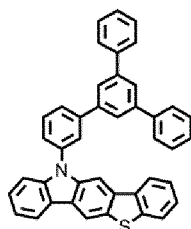
1-56



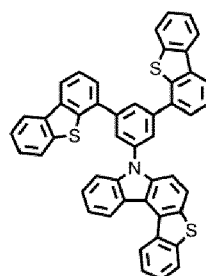
1-57



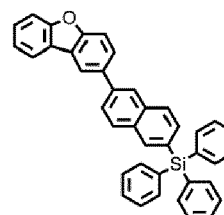
1-58



1-59

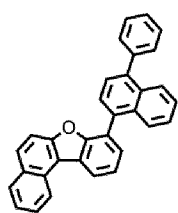


1-60

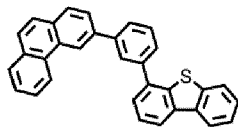


1-61

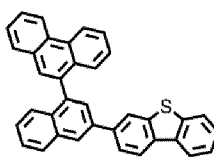




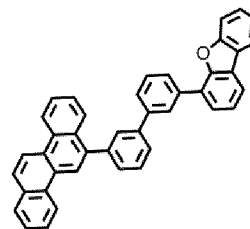
1-62



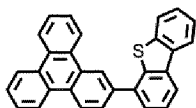
1-63



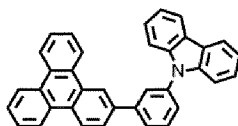
1-64



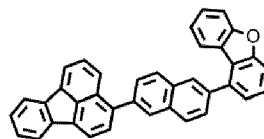
1-65



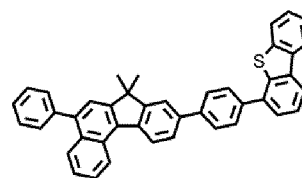
1-66



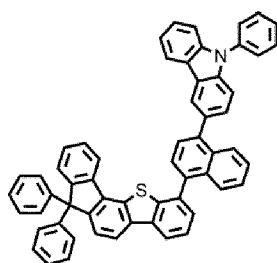
1-67



1-68



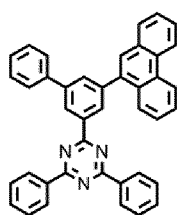
1-69



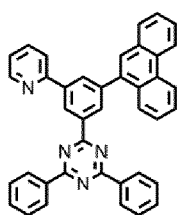
1-70

[0045] In one embodiment, the second compound may be selected from compounds of Group II:

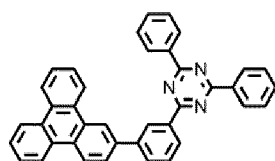
## Group II



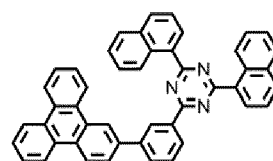
2-1



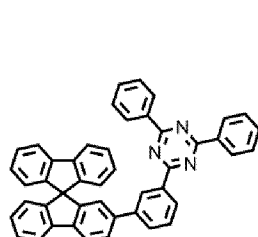
2-2



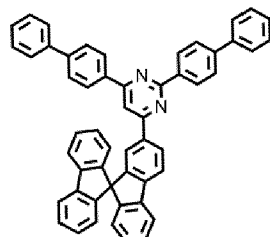
2-3



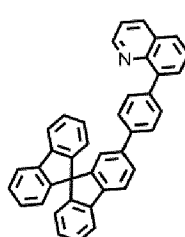
2-4



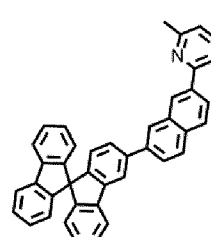
2-5



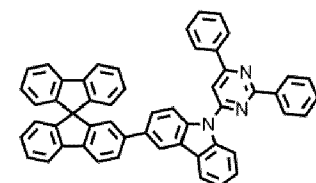
2-6



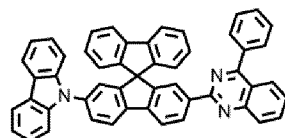
2-7



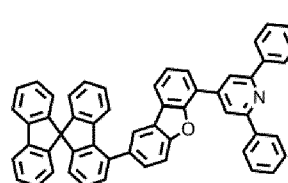
2-8



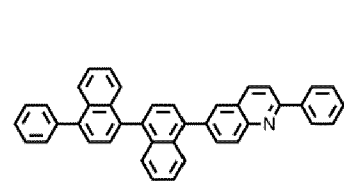
2-9



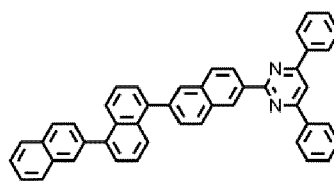
2-10



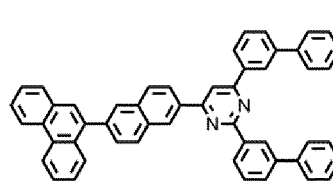
2-11



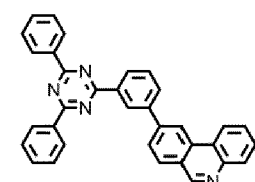
2-12



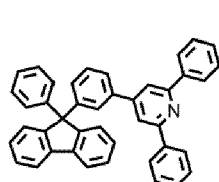
2-13



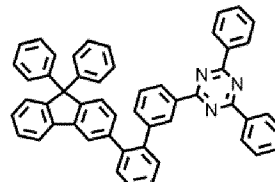
2-14



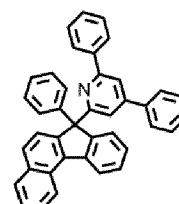
2-15



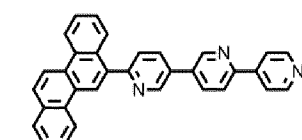
2-16



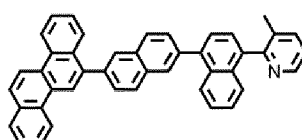
2-17



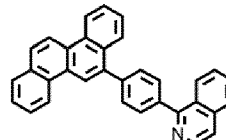
2-18



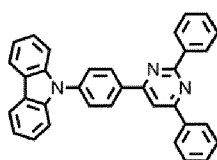
2-19



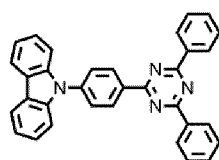
2-20



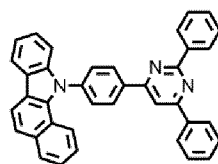
2-21



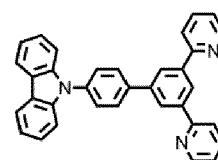
2-22



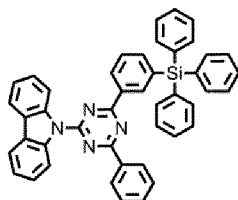
2-23



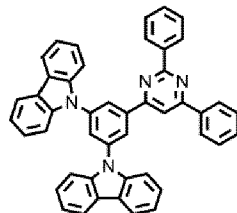
2-24



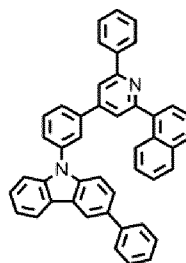
2-25



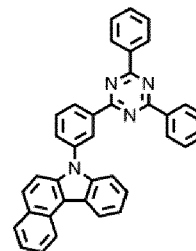
2-26



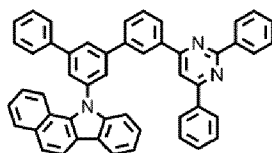
2-27



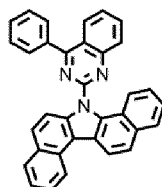
2-28



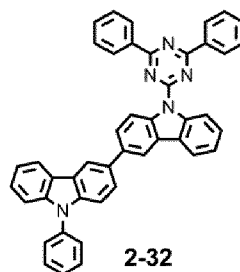
2-29



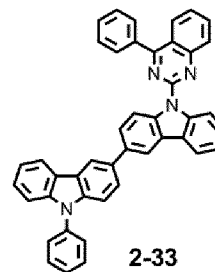
2-30



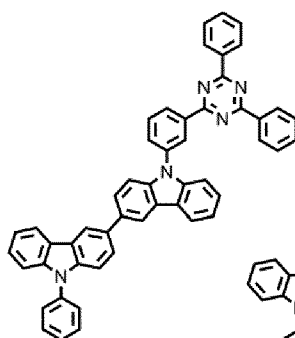
2-31



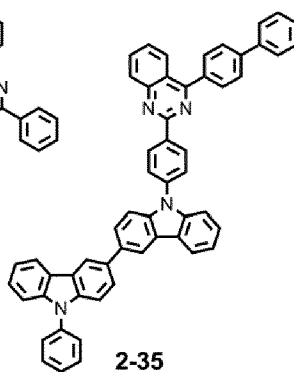
2-32



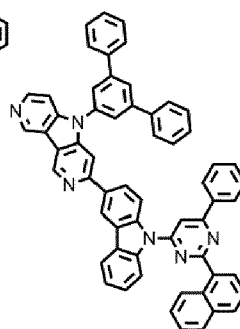
2-33



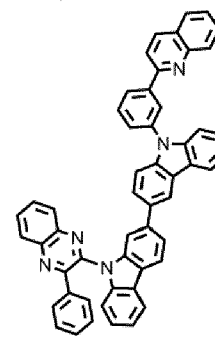
2-34



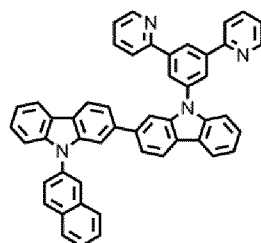
2-35



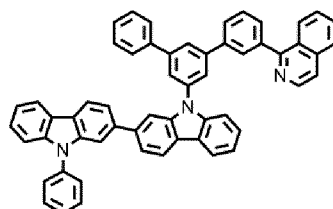
2-36



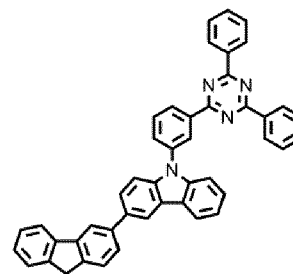
2-37



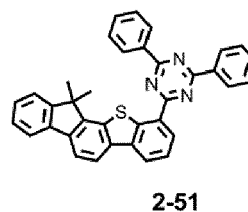
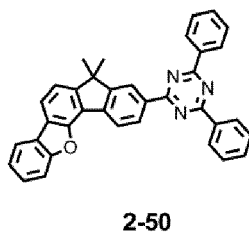
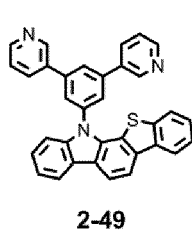
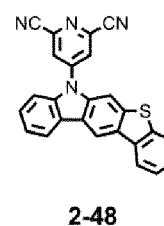
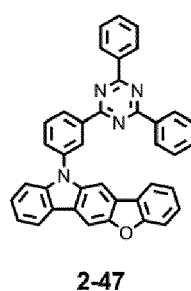
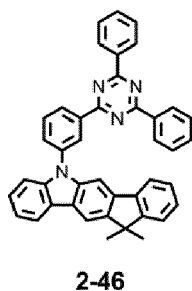
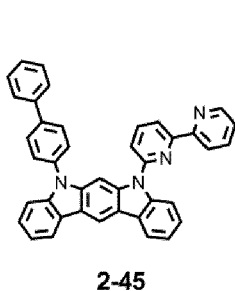
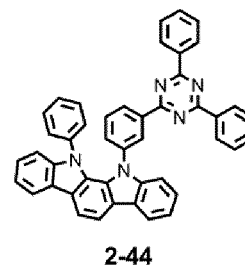
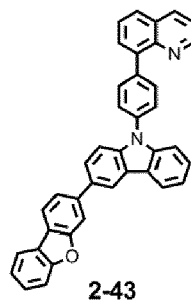
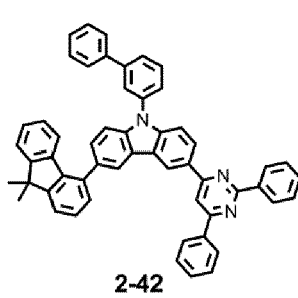
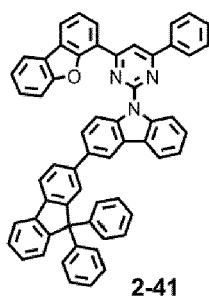
2-38



2-39

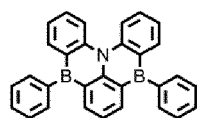


2-40

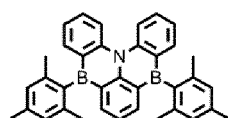


**[0046]** In one embodiment, the third compound may be selected from compounds of Group III:

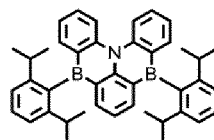
### Group III



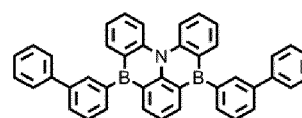
3-1



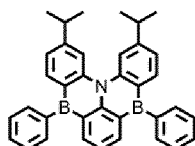
3-2



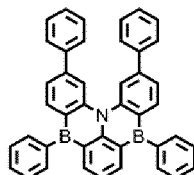
3-3



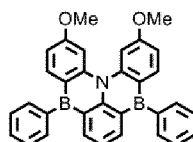
3-4



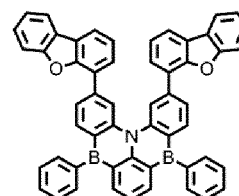
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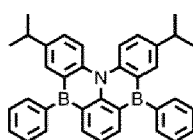
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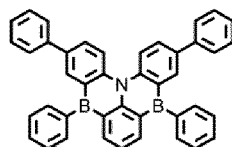
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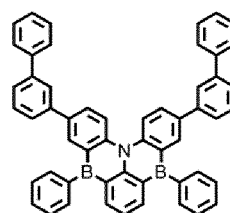
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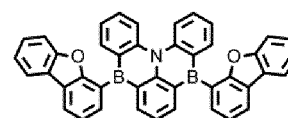
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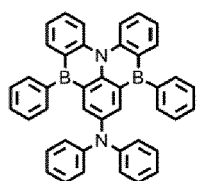
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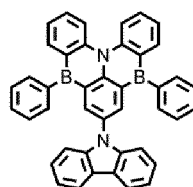
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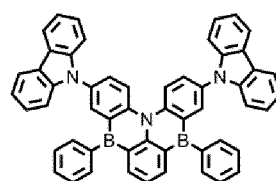
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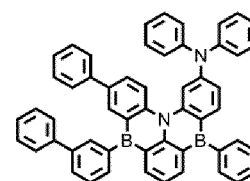
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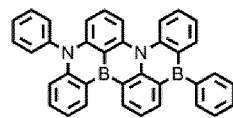
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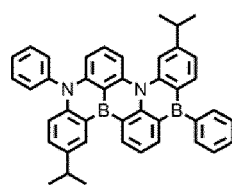
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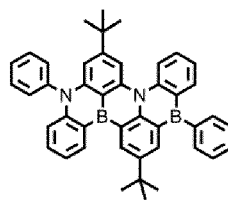
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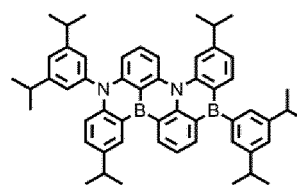
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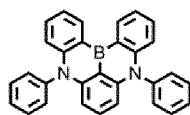


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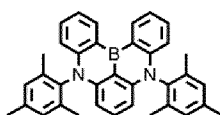


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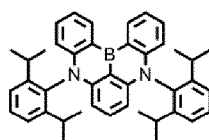
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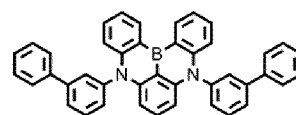
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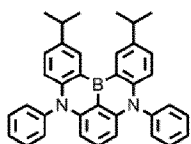


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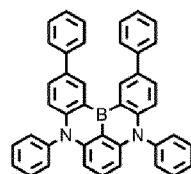


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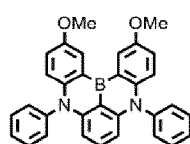
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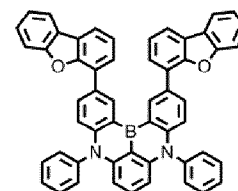
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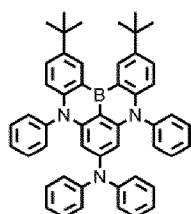
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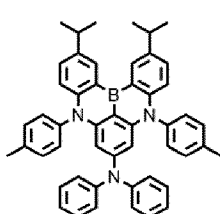
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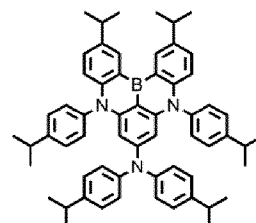
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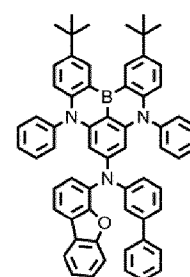
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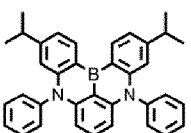
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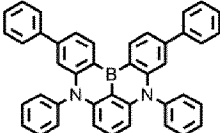
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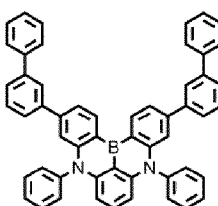
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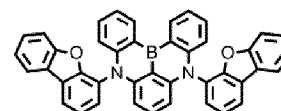
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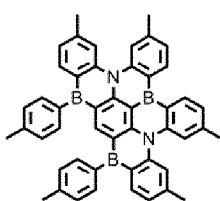
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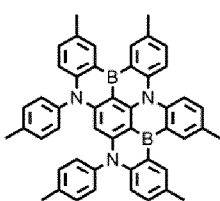
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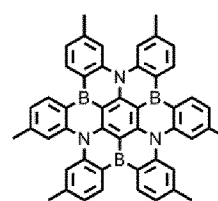
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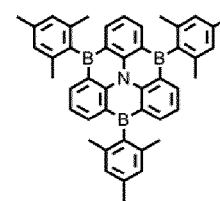
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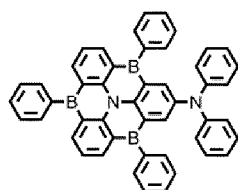
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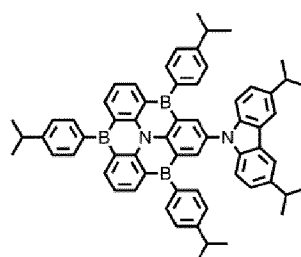
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**[0047]** Because the first compound does not essentially include an electron transporting moiety, the first compound may be easily used for controlling hole transporting characteristics of the organic light-emitting device. For example, in some embodiments, the first compound is free of an electron transporting moiety. Because the third compound has relatively high hole trap characteristics (e.g., high hole trapping characteristics), an emission region may be biased to a set or specific region in the emission layer based on the presence of the third compound. Therefore, in order to uniformly (e.g., substantially uniformly) distribute the emission region of the organic light-emitting device including the third compound throughout the emission layer, characteristics of the hole transporting host may be important. The emission region may be widened throughout the emission layer through by way of the hole transport capability of the first compound. Therefore, the efficiency and/or lifespan of the organic light-emitting device including the first compound may be improved.

**[0048]** Because the second compound includes (or essentially includes) an electron transporting moiety, the second compound may improve or optimize charge balance in the emission layer. If electrons are not smoothly injected from the electron transport layer to the emission layer, charges are accumulated at an interface between the emission layer and the electron transport layer, and, as a result, the interface may be deteriorated. Therefore, the lifespan of the organic light-emitting device may be deteriorated. Because the first compound has a relatively high hole transporting characteristics, the lowest unoccupied molecular orbital (LUMO) energy level is not suitable for electron injection. Therefore, the second compound is included in the emission layer so as to adjust electrons injected into the emission layer. Consequently, an organic light-emitting device having improved lifespan may be provided.

**[0049]** The third compound may be a thermally activated delayed fluorescence (TADF) emitter.

**[0050]** The third compound may have a maximum emission wavelength in a range of about 450 nm to about 650 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 may receive energy from the formed excitons and emit red delayed fluorescence.

**[0051]** The organic light-emitting device may emit delayed fluorescence in a range of about 450 nm to about 650 nm, but embodiments of the present disclosure are not limited thereto.

**[0052]** The third compound may satisfy Condition 1 below:

### Condition 1

$$\Delta E_{ST}(C3) \leq 0.3 \text{ eV.}$$

**[0053]** In Condition 1,

$\Delta E_{ST}(C3)$  is a difference between a lowest excitation singlet energy level ( $E_{S1}(C3)$ ) and a lowest excitation triplet energy level ( $E_{T1}(C3)$ ) of the third compound.

**[0054]**  $E_{S1}(C3)$  and  $E_{T1}(C3)$  may be evaluated by a density functional theory (DFT) method, utilizing any suitable version of the "Gaussian" software program, for example, where the compound is structurally optimized utilizing a B3LYP hybrid functional and a 6-31G(d,p) basis set.

**[0055]** When Condition 1 is satisfied, suitably or sufficiently high reverse intersystem crossing (RISC) efficiency may be obtained even at room temperature.

**[0056]** Because the organic light-emitting device has an energy level sufficient to emit fluorescence at or from the third compound, an organic light-emitting device with high color purity may be provided. In addition, because the second compound has suitably or sufficiently high RISC efficiency even at room temperature, the triplet energy of the first compound that may not participate in light emission may all (or substantially all) transfer to the third compound, and excitons that would otherwise disappear or dissociate without participating in light emission may be minimized or reduced, thereby improving the efficiency of the organic light-emitting device.

**[0057]** An amount of the first compound in the emission layer may be in a range of about 10 wt% to about 90 wt% based on the total weight of the emission layer, but embodiments of the present disclosure are not limited thereto.

**[0058]** An amount of the second compound in the emission layer may be in a range of about 10 wt% to about 90 wt% based on the total weight of the emission layer, but embodiments of the present disclosure are not limited thereto.

**[0059]** An 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.

**[0060]** An amount of the third compound may be in a range of about 0.01 parts by weight to about 30 parts by weight based on 100 parts by weight of the first compound and the second compound, but embodiments of the present disclosure are not limited thereto. For example, an amount of the third compound may be in a range of about 0.01 parts by weight to about 20 parts by weight based on 100 parts by weight of the first compound and the second compound. For example, an amount of the third compound may be in a range of about 0.01 parts by weight to about 10 parts by weight based on 100 parts by weight of the first compound and the second compound. For example, an amount of the third compound may be in a range of about 0.01 parts by weight to about 5 parts by weight based on 100 parts by weight of the first

compound and the second compound. For example, an amount of the third compound may be in a range of about 1 parts by weight to about 3 parts by weight based on 100 parts by weight of the first compound and the second compound.

[0061] When the first compound, the second compound, and the third compound satisfy these ranges, an organic light-emitting device having both improved efficiency and improved lifespan may be provided.

[0062] In one embodiment, the emission layer may include (or consist of) the first compound, the second compound, and the third compound, but embodiments of the present disclosure are not limited thereto.

[0063] In one embodiment, the first electrode may be an anode, the second electrode may be a cathode, the organic layer may further include a hole transport region between the first electrode and the emission layer and/or an electron transport region between the emission layer and the second electrode, the hole transport region may include a hole injection layer, a hole transport layer, an emission auxiliary layer, an electron blocking layer, or any combination thereof, and the electron transport region may include 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

[0064] FIG. 1 is a schematic view of an organic light-emitting device 10 according to an embodiment. The organic light-emitting device 10 includes a first electrode 110, an organic layer 150, and a second electrode 190.

[0065] 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

[0066] In FIG. 1, a substrate may be additionally 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 water resistance.

[0067] 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 a first electrode may be selected from materials having a high work function to facilitate hole injection.

[0068] 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 a first electrode may be selected from indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide ( $\text{SnO}_2$ ), 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 a first electrode may be selected from magnesium (Mg), silver (Ag), aluminium (Al), aluminium-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.

[0069] The first electrode 110 may have a single-layered structure, or a multi-layered structure including 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

[0070] The organic layer 150 is on the first electrode 110. The organic layer 150 includes an emission layer.

[0071] The organic layer 150 may further include 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]

[0072] The hole transport region may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

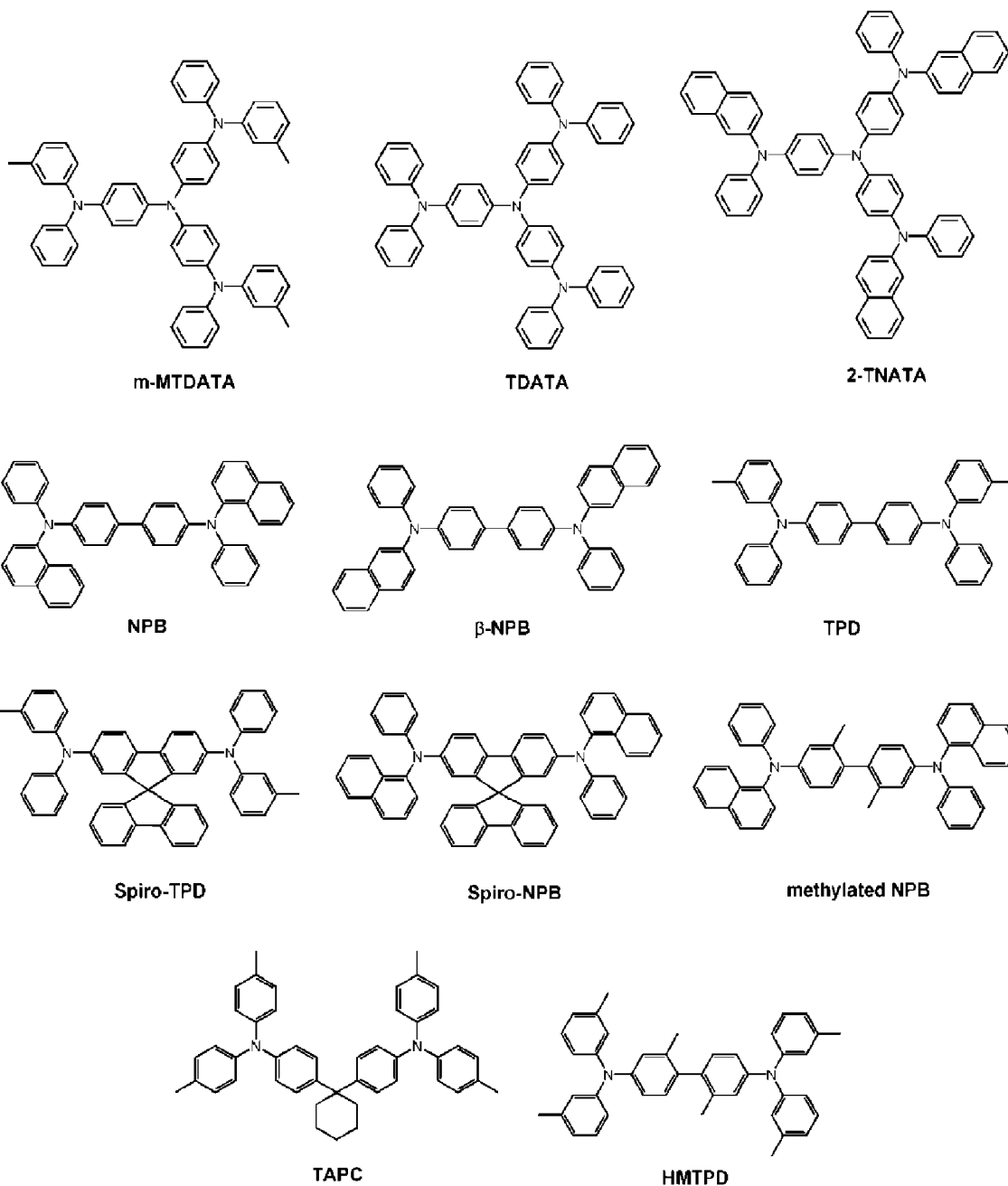
[0073] The hole transport region may include at least one layer selected from a hole injection layer, a hole transport layer, an emission auxiliary layer, and an electron blocking layer.

[0074] For example, the hole transport region may have a single-layered structure including a single layer including 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 from the first electrode

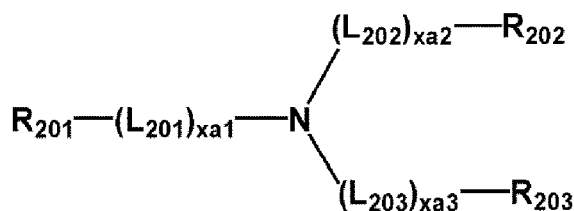


110 in this stated order, but the structure of the hole transport region is not limited thereto.

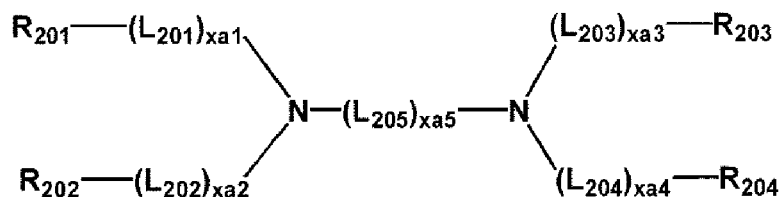
[0075] The hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB (NPD),  $\beta$ -NPB, TPD, spiro-TPD, spiro-NPB, methylated-NPB, TAPC, HMTDP, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201, and a compound represented by Formula 202:



Formula 201



Formula 202



**[0076]** In Formulae 201 and 202,

$\text{L}_{201}$  to  $\text{L}_{204}$  may each independently be selected from a substituted or unsubstituted  $\text{C}_3$ - $\text{C}_{10}$  cycloalkylene group, a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{10}$  heterocycloalkylene group, a substituted or unsubstituted  $\text{C}_3$ - $\text{C}_{10}$  cycloalkenylene group, a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{10}$  heterocycloalkenylene group, a substituted or unsubstituted  $\text{C}_6$ - $\text{C}_{60}$  (e.g.  $\text{C}_6$ - $\text{C}_{32}$ ) arylene group, a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{60}$  (e.g.  $\text{C}_1$ - $\text{C}_{20}$ ) heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

$\text{L}_{205}$  may be selected from  $^-\text{O}-^*$ ,  $^-\text{S}-^*$ ,  $^-\text{N}(\text{Q}_{201})-^*$ , a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{20}$  alkylene group, a substituted or unsubstituted  $\text{C}_2$ - $\text{C}_{20}$  alkenylene group, a substituted or unsubstituted  $\text{C}_3$ - $\text{C}_{10}$  cycloalkylene group, a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{10}$  heterocycloalkylene group, a substituted or unsubstituted  $\text{C}_3$ - $\text{C}_{10}$  cycloalkenylene group, a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{10}$  heterocycloalkenylene group, a substituted or unsubstituted  $\text{C}_6$ - $\text{C}_{60}$  (e.g.  $\text{C}_6$ - $\text{C}_{32}$ ) arylene group, a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{60}$  (e.g.  $\text{C}_1$ - $\text{C}_{20}$ ) heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

$\text{xa}1$  to  $\text{xa}4$  may each independently be an integer from 0 to 3,

$\text{xa}5$  may be an integer from 1 to 10, and

$\text{R}_{201}$  to  $\text{R}_{204}$  and  $\text{Q}_{201}$  may each independently be selected from a substituted or unsubstituted  $\text{C}_3$ - $\text{C}_{10}$  cycloalkyl group, a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $\text{C}_3$ - $\text{C}_{10}$  cycloalkenyl group, a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{10}$  heterocycloalkenyl group, a substituted or unsubstituted  $\text{C}_6$ - $\text{C}_{60}$  (e.g.  $\text{C}_6$ - $\text{C}_{32}$ ) aryl group, a substituted or unsubstituted  $\text{C}_6$ - $\text{C}_{60}$  (e.g.  $\text{C}_6$ - $\text{C}_{32}$ ) aryloxy group, a substituted or unsubstituted  $\text{C}_6$ - $\text{C}_{60}$  (e.g.  $\text{C}_6$ - $\text{C}_{32}$ ) arylthio group, a substituted or unsubstituted  $\text{C}_1$ - $\text{C}_{60}$  (e.g.  $\text{C}_1$ - $\text{C}_{20}$ ) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

**[0077]** In one embodiment, in Formula 202,  $\text{R}_{201}$  and  $\text{R}_{202}$  may optionally be linked via a single bond, a dimethyl-methylene group, or a diphenyl-methylene group, and  $\text{R}_{203}$  and  $\text{R}_{204}$  may optionally be linked via a single bond, a dimethyl-methylene group, or a diphenyl-methylene group.

**[0078]** In one embodiment, in Formulae 201 and 202,

$\text{L}_{201}$  to  $\text{L}_{205}$  may each independently be selected from:

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene 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 fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a thiophenylene group, a furanylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, and a pyridinylenylene group;

and  
a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene 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 fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a thiophenylene group, a furanylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group,

a benzocarbazolylenyl group, a dibenzocarbazolylenyl 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 fluoranthrenyl 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 carbazoly 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.

**[0079]** In one or more embodiments, xa1 to xa4 may each independently be 0, 1, or 2.

**[0080]** In one or more embodiments, xa5 may be 1, 2, 3, or 4.

**[0081]** 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 fluoranthrenyl 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 carbazoly 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 fluoranthrenyl 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 carbazoly 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 fluoranthrenyl 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 carbazoly 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, -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.

**[0082]** In one or more embodiments, in Formula 201, at least one selected from R<sub>201</sub> to R<sub>203</sub> may be selected from:

a fluorenyl group, a spiro-bifluorenyl group, a carbazoly group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

a fluorenyl group, a spiro-bifluorenyl group, a carbazoly 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.

**[0083]** In one or more embodiments, in Formula 202, 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.

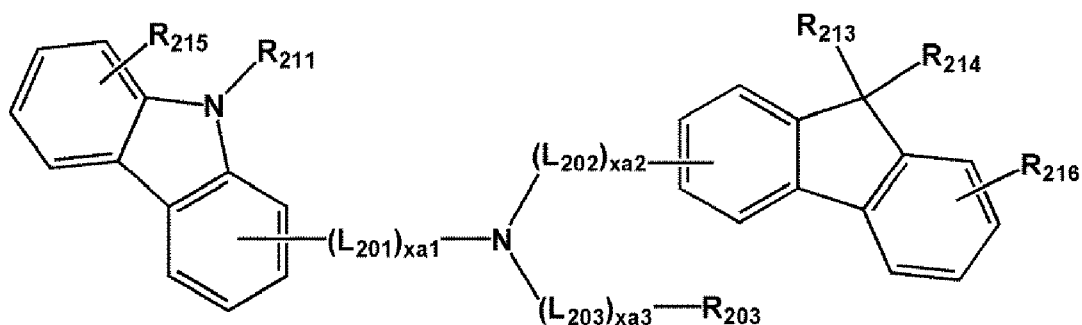
**[0084]** In one or more embodiments, in Formula 202, at least one selected from R<sub>201</sub> to R<sub>204</sub> may be selected from:

a carbazolyl group; and

a carbazolyl group substituted 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.

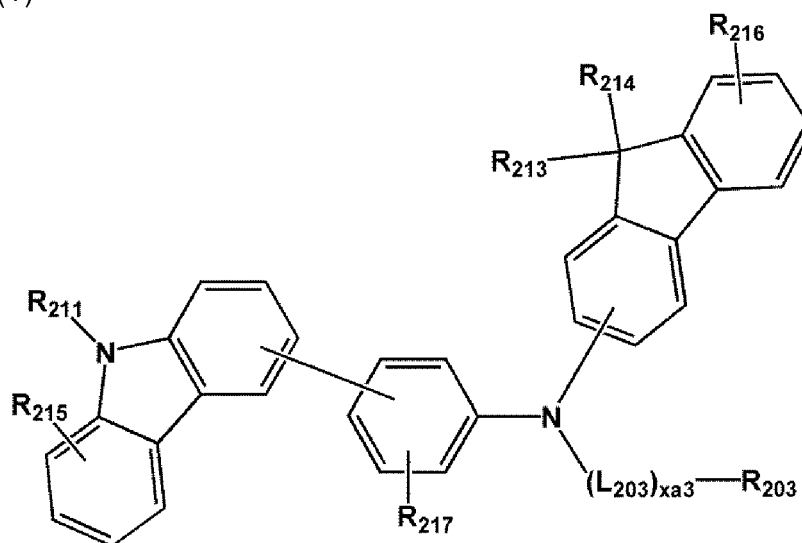
**[0085]** The compound represented by Formula 201 may be represented by Formula 201A:

Formula 201A



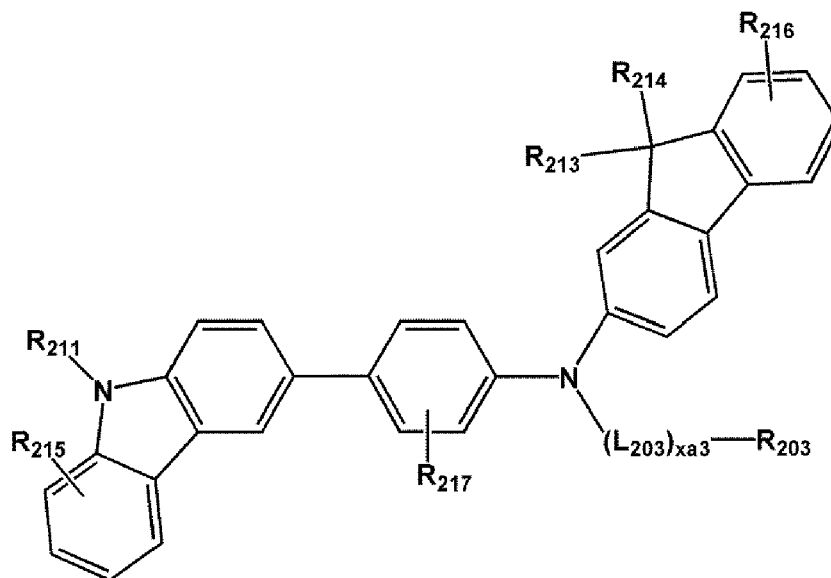
**[0086]** In one embodiment, the compound represented by Formula 201 may be represented by Formula 201 A(1) below, but embodiments of the present disclosure are not limited thereto:

Formula 201A(1)



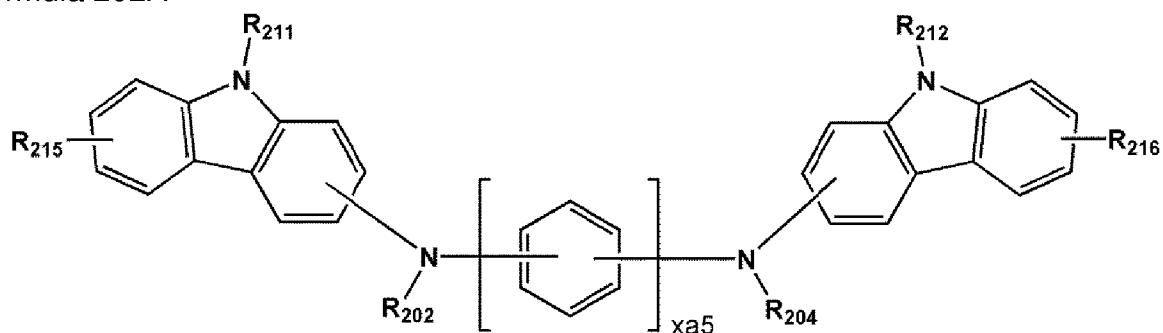
**[0087]** In one embodiment, the compound represented by Formula 201 may be represented by Formula 201A-1 below, but embodiments of the present disclosure are not limited thereto:

Formula 201A-1



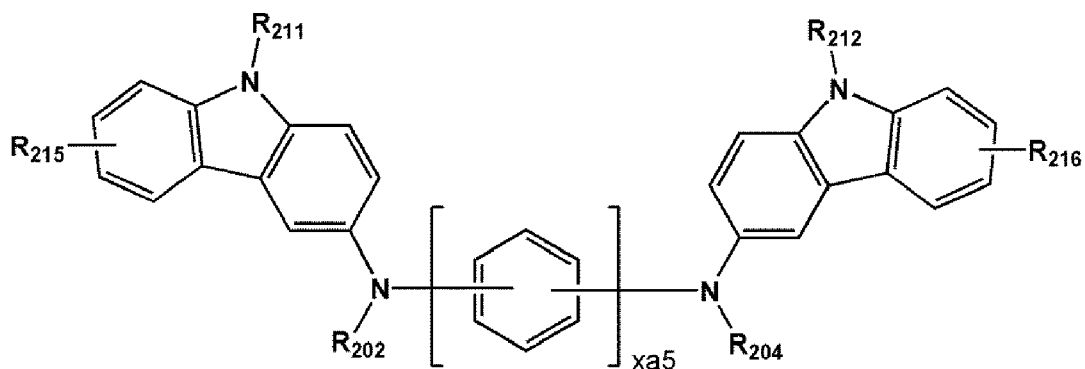
[0088] In one embodiment, the compound represented by Formula 202 may be represented by Formula 202A:

Formula 202A



[0089] In one embodiment, the compound represented by Formula 202 may be represented by Formula 202A-1:

Formula 202A-1

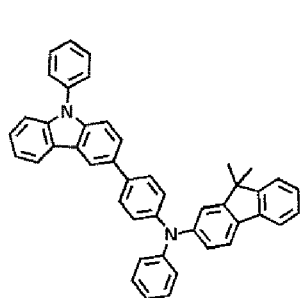


[0090] In Formulae 201A, 201A(1), 201A-1, 202A, and 202A-1,

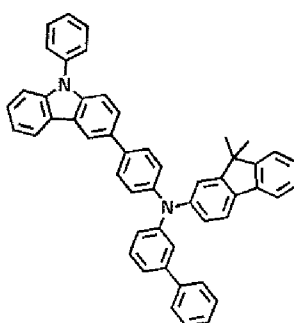
$L_{201}$  to  $L_{203}$ ,  $xa1$  to  $xa3$ ,  $xa5$ , and  $R_{202}$  to  $R_{204}$  are the same as described above,  $R_{211}$  and  $R_{212}$  may be the same as defined in connection with  $R_{203}$ , and  $R_{213}$  to  $R_{217}$  may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$

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 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, and a pyridinyl group.

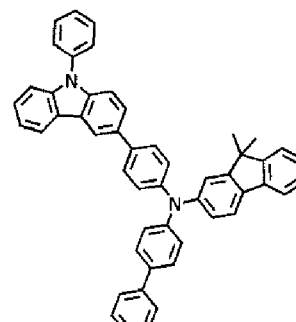
**[0091]** The hole transport region may include at least one compound selected from Compounds HT1 to HT39, but embodiments of the present disclosure are not limited thereto:



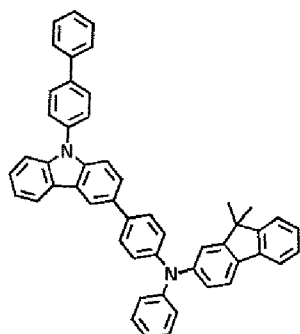
HT1



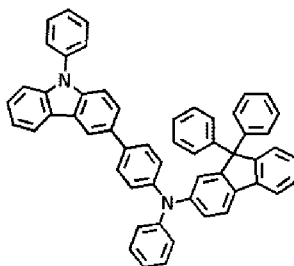
HT2



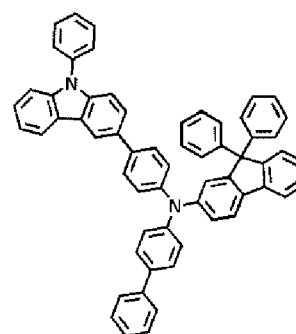
HT3



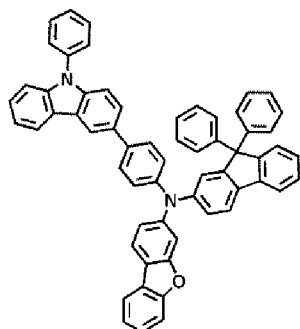
HT4



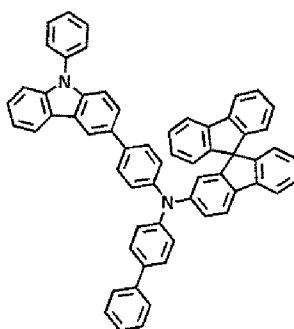
HT5



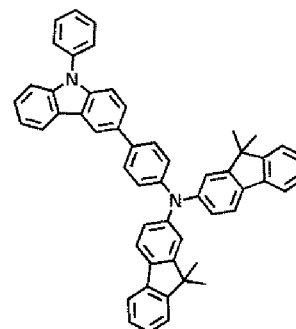
HT6



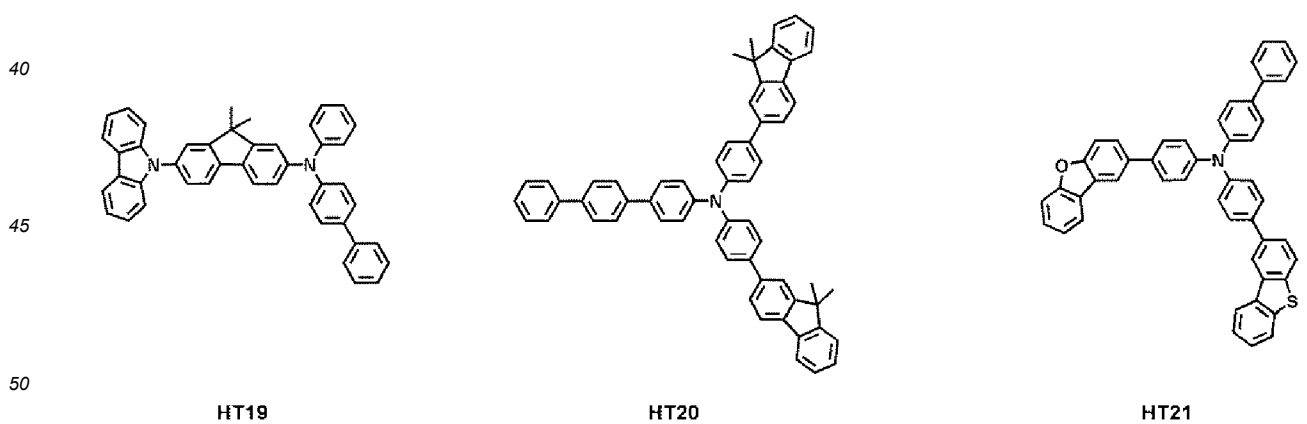
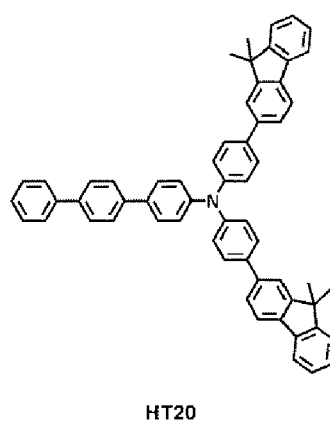
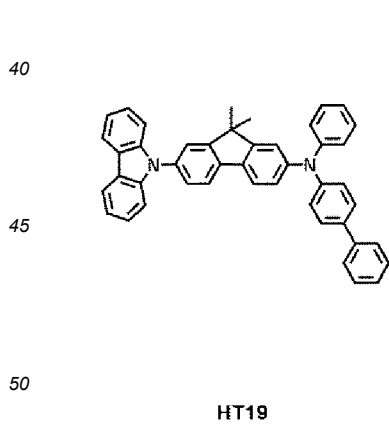
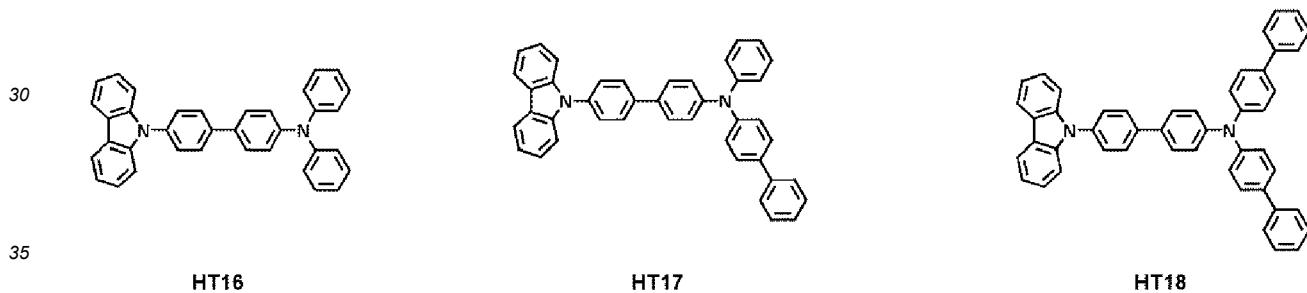
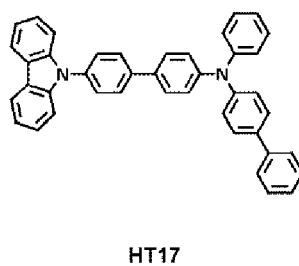
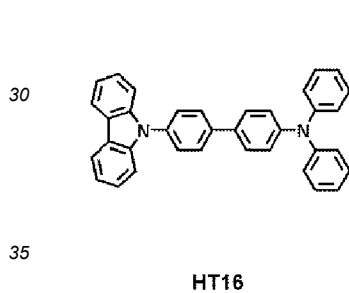
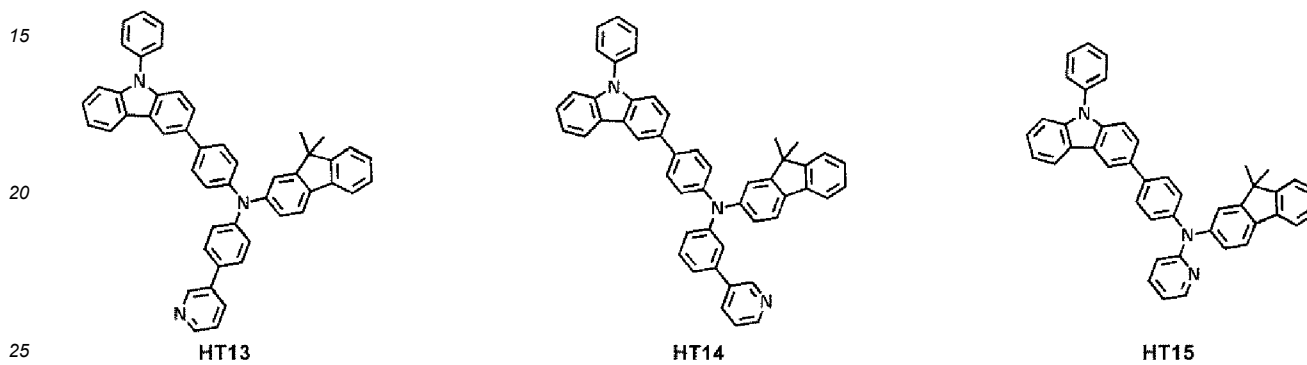
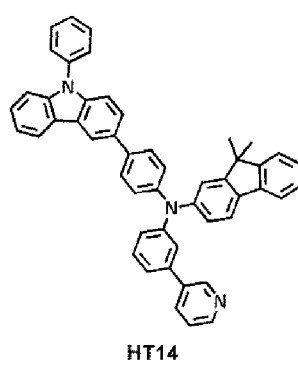
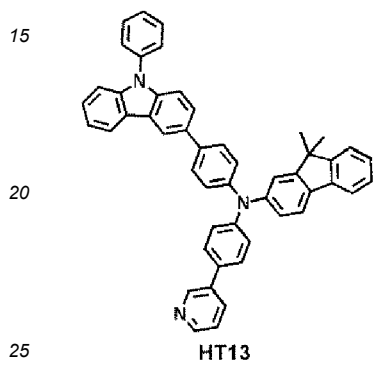
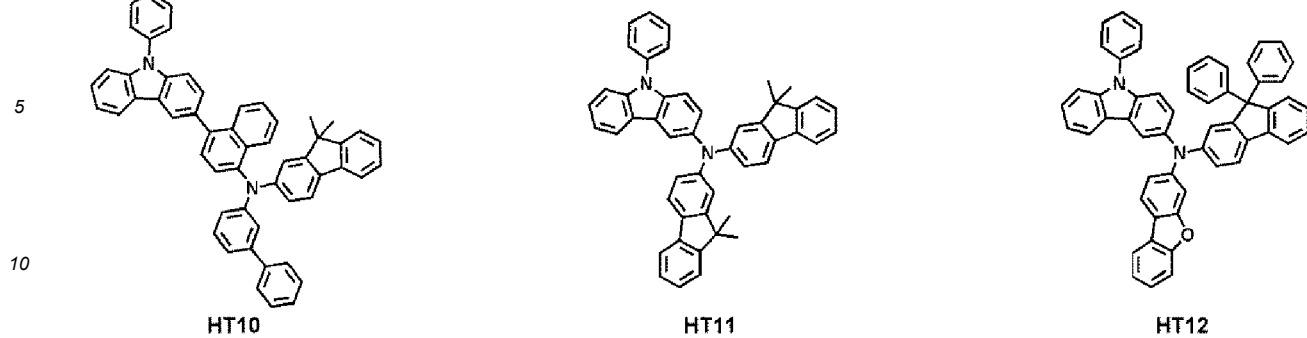
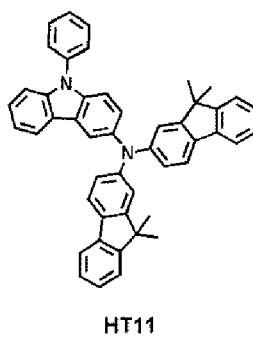
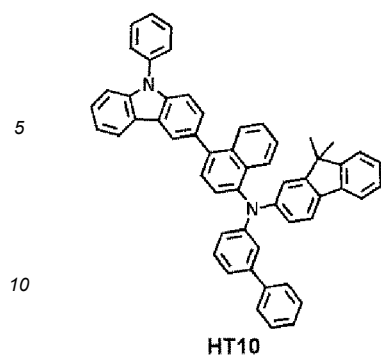
HT7



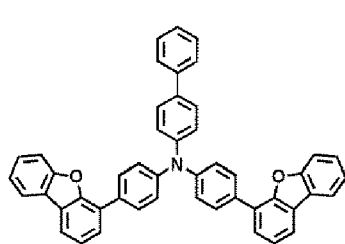
HT8



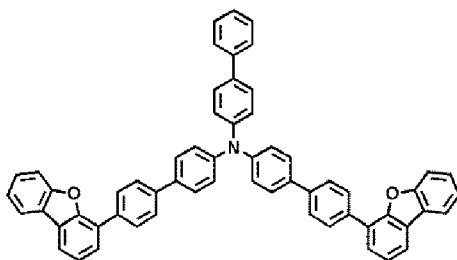
HT9



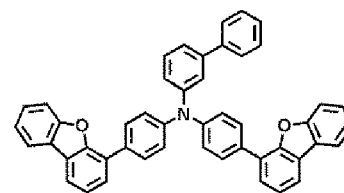
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HT22



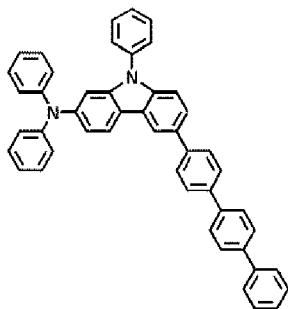
HT23



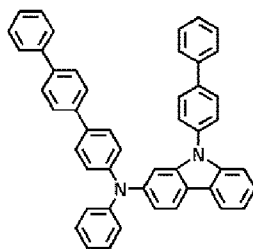
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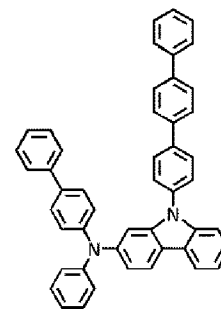
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HT25



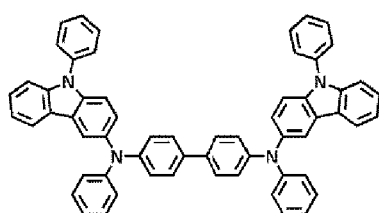
HT26



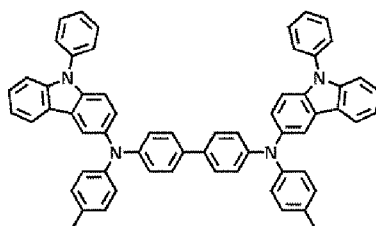
HT27

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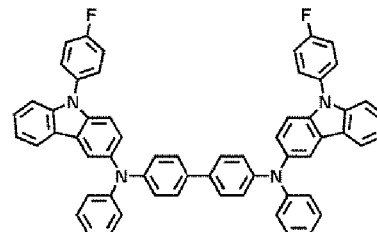
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HT28



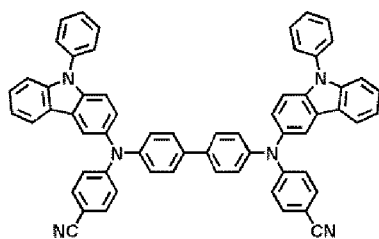
HT29



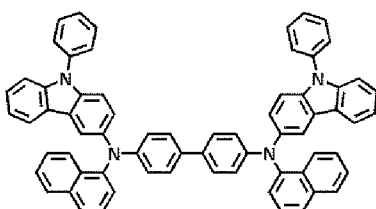
HT30

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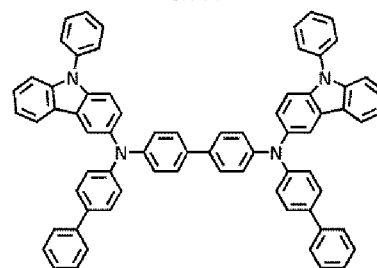
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HT31



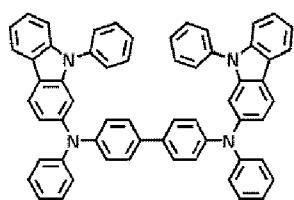
HT32



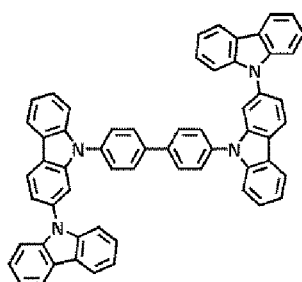
HT33

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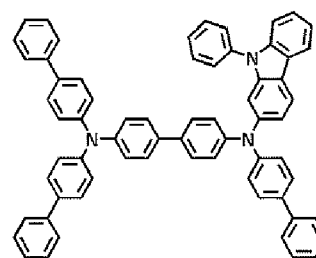
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HT34



HT35

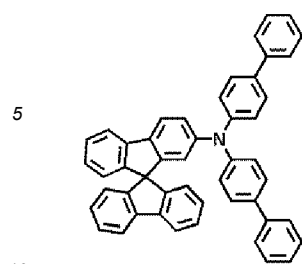


HT36

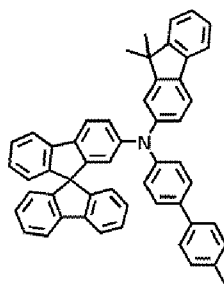
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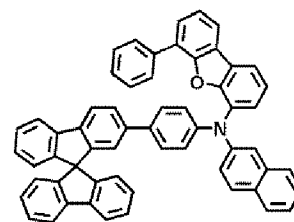




HT37



HT38



HT39

**[0092]** 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 7000 Å, about 100 Å to about 5000 Å, about 100 Å to about 3000 Å, or about 100 Å to about 1,000 Å. When the hole transport region includes 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 7,000 Å, about 100 Å to about 5,000 Å, about 100 Å to about 3,000 Å, about 100 Å to about 2,000 Å, about 100 Å to about 1,000 Å or about 100 Å to about 200 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, about 500 Å to about 1,500 Å, about 800 Å to about 1,500 Å, about 1,000 Å to about 1,500 Å, or about 1,100 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, suitable or satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

**[0093]** 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 include the materials as described above.

#### p-dopant

**[0094]** The hole transport region may further include, 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.

**[0095]** The charge-generation material may be, for example, a p-dopant.

**[0096]** In one embodiment, the p-dopant may have a LUMO level in a range of about -3.5 eV or less.

**[0097]** The p-dopant may include 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.

**[0098]** For example, the p-dopant may include at least one selected from:

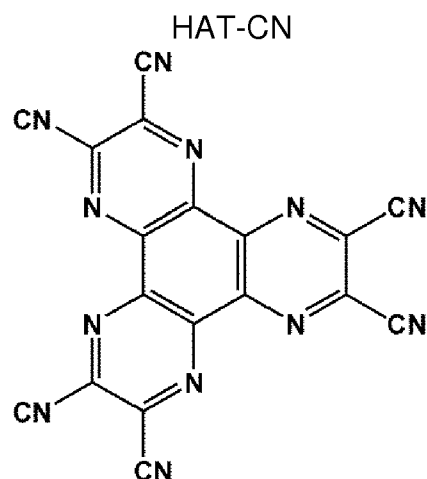
a quinone derivative, such as tetracyanoquinodimethane (TCNQ) or 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ);

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

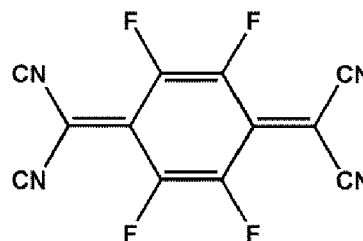
1,4,5,8,9,11 -hexaazatriphenylene-hexacarbonitrile (HAT-CN); and

a compound represented by Formula 221 below,

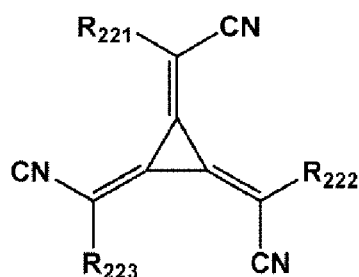
but embodiments of the present disclosure are not limited thereto:



F4-TCNQ



Formula 221



**[0099]** In Formula 221,

R<sub>221</sub> to R<sub>223</sub> may each independently 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> (e.g. C<sub>6</sub>-C<sub>32</sub>) aryl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, wherein at least one selected from R<sub>221</sub> to R<sub>223</sub> may have at least one substituent selected from a cyano group, -F, -Cl, -Br, -I, a C<sub>1</sub>-C<sub>20</sub> alkyl group substituted with -F, a C<sub>1</sub>-C<sub>20</sub> alkyl group substituted with -Cl, a C<sub>1</sub>-C<sub>20</sub> alkyl group substituted with -Br, and a C<sub>1</sub>-C<sub>20</sub> alkyl group substituted with -I.

#### Emission layer in organic layer 150

**[0100]** 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 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 include 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.

**[0101]** A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, for example, about 100 Å to about 800 Å, about 150 Å to about 800 Å, about 150 Å to about 700 Å, about 150 Å to about 650 Å, about 200 Å to about 600 Å or about 200 Å to about 400 Å. When the thickness of the emission layer is within this range, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

#### Electron transport region in organic layer 150

**[0102]** The electron transport region may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

**[0103]** The electron transport region may include 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.

**[0104]** 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 from an emission layer. However, embodiments of the structure of the electron transport region are not limited thereto.

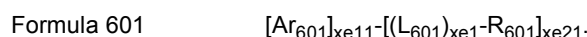
**[0105]** The electron transport region (for example, a buffer layer, a hole blocking layer, an electron control layer, or an electron transport layer in the electron transport region) may include a metal-free compound containing at least one  $\pi$  electron-depleted nitrogen-containing ring.

**[0106]** The term " $\pi$  electron-depleted nitrogen-containing ring," as used herein, indicates a  $C_1$ - $C_{60}$  (e.g. a  $C_1$ - $C_{30}$ ) heterocyclic group having at least one  $*-N=*$  moiety as a ring-forming moiety.

**[0107]** 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 (e.g., combined together), 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 (e.g., combined with) at least one  $C_5$ - $C_{60}$  (e.g. a  $C_5$ - $C_{30}$ ) carbocyclic group.

**[0108]** Examples of the  $\pi$  electron-depleted nitrogen-containing ring include 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, thiadiazole, an imidazopyridine, an imidazopyrimidine, and an azacarbazole, but are not limited thereto.

**[0109]** For example, the electron transport region may include a compound represented by Formula 601:



**[0110]** 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 polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

$xe1$  may be an integer from 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 polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,  $-Si(Q_{601})(Q_{602})(Q_{603})$ ,  $-C(=O)(Q_{601})$ ,  $-S(=O)_2(Q_{601})$ , 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 from 1 to 5.

**[0111]** 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 include the  $\pi$  electron-depleted nitrogen-containing ring.

**[0112]** For example,  $Ar_{601}$  may be a substituted or unsubstituted  $C_5$ - $C_{30}$  carbocyclic group or a substituted or unsubstituted  $C_1$ - $C_{20}$  heterocyclic group, but embodiments are not limited thereto.

**[0113]** 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 pen-

taphene 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

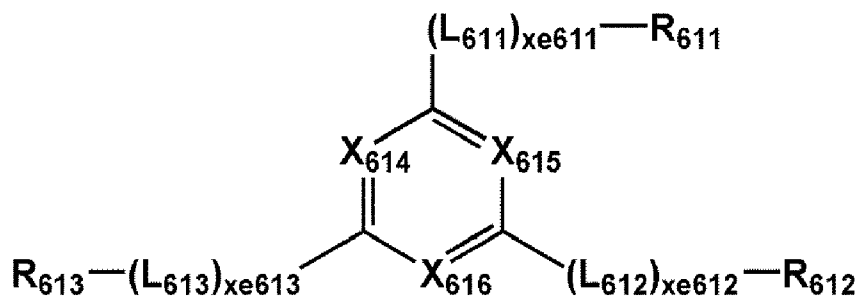
a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, 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>), 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.

**[0114]** When xe11 in Formula 601 is two or more, two or more Ar<sub>601</sub>(s) may be linked via a single bond.

**[0115]** In one or more embodiments, Ar<sub>601</sub> in Formula 601 may be an anthracene group.

**[0116]** In one or more embodiments, a compound represented by Formula 601 may be represented by Formula 601-1 :

Formula 601-1



**[0117]** 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 defined in connection with L<sub>601</sub>,

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

R<sub>611</sub> to R<sub>613</sub> may each independently be 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.

**[0118]** For example, 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 substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkylene group, a substituted or unsubstituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkylene group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenylene group, a substituted or unsubstituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkenylene group, a substituted or unsubstituted C<sub>6</sub>-C<sub>30</sub> arylene group, a substituted or unsubstituted C<sub>1</sub>-C<sub>20</sub> heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group, but embodiments are not limited thereto.

**[0119]** 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 anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a thiophenylenylene group, a furanylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylene group, a benzothiophenylenylene group, a dibenzofuranylene 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 quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene 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 fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a thiophenylenylene group, a furanylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylene group, a benzothiophenylenylene group, a dibenzofuranylene 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 quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene 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 quinoliny group, an isoquinoliny group, a benzoquinoliny group, a phthalazinyl group, a naphthyridinyl group, a quinoxaliny group, a quinazoliny group, a cinnoliny 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.

**[0120]** In one or more embodiments, xe1 and xe611 to xe613 in Formulae 601 and 601-1 may each independently be 0, 1, or 2.

**[0121]** For example, R<sub>601</sub> and R<sub>611</sub> to R<sub>613</sub> in Formulae 601 and 601-1 may each independently 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>30</sub> aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>30</sub> aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>30</sub> arylthio group, a substituted or unsubstituted C<sub>1</sub>-C<sub>20</sub> heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, -Si(Q<sub>601</sub>)(Q<sub>602</sub>)(Q<sub>603</sub>), -C(=O)(Q<sub>601</sub>), -S(=O)<sub>2</sub>(Q<sub>601</sub>), and -P(=O)(Q<sub>601</sub>)(Q<sub>602</sub>).

**[0122]** In one or more embodiments, R<sub>601</sub> and R<sub>611</sub> to R<sub>613</sub> in Formulae 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 fluoranthrenyl 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;

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 fluoranthrenyl 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 fluoranthrenyl 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

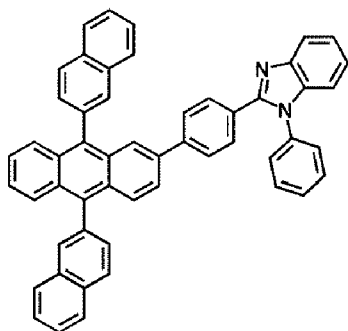
-S(=O)<sub>2</sub>(Q<sub>601</sub>) and -P(=O)(Q<sub>601</sub>)(Q<sub>602</sub>), and  
Q<sub>601</sub> and Q<sub>602</sub> are the same as described above.

**[0123]** The electron transport region may include at least one compound selected from Compounds ET1 to ET36, but embodiments of the present disclosure are not limited thereto:

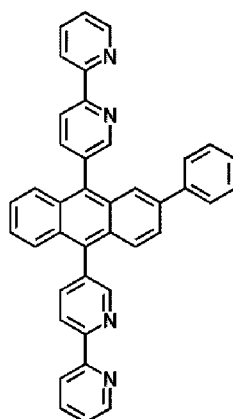
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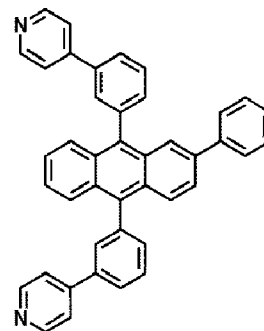
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ET1



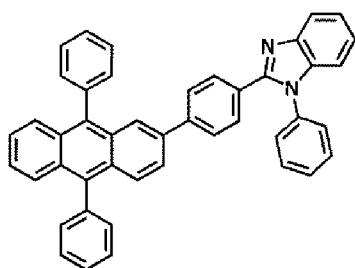
ET2



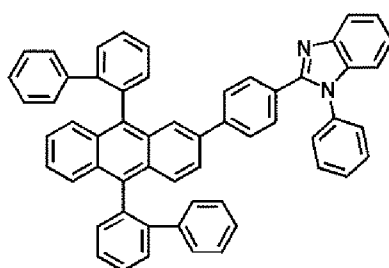
ET3

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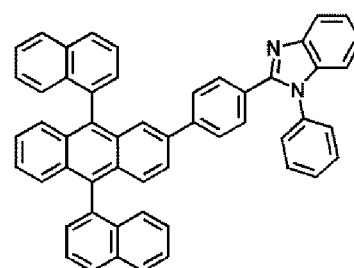
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ET4



ET5



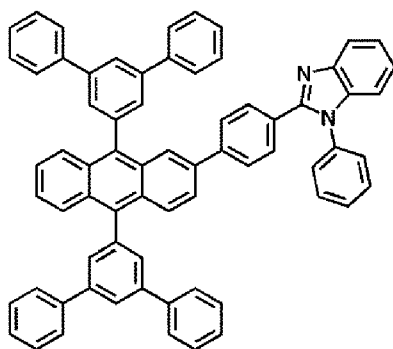
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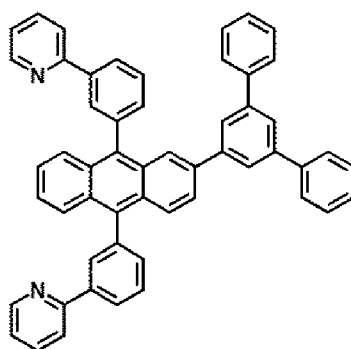
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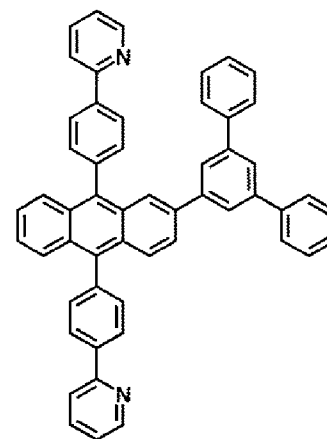
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ET7



ET8

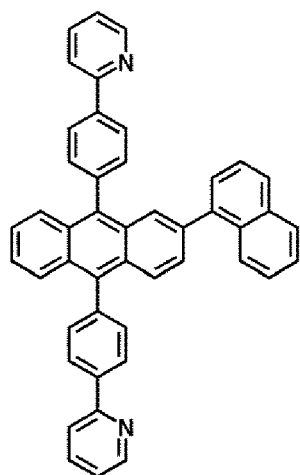


ET9

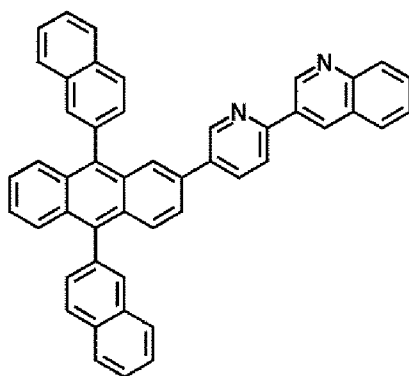
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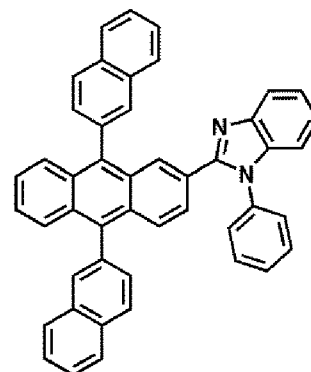
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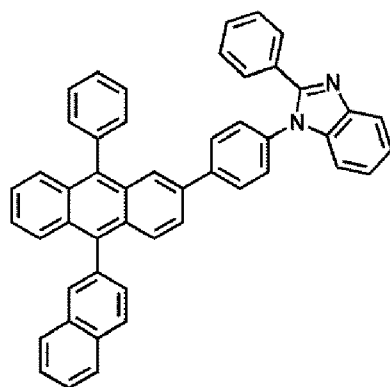
ET10



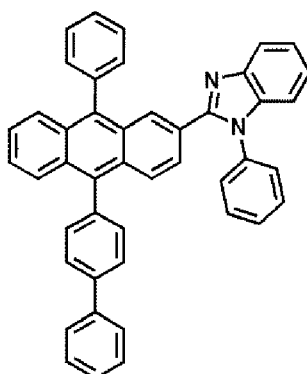
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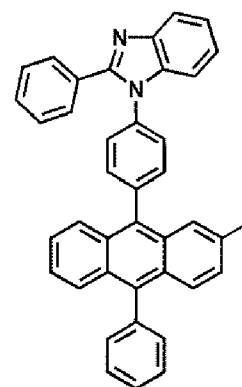
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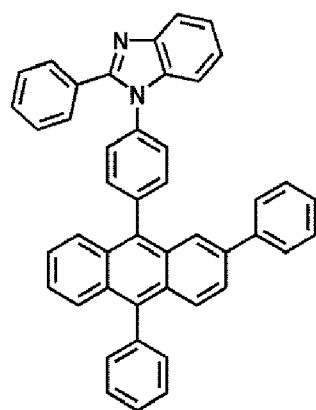
ET13



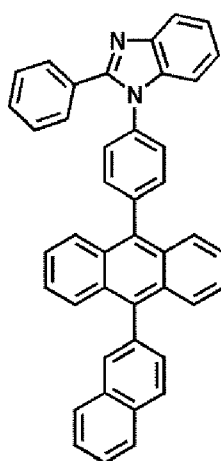
ET14



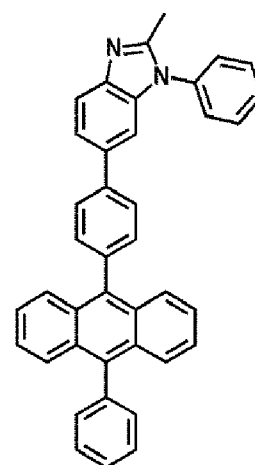
ET15



ET16



ET17



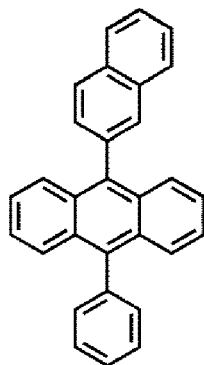
ET18



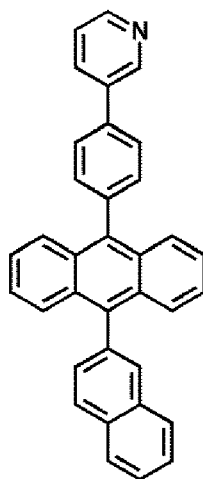
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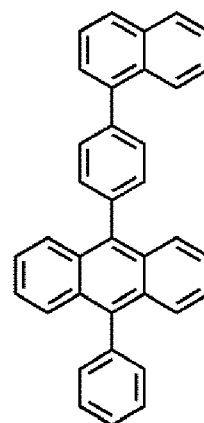
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ET19



ET20

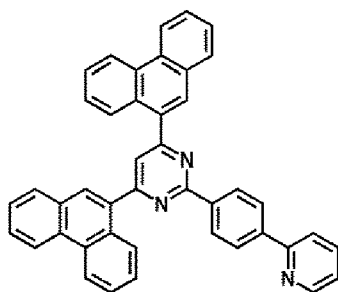


ET21

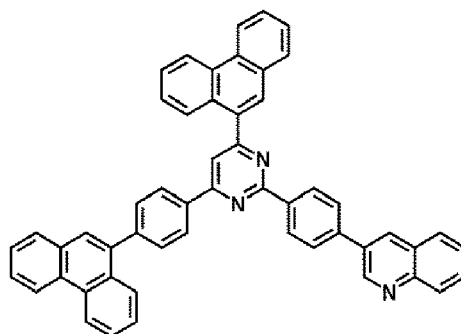
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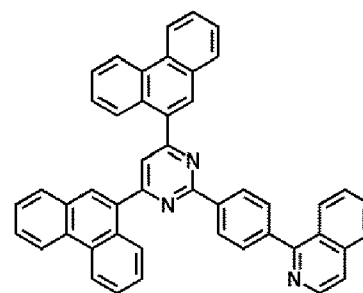
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ET22



ET23

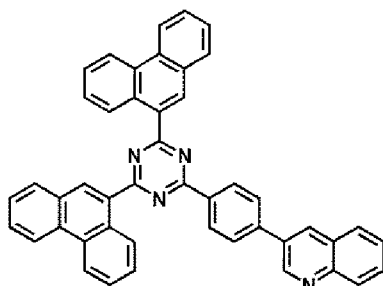


ET24

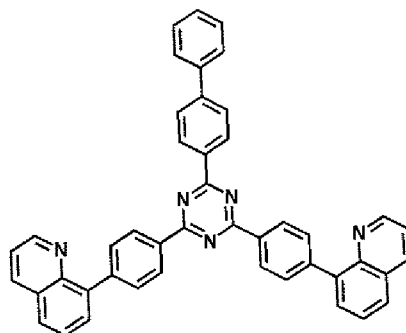
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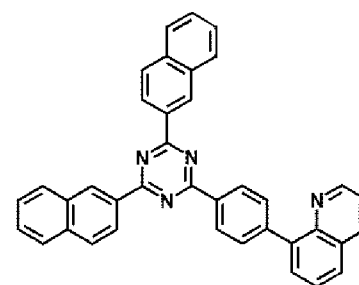
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ET25



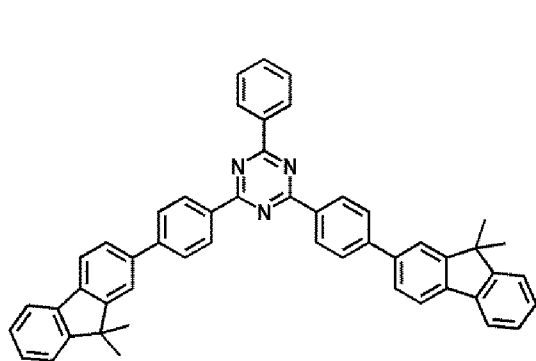
ET26



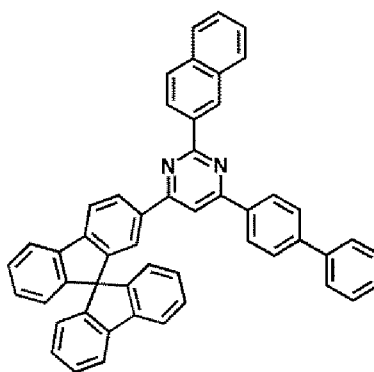
ET27

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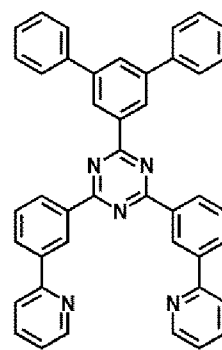
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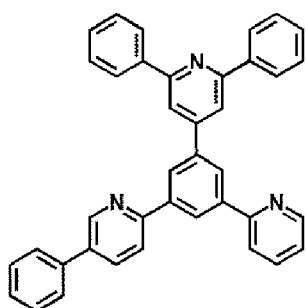
ET28



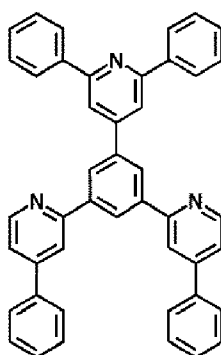
ET29



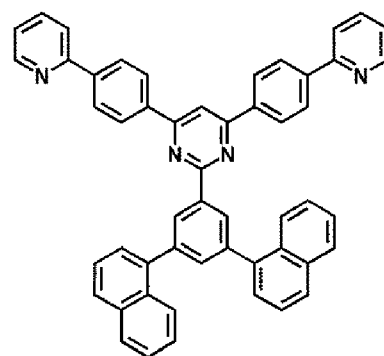
ET30



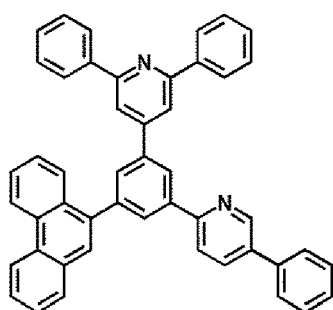
ET31



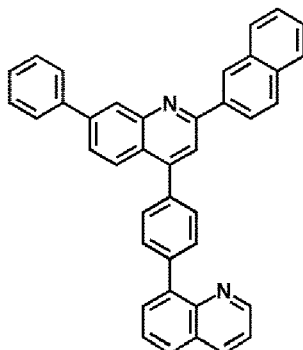
ET32



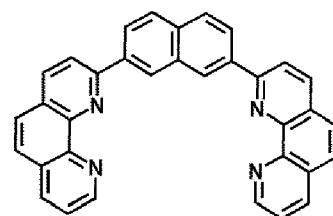
ET33



ET34

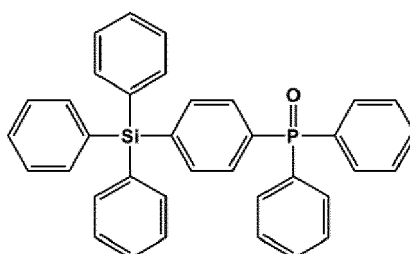
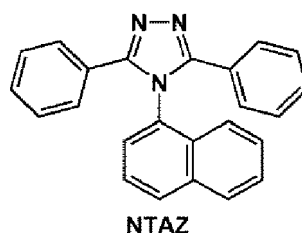
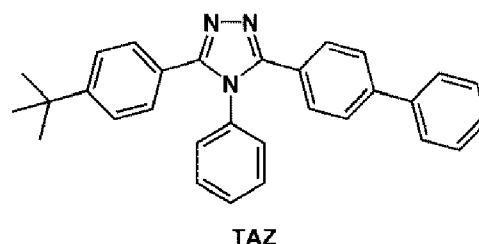
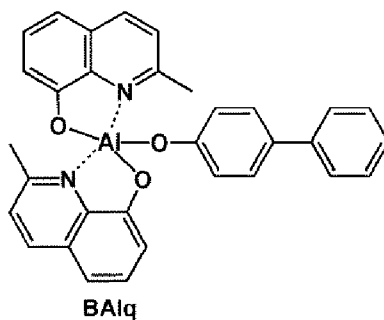
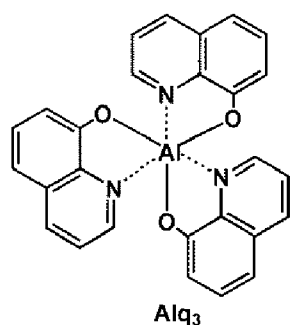


ET35



ET36

**[0124]** In one or more embodiments, the electron transport region may include 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>, BAQ, 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):



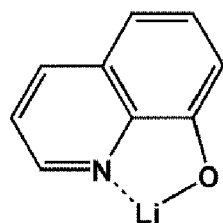
**[0125]** A thickness of the buffer layer, the hole blocking layer, or the electron control layer may be in a range of about 20 Å to about 1,000 Å, for example, about 20 Å to about 700 Å, about 20 Å to about 500 Å, about 20 Å to about 400 Å, about 30 Å to about 400 Å or about 30 Å to about 300 Å. When the thicknesses of the buffer layer, the hole blocking layer, and the electron control layer are within these ranges, the electron transport region may have excellent hole blocking characteristics or electron control characteristics without a substantial increase in driving voltage.

**[0126]** A thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, for example, about 100 Å to about 700 Å, about 100 Å to about 600 Å, about 150 Å to about 600 Å, about 150 Å to about 500 Å or about 250 Å to about 350 Å. When the thickness of the electron transport layer is within the range described above, the electron transport layer may have suitable or satisfactory electron transport characteristics without a substantial increase in driving voltage.

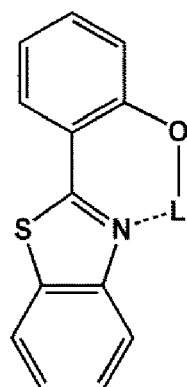
**[0127]** The electron transport region (for example, the electron transport layer in the electron transport region) may further include, in addition to the materials described above, a metal-containing material.

**[0128]** The metal-containing material may include at least one selected from an alkali metal complex and an alkaline earth-metal complex. The alkali metal complex may include 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 include 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 diphenylthiadiazole, 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.

**[0129]** For example, the metal-containing material may include a Li complex. The Li complex may include, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2.



ET-D1



ET-D2

**[0130]** The electron transport region may include 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.

**[0131]** The electron injection layer may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

**[0132]** The electron injection layer may include 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.

**[0133]** The alkali metal may be selected from Li, Na, K, Rb, and Cs. In one embodiment, the alkali metal may be Li, Na, or Cs. In one or more embodiments, the alkali metal may be Li or Cs, but embodiments of the present disclosure are not limited thereto.

**[0134]** The alkaline earth metal may be selected from Mg, Ca, Sr, and Ba.

**[0135]** The rare earth metal may be selected from Sc, Y, Ce, Tb, Yb, and Gd.

**[0136]** 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, or iodides) of the alkali metal, the alkaline earth-metal, and the rare earth metal.

**[0137]** The alkali metal compound may be selected from alkali metal oxides, such as  $\text{Li}_2\text{O}$ ,  $\text{Cs}_2\text{O}$ , or  $\text{K}_2\text{O}$ , and alkali metal halides, such as  $\text{LiF}$ ,  $\text{NaF}$ ,  $\text{CsF}$ ,  $\text{KF}$ ,  $\text{LiI}$ ,  $\text{NaI}$ ,  $\text{CsI}$ , or  $\text{KI}$ . In one embodiment, the alkali metal compound may be selected from  $\text{LiF}$ ,  $\text{Li}_2\text{O}$ ,  $\text{NaF}$ ,  $\text{LiI}$ ,  $\text{NaI}$ ,  $\text{CsI}$ , and  $\text{KI}$ , but embodiments of the present disclosure are not limited thereto.

**[0138]** The alkaline earth-metal compound may be selected from alkaline earth-metal oxides, such as  $\text{BaO}$ ,  $\text{SrO}$ ,  $\text{CaO}$ ,  $\text{Ba}_x\text{Sr}_{1-x}\text{O}$  ( $0 < x < 1$ ),  $\text{Ba}_x\text{Ca}_{1-x}\text{O}$  ( $0 < x < 1$ ). In one embodiment, the alkaline earth-metal compound may be selected from  $\text{BaO}$ ,  $\text{SrO}$ , and  $\text{CaO}$ , but embodiments of the present disclosure are not limited thereto.

**[0139]** The rare earth metal compound may be selected from  $\text{YbF}_3$ ,  $\text{ScF}_3$ ,  $\text{Sc}_2\text{O}_3$ ,  $\text{Y}_2\text{O}_3$ ,  $\text{Ce}_2\text{O}_3$ ,  $\text{GdF}_3$ , 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.

**[0140]** The alkali metal complex, the alkaline earth-metal complex, and the rare earth metal complex may include 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 diphenylthiadiazole, hydroxy phenylpyridine, hydroxy phenylbenzimidazole, hydroxy phenylbenzothiazole, bipyridine, phenanthroline, and cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

**[0141]** The electron injection layer may consist of 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 include an organic material. When the electron injection layer further includes 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 including the organic material.

**[0142]** 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 or about 3 Å to about 20 Å. When the thickness of the electron injection layer is within the range described above, the electron injection layer may have suitable or satisfactory electron injection characteristics without

a substantial increase in driving voltage.

## Second electrode 190

**[0143]** The second electrode 190 may be 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 metal, an alloy, an electrically conductive compound, and a combination thereof, which have a relatively low work function.

**[0144]** The second electrode 190 may include at least one selected from lithium (Li), silver (Ag), magnesium (Mg), aluminium (Al), aluminium-lithium (Al-Li), calcium (Ca), magnesium-indium (Mg-In), magnesium-silver (Mg-Ag), indium tin oxide (ITO), and indium zinc oxide (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.

**[0145]** The second electrode 190 may have a single-layered structure, or a multi-layered structure including two or more layers.

## Description of FIGS. 2 to 4

**[0146]** An organic light-emitting device 20 of FIG. 2 includes 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 includes 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. An organic light-emitting device 40 of FIG. 4 includes a first capping layer 210, a first electrode 110, an organic layer 150, a second electrode 190, and a second capping layer 220.

**[0147]** 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.

**[0148]** 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.

**[0149]** The first capping layer 210 and the second capping layer 220 may increase external luminescent efficiency according to the principle of constructive interference.

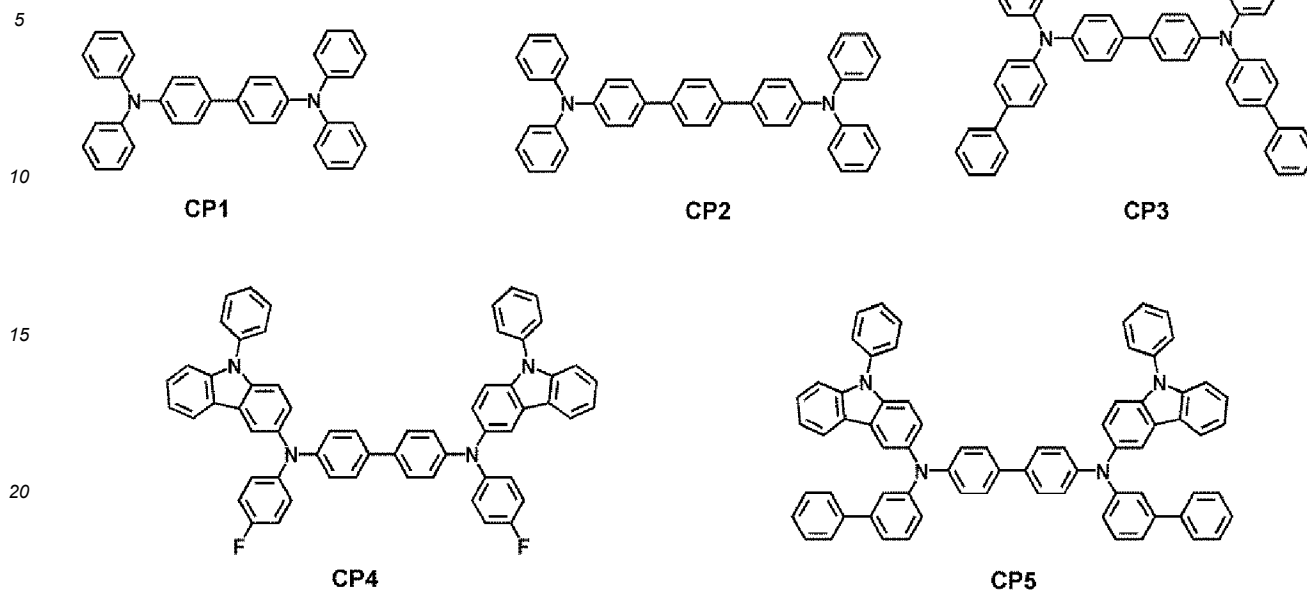
**[0150]** The first capping layer 210 and the second capping layer 220 may each independently be an organic capping layer including an organic material, an inorganic capping layer including an inorganic material, or a composite capping layer including an organic material and an inorganic material.

**[0151]** At least one selected from the first capping layer 210 and the second capping layer 220 may each independently include at least one material selected from carbocyclic compounds, heterocyclic compounds, amine-based compounds, porphyrine derivatives, phthalocyanine derivatives, a 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 at least one element selected from O, N, S, Se, Si, F, Cl, Br, and I.

**[0152]** In one embodiment, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently include an amine-based compound.

**[0153]** In one embodiment, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently include the compound represented by Formula 201 or the compound represented by Formula 202.

**[0154]** In one or more embodiments, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently include a compound selected from Compounds HT28 to HT33 and Compounds CP1 to CP5, but embodiments of the present disclosure are not limited thereto.



**[0155]** 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.

**[0156]** Layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region may be formed in a certain region by using 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.

**[0157]** 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 in a range of about 100 °C to about 500 °C, a vacuum degree in a range of about  $10^{-8}$  torr to about  $10^{-3}$  torr, and a deposition speed in a range of about 0.01 Å/sec to about 100 Å/sec by taking into account a material to be included in a layer to be formed, and the structure of a layer to be formed.

**[0158]** 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 in a range of about 2,000 rpm to about 5,000 rpm and at a heat treatment temperature in a range of about 80 °C to 200 °C by taking into account a material to be included in a layer to be formed, and the structure of a layer to be formed.

#### Display device

**[0159]** The organic light-emitting device may be included in a display device including a thin-film transistor. The thin-film transistor may include a source electrode, a drain electrode, and an active layer, and one of the source electrode and the drain electrode may electrically contact a first electrode of the organic light-emitting device.

**[0160]** The thin-film transistor may further include a gate electrode, a gate insulation layer, or the like.

**[0161]** The active layer may include crystalline silicon, amorphous silicon, an organic semiconductor, an oxide semiconductor, or the like, but embodiments of the present disclosure are not limited thereto.

**[0162]** The display apparatus may further include a sealing member that seals the organic light-emitting device. The sealing member may enable to implement an image from the organic light-emitting device, and may prevent or reduce penetration of external air and moisture into the organic light-emitting device. The sealing member may be a sealing substrate made of glass or plastic. The sealing member may be a thin-film encapsulation layer including a plurality of organic layers and/or a plurality of inorganic layers. When sealing member is a thin-film encapsulation layer, the whole flat display apparatus may be made flexible.

#### General definition of at least some of the substituents

**[0163]** The term " $\pi$  electron-depleted nitrogen-containing cyclic group," as used herein, refers to a cyclic group including at least one  $-N=$  moiety, and examples of the  $\pi$  electron-depleted nitrogen-containing ring include 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, a thiadiazol group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group, but are not limited thereto.

**[0164]** The term " $\pi$  electron-depleted nitrogen-free cyclic group," as used herein, refers to a cyclic group that does not include nitrogen, and examples of the  $\pi$  electron-depleted nitrogen-free cyclic group may include 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 corogene 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.

**[0165]** The term " $C_1$ - $C_{60}$  alkyl group," as used herein, refers to a linear or branched saturated aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms, and examples thereof include 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 " $C_1$ - $C_{60}$  alkylene group," as used herein, refers to a divalent group having substantially the same structure as the  $C_1$ - $C_{60}$  alkyl group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkyl/alkylene group.

**[0166]** The term " $C_2$ - $C_{60}$  alkenyl group," as used herein, refers to a hydrocarbon group having at least one carbon-carbon double bond at a main chain (e.g., in the middle) or at a terminal end (e.g., at the terminus) of the  $C_2$ - $C_{60}$  alkyl group, and examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term " $C_2$ - $C_{60}$  alkenylene group," as used herein, refers to a divalent group having substantially the same structure as the  $C_2$ - $C_{60}$  alkenyl group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkenyl/alkenylene group.

**[0167]** The term " $C_2$ - $C_{60}$  alkynyl group," as used herein, refers to a hydrocarbon group having at least one carbon-carbon triple bond at a main chain (e.g., in the middle) or at a terminal end (e.g., at the terminus) of the  $C_2$ - $C_{60}$  alkyl group, and examples thereof include an ethynyl group, and a propynyl group. The term " $C_2$ - $C_{60}$  alkynylene group," as used herein, refers to a divalent group having substantially the same structure as the  $C_2$ - $C_{60}$  alkynyl group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkynyl/alkynylene group.

**[0168]** The term " $C_1$ - $C_{60}$  alkoxy group," as used herein, refers to a monovalent group represented by  $-OA_{101}$  (wherein  $A_{101}$  is the  $C_1$ - $C_{60}$  alkyl group), and examples thereof include a methoxy group, an ethoxy group, and an isopropoxy group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkoxy group.

**[0169]** The term " $C_3$ - $C_{10}$  cycloalkyl group," as used herein, refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term " $C_3$ - $C_{10}$  cycloalkylene group," as used herein refers to a divalent group having substantially the same structure as the  $C_3$ - $C_{10}$  cycloalkyl group.

**[0170]** The term " $C_1$ - $C_{10}$  heterocycloalkyl group," as used herein, refers to a monovalent monocyclic group having at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom and 1 to 10 carbon atoms, and examples thereof include a 1,2,3,4-oxatriazolidinyl group, a tetrahydrofuran group, and a tetrahydrothiophenyl group. The term " $C_1$ - $C_{10}$  heterocycloalkylene group," as used herein, refers to a divalent group having substantially the same structure as the  $C_1$ - $C_{10}$  heterocycloalkyl group.

**[0171]** The term " $C_3$ - $C_{10}$  cycloalkenyl group," as used herein, refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one carbon-carbon double bond in the ring thereof and no aromaticity, and examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term " $C_3$ - $C_{10}$  cycloalkenylene group," as used herein, refers to a divalent group having substantially the same structure as the  $C_3$ - $C_{10}$  cycloalkenyl group.

**[0172]** The term " $C_1$ - $C_{10}$  heterocycloalkenyl group," as used herein, refers to a monovalent monocyclic group that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, 1 to 10 carbon atoms, and at least one carbon-carbon double bond in its ring. Non-limiting examples of the  $C_1$ - $C_{10}$  heterocycloalkenyl group include a 4,5-dihydro-1,2,3,4-oxatriazolyl group, a 2,3-dihydrofuran group, and a 2,3-dihydrothiophenyl group. The term " $C_1$ - $C_{10}$  heterocycloalkenylene group," as used herein, refers to a divalent group having substantially the same structure as the

C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group.

**[0173]** 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, and a C<sub>6</sub>-C<sub>60</sub> arylene group used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 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 include two or more rings, the rings may be fused to each other (e.g., combined together). Corresponding definitions apply to other ranges given for the number of carbon atoms in an aryl/arylene group.

**[0174]** 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 selected from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 1 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 from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 60 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 include two or more rings, the rings may be fused to each other (e.g., combined together). Corresponding definitions apply to other ranges given for the number of carbon atoms in a heteroaryl/heteroarylene group.

**[0175]** The term "C<sub>6</sub>-C<sub>60</sub> aryloxy group," as used herein, indicates -OA<sub>102</sub> (wherein A<sub>102</sub> is the C<sub>6</sub>-C<sub>60</sub> aryl group), and a C<sub>6</sub>-C<sub>60</sub> arylthio group indicates -SA<sub>103</sub> (wherein A<sub>103</sub> is the C<sub>6</sub>-C<sub>60</sub> aryl group). Corresponding definitions apply to other ranges given for the number of carbon atoms in an aryloxy group and an arylthio group.

**[0176]** The term "C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group," as used herein, indicates -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>1</sub>-C<sub>60</sub> heteroarylthio group," as used herein, indicates -SA<sub>105</sub> (wherein A<sub>105</sub> is the C<sub>1</sub>-C<sub>60</sub> heteroaryl group).

**[0177]** The term "monovalent non-aromatic condensed polycyclic group," as used herein, refers to a monovalent group (for example, having 8 to 60 carbon atoms) having two or more rings condensed with each other (e.g., combined together), only carbon atoms as ring-forming atoms, and no aromaticity in its entire molecular structure. An example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. The term "divalent non-aromatic condensed polycyclic group," as used herein, refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed polycyclic group.

**[0178]** The term "monovalent non-aromatic condensed heteropolycyclic group," as used herein, refers to a monovalent group (for example, having 1 to 60 carbon atoms) having two or more rings condensed to each other (e.g., combined together), at least one heteroatom selected from N, O, Si, P, and S, other than carbon atoms, as a ring-forming atom, and no aromaticity in its entire molecular structure. An example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazoyl group. The term "divalent non-aromatic condensed heteropolycyclic group," as used herein, refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

**[0179]** 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 in which a ring-forming atom is a carbon atom only. 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. Corresponding definitions apply to other ranges given for the number of carbon atoms in a carbocyclic group.

**[0180]** The term "C<sub>1</sub>-C<sub>60</sub> heterocyclic group," as used herein, refers to a group having substantially 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 selected from N, O, Si, P, and S is used in addition to carbon (the number of carbon atoms may be in a range of 1 to 60). Corresponding definitions apply to other ranges given for the number of carbon atoms in a heterocyclic group.

**[0181]** In the present specification, at least one substituent of the substituted C<sub>5</sub>-C<sub>60</sub> (e.g. C<sub>5</sub>-C<sub>30</sub>) carbocyclic group, the substituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heterocyclic group, the substituted C<sub>3</sub>-C<sub>10</sub> cycloalkylene group, the substituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkylene group, the substituted C<sub>3</sub>-C<sub>10</sub> cycloalkenylene group, the substituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkenylene group, the substituted C<sub>6</sub>-C<sub>60</sub> arylene group, the substituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, the substituted C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkenyl group, the substituted C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkynyl group, the substituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkoxy group, the substituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, the substituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, the substituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, the substituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, the substituted C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryl group, the substituted C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryloxy group, the substituted C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) arylthio group, the substituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryl group, the substituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryloxy group, the substituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) hetero-



oarylthio group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be 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> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkenyl group, a C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkoxy group;

a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkenyl group, a C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</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> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryl group, a C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryloxy group, a C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) arylthio group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed 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>);

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> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryl group, a C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryloxy group, a C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) arylthio group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>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> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryl group, a C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryloxy group, a C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) arylthio group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed 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> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkenyl group, a C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkynyl group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</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> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryl group, a C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryloxy group, a C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) arylthio group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, -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 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> (e.g. C<sub>1</sub>-C<sub>20</sub>) alkyl group, a C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkenyl group, a C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>20</sub>) alkynyl group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</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> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryl group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</sub>) heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>20</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> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryl group substituted with at least one selected from deuterium, -F, and a cyano group, a biphenyl group, and a terphenyl group.

**[0182]** 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 "Bu<sup>t</sup>," as used herein, refers to a tert-butyl group, and the term "OMe," as used herein, refers to a methoxy group.

**[0183]** 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.

**[0184]** 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.

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

**[0185]** 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 used instead of A" used in describing Synthesis Examples refers to that an identical molar equivalent of B was used in place of A.

**Examples****Example 1**

**[0186]** 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 each for 5 minutes, and then cleaned by exposure to ultraviolet rays and ozone for 30 minutes. Then, the ITO substrate was provided to a vacuum deposition apparatus.

**[0187]** Compound HT3 and F4-TCNQ were vacuum-deposited on the ITO substrate to 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 1-1, 2-27, and 3-29 were co-deposited on the hole transport layer to a weight ratio of 50:50:3 to form an emission layer having a thickness of 200 Å. Compound ET-1 and LiQ were co-deposited on the emission layer to 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 were co-deposited on the electron injection layer to a weight ratio of 130:10 to form a cathode having a thickness of 130 Å, thereby completing the manufacture of an organic light-emitting device.

**Examples 2 to 14 and Comparative Examples 1 and 2**

**[0188]** Organic light-emitting devices were manufactured in substantially the same manner as in Example 1, except that Compounds shown in Table 1 were each used in forming an emission layer.

**Example 15**

**[0189]** 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 each for 5 minutes, and then cleaned by exposure to ultraviolet rays and ozone for 30 minutes. Then, the ITO substrate was provided to a vacuum deposition apparatus.

**[0190]** Compound HT3 and F4-TCNQ were vacuum-deposited on the ITO substrate to 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 1,400 Å, and Compounds 1-1, 2-30, and 3-20 were co-deposited on the hole transport layer to a weight ratio of 50:50:3 to form an emission layer having a thickness of 400 Å. Compound ET-1 and LiQ were co-deposited on the emission layer to 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, Mg and Ag were co-deposited on the electron injection layer to a weight ratio of 130:10 to form a cathode having a thickness of 130 Å, thereby completing the manufacture of an organic light-emitting device.

**Examples 16 to 18 and Comparative Example 3**

**[0191]** Organic light-emitting devices were manufactured in substantially the same manner as in Example 15, except that Compounds shown in Table 2 were each used in forming an emission layer.

**Evaluation Example**

**[0192]** Current efficiencies of the organic light-emitting devices manufactured according to Examples 1 to 14 and Comparative Examples 1 and 2 were measured at a current density of 10 mA/cm<sup>2</sup> by using Keithley SMU 236 and a luminance meter PR650, and results thereof are shown in Table 1. Current efficiencies of the organic light-emitting devices manufactured according to Examples 15 to 18 and Comparative Example 3 were measured at a current density of 10 mA/cm<sup>2</sup> by using Keithley SMU 236 and a luminance meter PR650, and results thereof are shown in Table 2. In addition, the lifespan is expressed by a relative value with respect to Comparative Example 1 or Comparative Example 3.

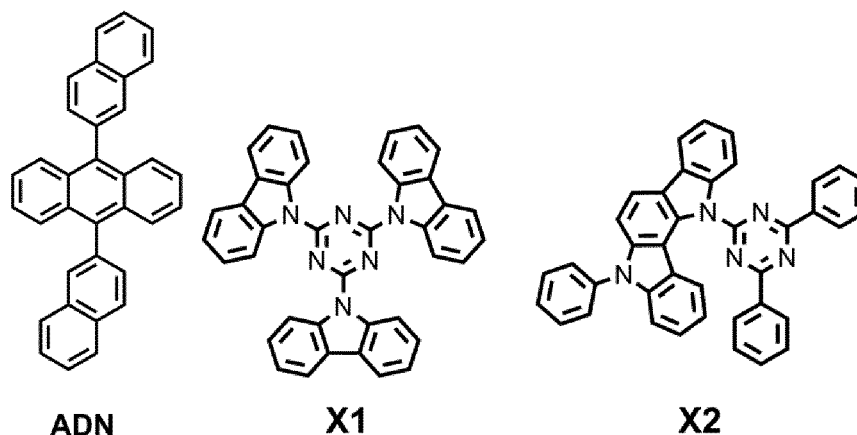
# EP 3 686 947 A1

Table 1

	Emission layer				Emission color	Efficiency (cd/A)	Lifespan (%)
	First compound	Second compound	Third compound	Weight ratio (first compound: second compound: third compound)			
Example 1	1-1	2-27	3-29	50:50:3	Blue	8.2	180
Example 2	1-1	2-27	3-29	70:30:3	Blue	7.9	205
Example 3	1-1	2-27	3-29	30:70:3	Blue	8.3	165
Example 4	1-1	2-27	3-29	50:50:1	Blue	8.5	200
Example 5	1-2	2-27	3-29	50:50:3	Blue	8.3	195
Example 6	1-5	2-27	3-29	50:50:3	Blue	8.1	205
Example 7	1-17	2-27	3-29	50:50:3	Blue	8.5	210
Example 8	1-61	2-27	3-29	50:50:3	Blue	8.2	175
Example 9	1-1	2-3	3-29	50:50:3	Blue	8.2	190
Example 10	1-1	2-23	3-29	50:50:3	Blue	8.4	200
Example 11	1-1	2-32	3-29	50:50:3	Blue	8.1	185
Example 12	1-1	2-44	3-29	50:50:3	Blue	8.6	220
Example 13	1-1	2-50	3-29	50:50:3	Blue	8.3	180
Example 14	1-1	2-28	3-29	50:50:3	Blue	8.4	180
Comparative Example 1	1-1	-	3-29	97:3	Blue	6.1	100
Comparative Example 2	-	2-27	3-29	97:3	Blue	6.7	140

Table 2

	Emission layer				Emission color	Efficiency (cd/A)	Lifespan (%)
	First compound	Second compound	Third compound	Weight ratio (first compound: second compound: third compound)			
Example 15	1-1	2-30	3-20	50:50:3	Green	48	250
Example 16	1-1	2-32	3-20	50:50:3	Green	52	260
Example 17	1-1	2-44	3-20	50:50:3	Green	55	305
Example 18	1-1	2-50	3-20	50:50:3	Green	50	300
Comparative Example 3	1-1	X1	X2	40:40:20	Bluish green	6.9	100



**[0193]** From Tables 1 and 2, it is confirmed that the organic light-emitting devices of Examples 1 to 18 have excellent current efficiency and lifespan as compared with those of the organic light-emitting devices of Comparative Examples 1 to 3.

**[0194]** The organic light-emitting device may have high efficiency and a long lifespan.

**[0195]** 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.

**[0196]** It will be understood that, although the terms "first," "second," "third," etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section described below could be termed a second element, component, region, layer or section, without departing from the spirit and scope of the present disclosure.

**[0197]** Spatially relative terms, such as "beneath," "below," "lower," "under," "above," "upper," and the like, may be used herein for ease of explanation to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or in operation, in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" or "under" other elements or features would then be oriented "above" the other elements or features. Thus, the example terms "below" and "under" can encompass both an orientation of above and below. The device may be otherwise oriented (e.g., rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein should be interpreted accordingly.

**[0198]** 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." As used herein, the terms "use," "using," and "used" may be considered synonymous with the terms "utilize," "utilizing," and "utilized," respectively.

**[0199]** Also, any numerical range recited herein is intended to include 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 include all subranges between (and including) 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 include all lower numerical limitations subsumed therein, and any minimum numerical limitation recited in this specification is intended to include all higher numerical limitations subsumed therein.

**[0200]** 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 of the present disclosure as defined by the following claims.

## Claims

1. An organic light-emitting device comprising:

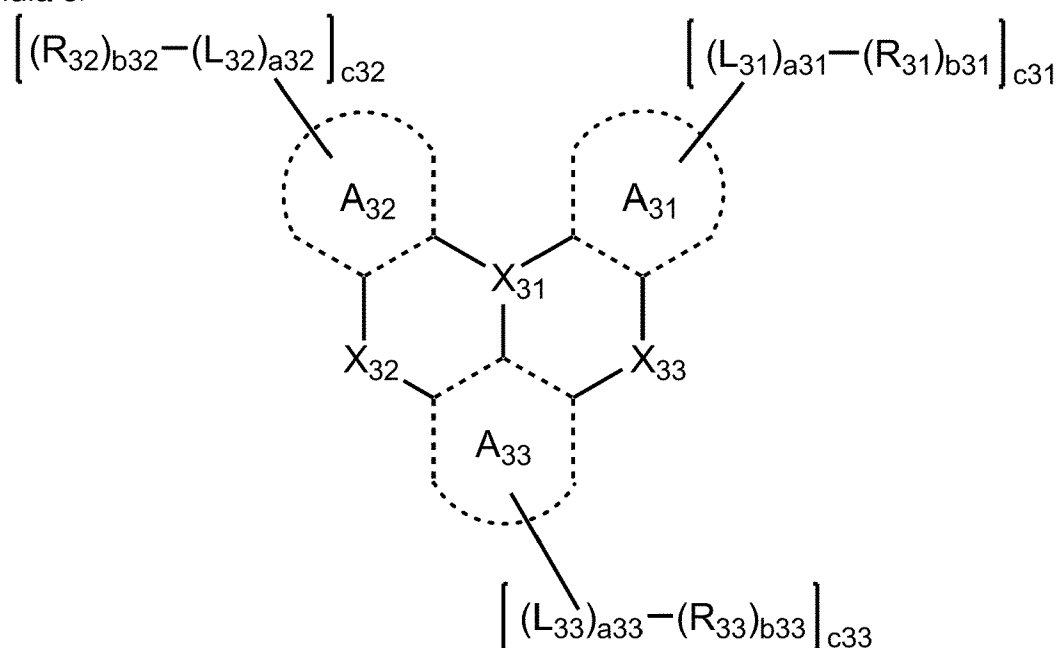
a first electrode;

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:

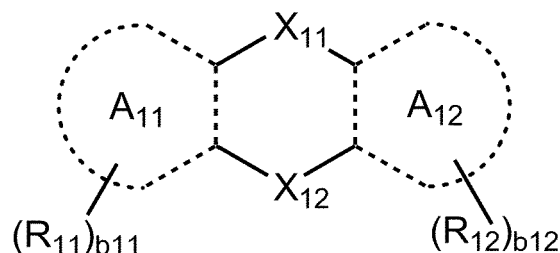
<Formula 1>  $(Y_{11})_{c11}-(L_{11})_{a11}-(Y_{12})_{c12}$

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

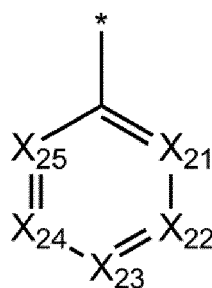
<Formula 3>



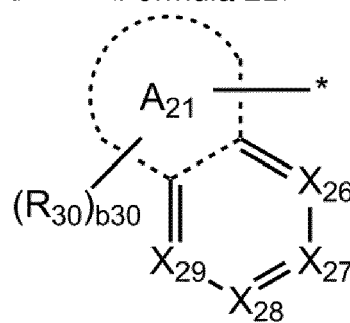
&lt;Formula 1A&gt;



&lt;Formula 2A&gt;



&lt;Formula 2B&gt;



wherein, in Formulae 1 to 3, 1A, 2A, and 2B,

$L_{11}$  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,

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

$Y_{12}$  is selected from:

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  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ ,

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

$X_{11}$  is selected from a single bond,  $\text{C}(\text{R}_{13})(\text{R}_{14})$ ,  $\text{N}(\text{R}_{13})$ , O, and S,

$X_{12}$  is selected from a single bond,  $\text{C}(\text{R}_{15})(\text{R}_{16})$ ,  $\text{N}(\text{R}_{15})$ , O, and S,

$X_{11}$  and  $X_{12}$  are not both a single bond,

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

$R_{11}$  to  $R_{16}$  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  $R_{13}$  and  $R_{15}$  is a binding site,

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

L<sub>21</sub> is selected from:

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

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

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

Y<sub>21</sub> is a group represented by Formula 2A or 2B,

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

-F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic group, a  $\pi$  electron-depleted nitrogen-free cyclic group, and -Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>);

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 deuterium, -F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic 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-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group, each substituted with at least one selected from a  $\pi$  electron-depleted nitrogen-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group that are each 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, a  $\pi$  electron-depleted nitrogen-free cyclic group, and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>),

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

A<sub>21</sub> is selected from a C<sub>5</sub>-C<sub>60</sub> carbocyclic group and a C<sub>1</sub>-C<sub>60</sub> heterocyclic group,

X<sub>21</sub> is selected from C(R<sub>21</sub>) and N, X<sub>22</sub> is selected from C(R<sub>22</sub>) and N, X<sub>23</sub> is selected from C(R<sub>23</sub>) and N,

X<sub>24</sub> is selected from C(R<sub>24</sub>) and N, X<sub>25</sub> is selected from C(R<sub>25</sub>) and N, X<sub>26</sub> is selected from C(R<sub>26</sub>) and N,

X<sub>27</sub> is selected from C(R<sub>27</sub>) and N, X<sub>28</sub> is selected from C(R<sub>28</sub>) and N, and X<sub>29</sub> is selected from C(R<sub>29</sub>) and N, wherein at least one selected from X<sub>21</sub> to X<sub>25</sub> is N, and at least one selected from X<sub>26</sub> to X<sub>29</sub> is N,

R<sub>21</sub> to R<sub>30</sub> are each independently selected from:

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

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 deuterium, -F, a cyano group, a C<sub>1</sub>-C<sub>60</sub> alkyl group, a  $\pi$  electron-depleted nitrogen-containing cyclic 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-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group, each substituted with at least one selected from a  $\pi$  electron-depleted nitrogen-containing cyclic group and a  $\pi$  electron-depleted nitrogen-free cyclic group that are each 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, a  $\pi$  electron-depleted nitrogen-free cyclic group, and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>), wherein R<sub>21</sub> to R<sub>25</sub> are optionally 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 R<sub>26</sub> to R<sub>30</sub> are optionally 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>30</sub> is selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10,

X<sub>31</sub> is selected from B and N, and X<sub>32</sub> and X<sub>33</sub> are each independently selected from B(R<sub>34</sub>), N(R<sub>34</sub>), O,

S, C(R<sub>34</sub>)(R<sub>35</sub>), and Si(R<sub>34</sub>)(R<sub>35</sub>), wherein, when X<sub>31</sub> is B, X<sub>32</sub> and X<sub>33</sub> are each independently selected from N(R<sub>34</sub>), O, S, C(R<sub>34</sub>)(R<sub>35</sub>), and Si(R<sub>34</sub>)(R<sub>35</sub>), and when X<sub>31</sub> is N, X<sub>32</sub> and X<sub>33</sub> are each independently selected from B(R<sub>34</sub>), O, S, C(R<sub>34</sub>)(R<sub>35</sub>), and Si(R<sub>34</sub>)(R<sub>35</sub>),

A<sub>31</sub> to A<sub>33</sub> are each independently selected from a C<sub>5</sub>-C<sub>60</sub> carbocyclic group and a C<sub>1</sub>-C<sub>60</sub> heterocyclic group,

L<sub>31</sub> to L<sub>33</sub> are each independently 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> to a<sub>33</sub> are each independently selected from 0, 1, 2, and 3,

R<sub>31</sub> to R<sub>35</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 polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed 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>), and R<sub>31</sub> to R<sub>33</sub> are optionally 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, b31 to b33 are each independently selected from 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, c31 to c33 are each independently selected from 1, 2, 3, 4, 5, and 6, 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> heteroaryloxy group, a C<sub>1</sub>-C<sub>60</sub> heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, and

\* indicates a binding site to a neighboring atom.

## 2. An organic light-emitting device according to claim 1, wherein:

L<sub>11</sub> is 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, and

L<sub>21</sub> and L<sub>31</sub> to L<sub>33</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 quiazoline 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 quiazoline 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, and



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 benzoquinolinyl group, a benzoisoquinolinyl 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.** An organic light-emitting device according to claim 1 or claim 2, wherein:

$A_{11}$  and  $A_{12}$  are each independently 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.

**4.** An organic light-emitting device according to any one of claims 1 to 3, wherein:

$R_{11}$  to  $R_{16}$  are each independently selected from:

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 benzocarbazolyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, and  $-Si(Q_1)(Q_2)(Q_3)$ ; 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 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  $-Si(Q_{31})(Q_{32})(Q_{33})$ ; 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 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  $C_1$ - $C_{20}$  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, and  $-Si(Q_{21})(Q_{22})(Q_{23})$ .

one selected from  $R_{11}$  to  $R_{13}$  and  $R_{15}$  is a binding site, and

$Q_1$  to  $Q_3$ ,  $Q_{21}$  to  $Q_{23}$ , and  $Q_{31}$  to  $Q_{33}$  are each independently 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.

and a dinaphthothiophenyl group.

5. An organic light-emitting device according to any one of claims 1 to 4, wherein:

$Y_{12}$  is selected from:

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, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, a benzothienodibenzothiophenyl 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 fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, and a benzothienodibenzothiophenyl 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, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl 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 fluorenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, and a benzothienodibenzothiophenyl 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, a dibenzothiophenyl group, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, and a benzothienodibenzothiophenyl 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, an indenofluorenyl group, an indolofluorenyl group, a benzofurofluorenyl group, a benzothienofluorenyl group, an indenocarbazolyl group, an indolocarbazolyl group, a benzofurocarbazolyl group, a benzothienocarbazolyl group, an indenodibenzofuranyl group, an indolodibenzofuranyl group, a benzofurodibenzofuranyl group, a benzothienodibenzofuranyl group, an indenodibenzothiophenyl group, an indolodibenzothiophenyl group, a benzofurodibenzothiophenyl group, and  $-Si(Q_{21})(Q_{22})(Q_{23})$ , and  $Q_1$  to  $Q_3$ ,  $Q_{21}$  to  $Q_{23}$ , and  $Q_{31}$  to  $Q_{33}$  are each independently 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.

6. An organic light-emitting device according to any one of claims 1 to 5, wherein:  $c_{11}$  and  $c_{12}$  are each 1.

7. An organic light-emitting device according to any one of claims 1 to 6, wherein:

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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 fluoranthrenyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, and  $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$ , and

$\text{Q}_1$  to  $\text{Q}_3$ ,  $\text{Q}_{21}$  to  $\text{Q}_{23}$ , and  $\text{Q}_{31}$  to  $\text{Q}_{33}$  are each independently selected from 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 fluoranthrenyl group, a fluorenyl group, a carbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, and a quinazolinyl group.

8. An organic light-emitting device according to any one of claims 1 to 7, wherein:  $\text{c}_{21}$  and  $\text{c}_{22}$  are each independently selected from 1 and 2.

9. An organic light-emitting device according to any one of claims 1 to 8, wherein:  $\text{R}_{21}$  to  $\text{R}_{30}$  are each independently selected from:

hydrogen, deuterium, -F, a cyano 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 fluoranthrenyl group, a fluorenyl group, a carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl group, a diazadibenzofuranyl group, a diazadibenzothiophenyl group, and  $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$ ;

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 fluoranthrenyl group, a fluorenyl group, a carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group, each substituted with at least one selected from deuterium, -F, a cyano 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 fluoranthrenyl group, a fluorenyl group, a carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl group, a diazadibenzofuranyl group, a diazadibenzothiophenyl 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 triphenylenyl group, a chrysenyl group, a fluoranthrenyl group, a fluorenyl group, a carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl group, a diazadibenzofuranyl group, a diazadibenzothiophenyl group, and -Si(Q<sub>21</sub>)(Q<sub>22</sub>)(Q<sub>23</sub>), 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group.

10. An organic light-emitting device according to any of claims 1 to 9, wherein:

(i) 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

(ii) X<sub>21</sub> is N, X<sub>22</sub> is C(R<sub>22</sub>), X<sub>23</sub> is C(R<sub>23</sub>), X<sub>24</sub> is C(R<sub>24</sub>), and X<sub>25</sub> is C(R<sub>25</sub>);

X<sub>21</sub> is C(R<sub>21</sub>), X<sub>22</sub> is N, X<sub>23</sub> is C(R<sub>23</sub>), X<sub>24</sub> is C(R<sub>24</sub>), and X<sub>25</sub> is C(R<sub>25</sub>);

X<sub>21</sub> is C(R<sub>21</sub>), X<sub>22</sub> is C(R<sub>22</sub>), X<sub>23</sub> is N, X<sub>24</sub> is C(R<sub>24</sub>), and X<sub>25</sub> is C(R<sub>25</sub>);

X<sub>21</sub> is N, X<sub>22</sub> is C(R<sub>22</sub>), X<sub>23</sub> is N, X<sub>24</sub> is C(R<sub>24</sub>), and X<sub>25</sub> is C(R<sub>25</sub>);

X<sub>21</sub> is C(R<sub>21</sub>), X<sub>22</sub> is N, X<sub>23</sub> is C(R<sub>23</sub>), X<sub>24</sub> is N, and X<sub>25</sub> is C(R<sub>25</sub>);

X<sub>21</sub> is N, X<sub>22</sub> is C(R<sub>22</sub>), X<sub>23</sub> is C(R<sub>23</sub>), X<sub>24</sub> is N, and X<sub>25</sub> is C(R<sub>25</sub>);

X<sub>21</sub> is N, X<sub>22</sub> is C(R<sub>22</sub>), X<sub>23</sub> is N, X<sub>24</sub> is C(R<sub>24</sub>), and X<sub>25</sub> is N;

X<sub>26</sub> is N, X<sub>27</sub> is C(R<sub>27</sub>), X<sub>28</sub> is C(R<sub>28</sub>), and X<sub>29</sub> is C(R<sub>29</sub>);

X<sub>26</sub> is C(R<sub>26</sub>), X<sub>27</sub> is N, X<sub>28</sub> is C(R<sub>28</sub>), and X<sub>29</sub> is C(R<sub>29</sub>);

X<sub>26</sub> is N, X<sub>27</sub> is C(R<sub>27</sub>), X<sub>28</sub> is N, and X<sub>29</sub> is C(R<sub>29</sub>); or

X<sub>26</sub> is N, X<sub>27</sub> is C(R<sub>27</sub>), X<sub>28</sub> is C(R<sub>28</sub>), and X<sub>29</sub> is N; and/or

(iii) X<sub>31</sub> is B, and X<sub>32</sub> and X<sub>33</sub> are N(R<sub>34</sub>); or

X<sub>31</sub> is N, and X<sub>32</sub> and X<sub>33</sub> are B(R<sub>34</sub>).

11. An organic light-emitting device according to any one of claims 1 to 10, wherein:

A<sub>31</sub> to A<sub>33</sub> are each independently selected from a benzene group, a naphthalene group, a fluorene group, a spirobifluorene group, a benzofluorene group, a dibenzofluorene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a perylene group, a thiophene group, a furan group, a silole group, a carbazole group, an indole group, an isoindole group, a benzofuran group, a benzothiophene group, a benzosilole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, a dibenzocarbazole group, and a dibenzosilole group.

12. An organic light-emitting device according to any one of claims 1 to 11, wherein:

R<sub>31</sub> to R<sub>35</sub> are each independently 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a

benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl 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

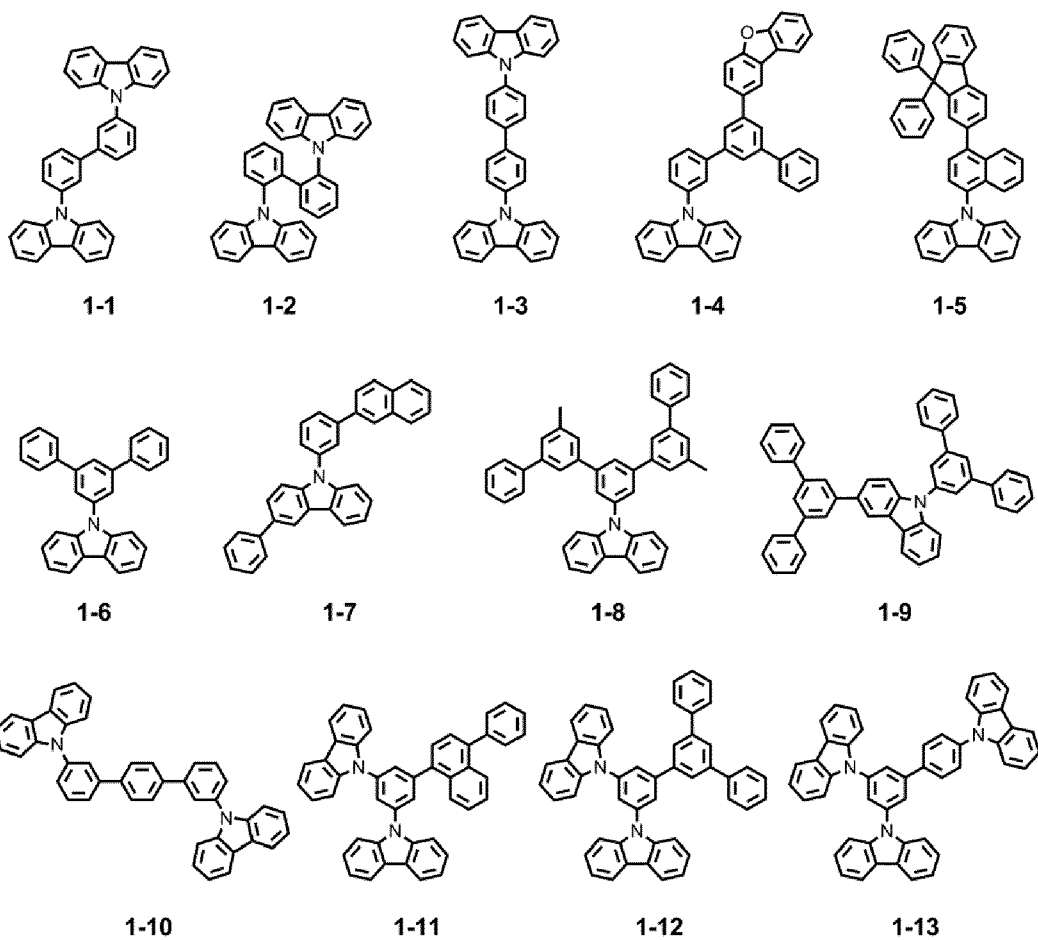
Q<sub>1</sub> and Q<sub>2</sub> are each independently selected from:

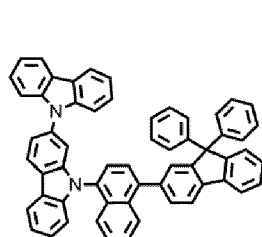
hydrogen, deuterium, and a C<sub>1</sub>-C<sub>20</sub> alkyl group; a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a phenanthrenyl group, a triphenylenyl group, a chrysenyl group, a fluoranthenyl group, a fluorenyl group, a carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl 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 carbazoyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzofluorenyl group, a benzocarbazoyl group, a benzonaphthofuranyl group, a benzonaphthothiophenyl group, a dibenzofluorenyl group, a dibenzocarbazoyl 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 benzoquinolinyl group, a benzoisoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, an azafluorenyl group, an azacarbazoyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, a diazafluorenyl group, a diazacarbazoyl group, a diazadibenzofuranyl group, and a diazadibenzothiophenyl group.

13. An organic light-emitting device according to any one of claims 1 to 12, wherein:

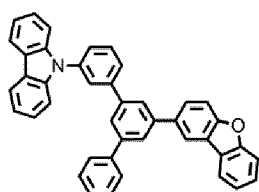
the first compound is selected from compounds of Group I,  
the second compound is selected from compounds of Group II, and  
the third compound is selected from compounds of Group III:

## Group I

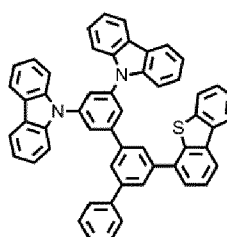




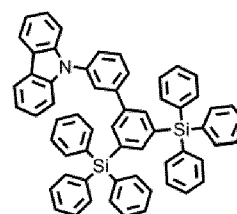
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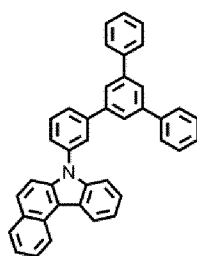
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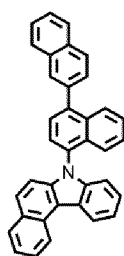
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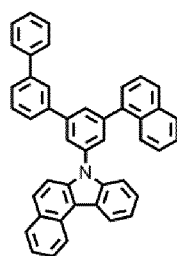
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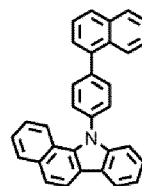
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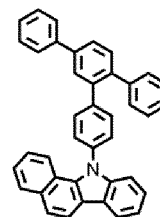
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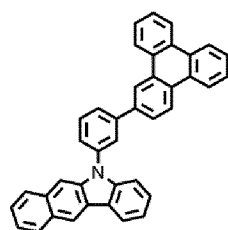
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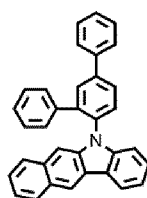
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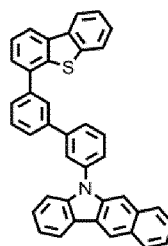
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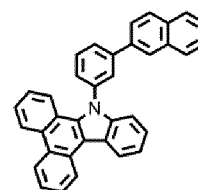
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1-24

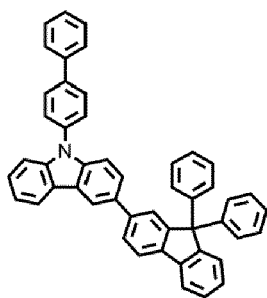


1-25

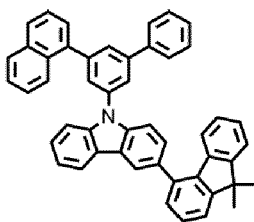


1-26

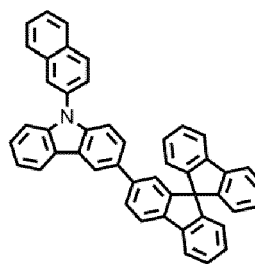




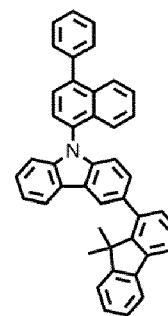
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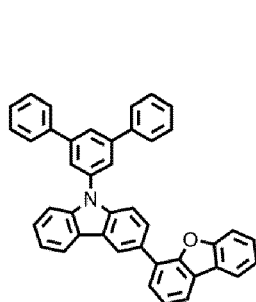
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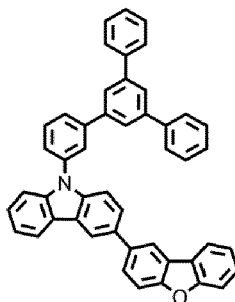
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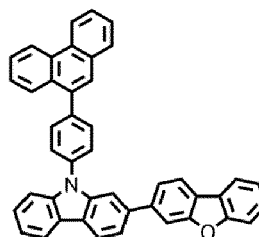
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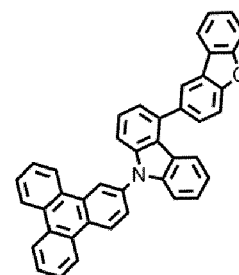
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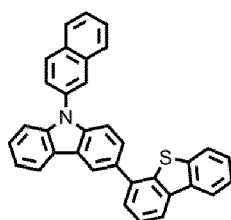
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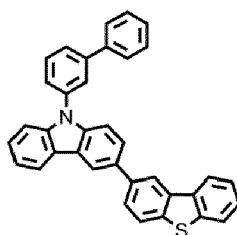
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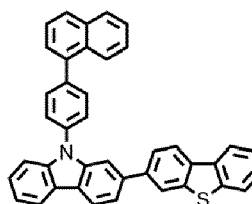
1-33



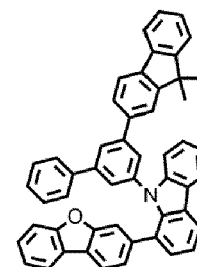
1-34



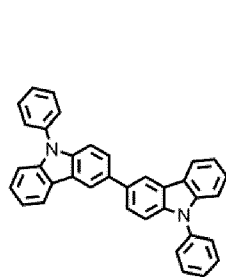
1-35



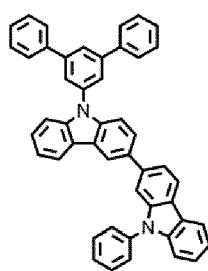
1-36



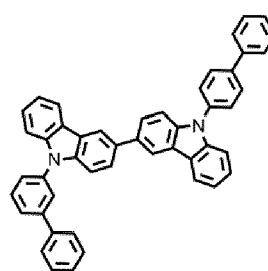
1-37



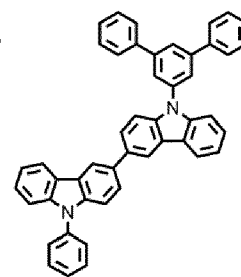
1-38



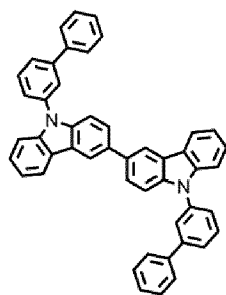
1-39



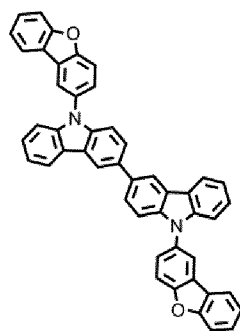
1-40



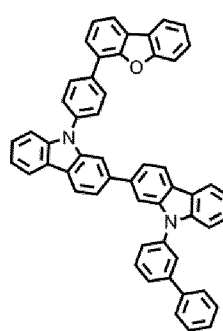
1-41



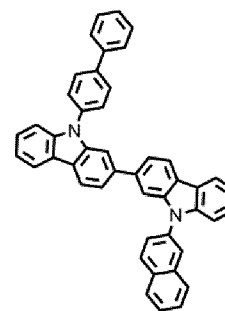
1-42



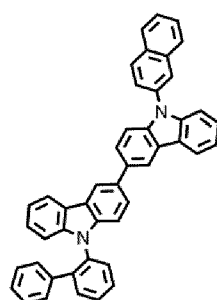
1-43



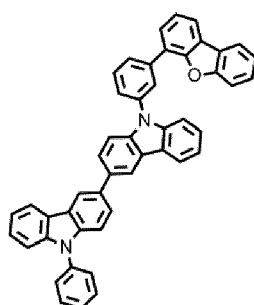
1-44



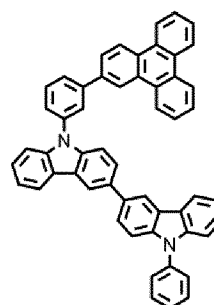
1-45



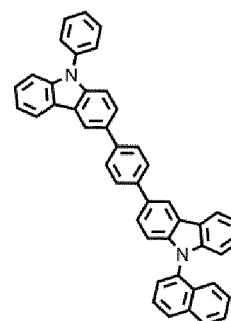
1-46



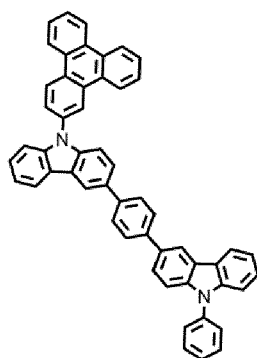
1-47



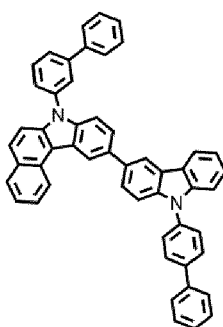
1-48



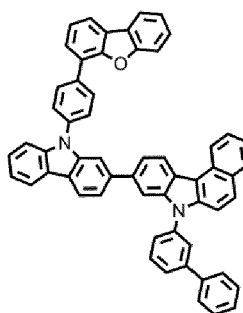
1-49



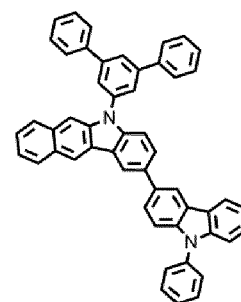
1-50



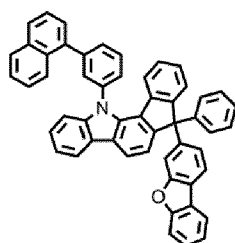
1-51



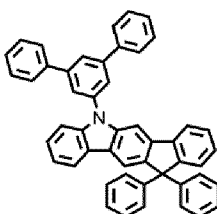
1-52



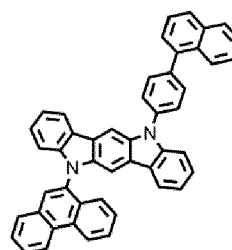
1-53



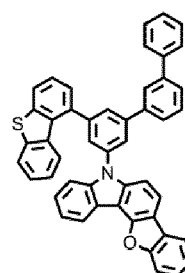
1-54



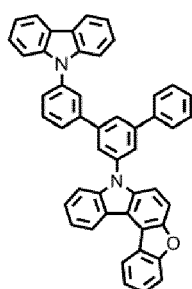
1-55



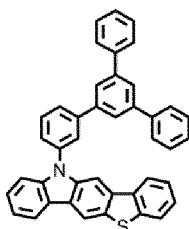
1-56



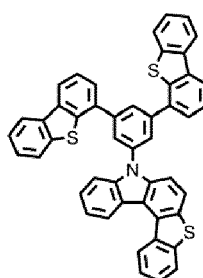
1-57



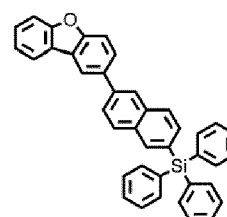
1-58



1-59

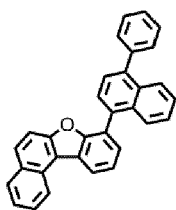


1-60

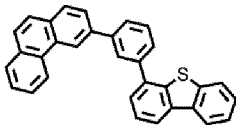


1-61

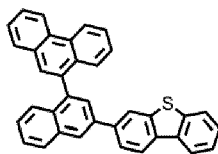
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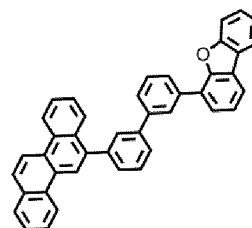
1-62



1-63

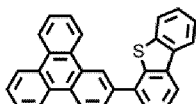


1-64

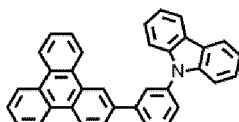


1-65

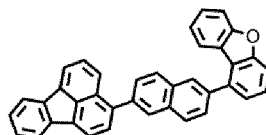
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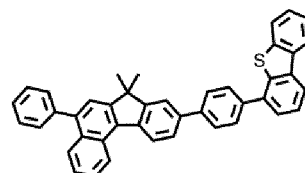
1-66



1-67



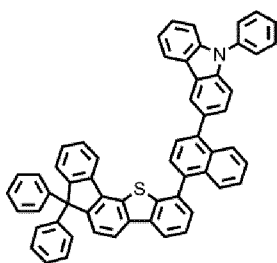
1-68



1-69

15

20



1-70

25

30

Group II

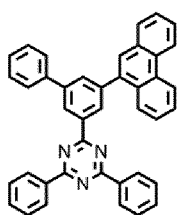
35

40

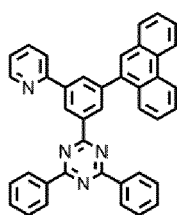
45

50

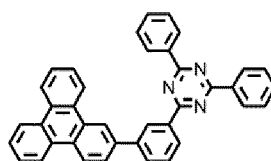
55



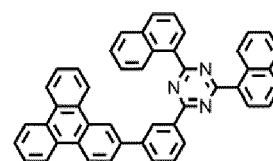
2-1



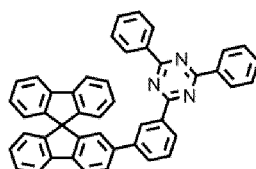
2-2



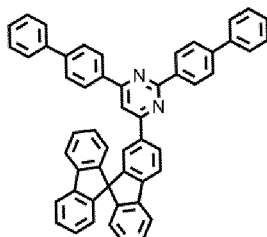
2-3



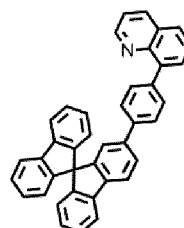
2-4



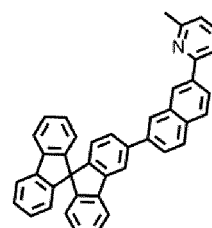
2-5



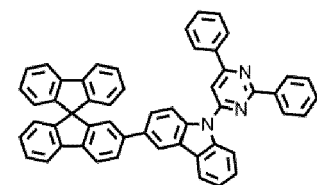
2-6



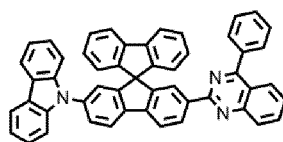
2-7



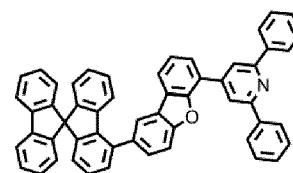
2-8



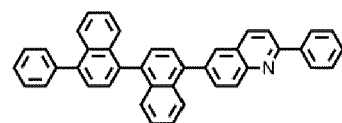
2-9



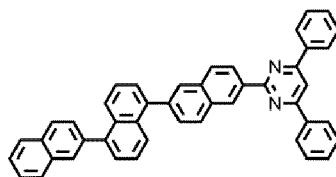
2-10



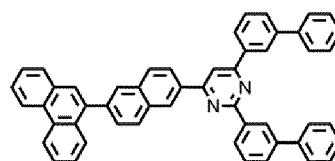
2-11



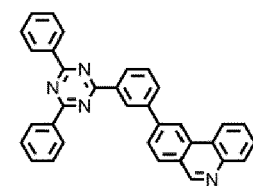
2-12



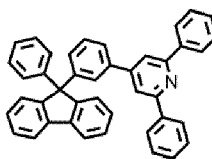
2-13



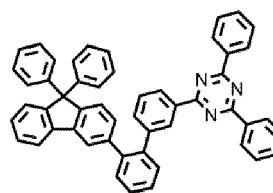
2-14



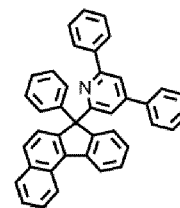
2-15



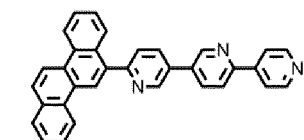
2-16



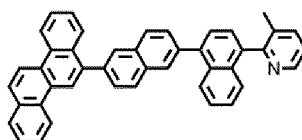
2-17



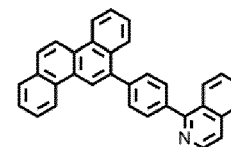
2-18



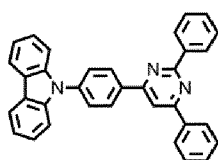
2-19



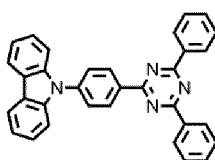
2-20



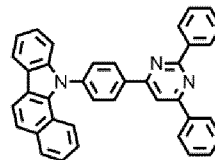
2-21



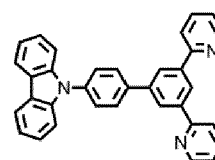
2-22



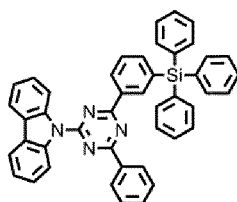
2-23



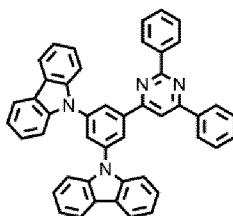
2-24



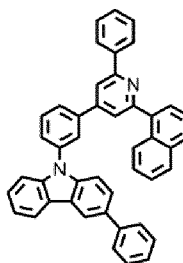
2-25



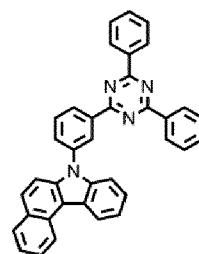
2-26



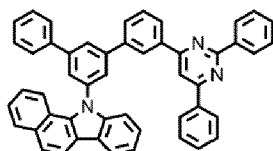
2-27



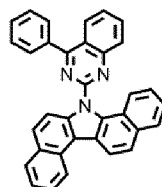
2-28



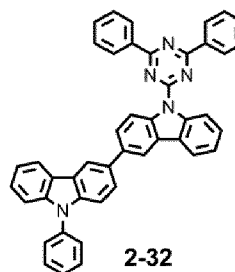
2-29



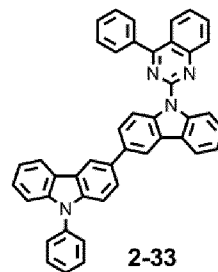
2-30



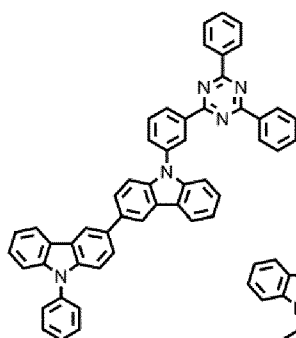
2-31



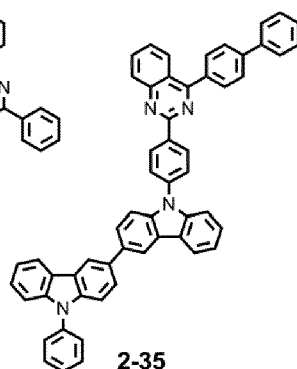
2-32



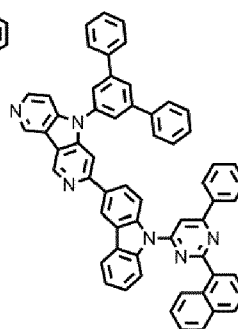
2-33



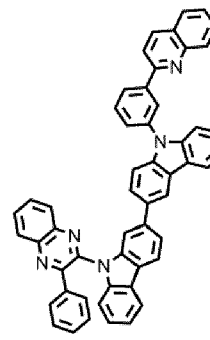
2-34



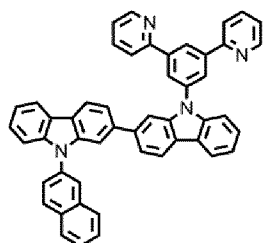
2-35



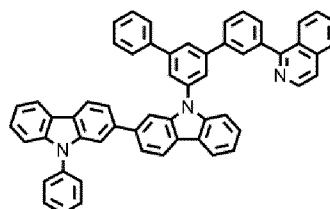
2-36



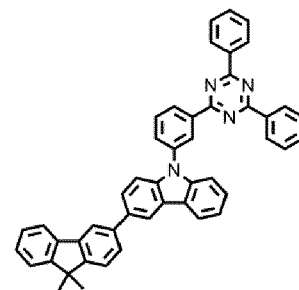
2-37



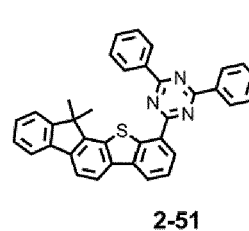
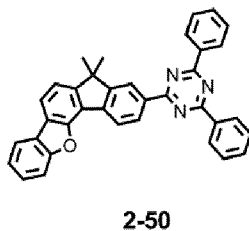
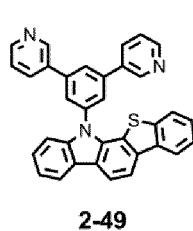
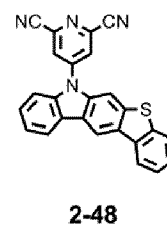
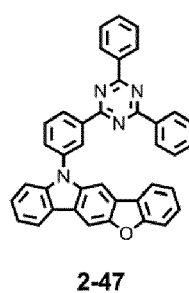
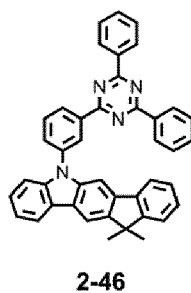
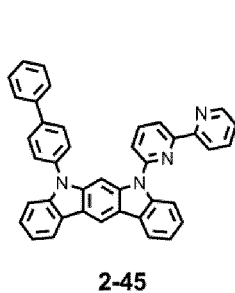
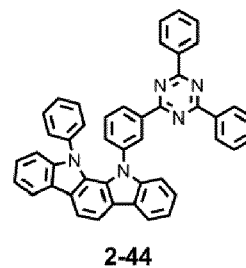
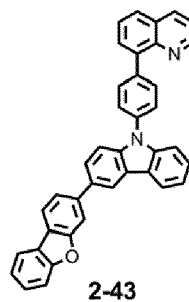
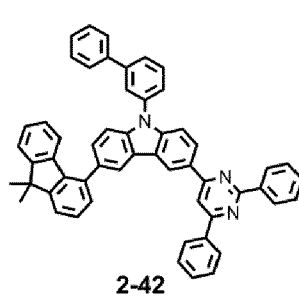
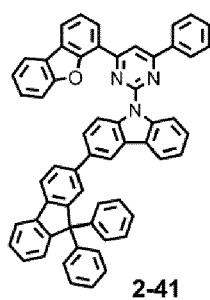
2-38



2-39

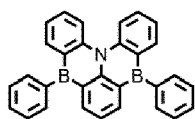


2-40

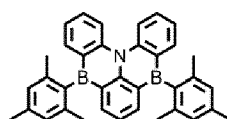


## Group III

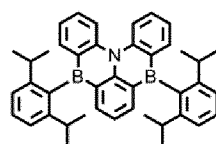
5



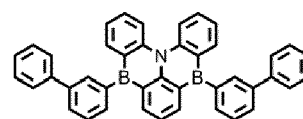
3-1



3-2

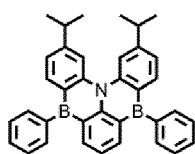


3-3

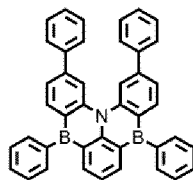


3-4

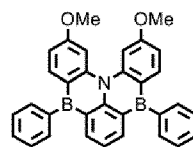
10



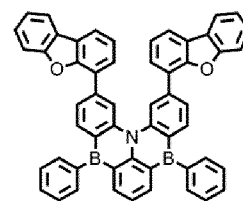
3-5



3-6



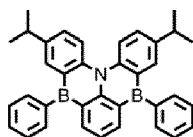
3-7



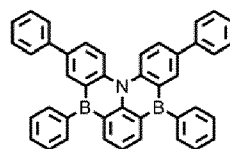
3-8

15

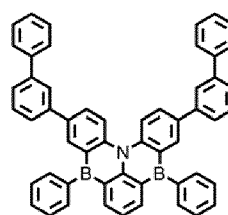
20



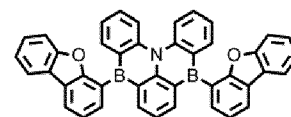
3-9



3-10



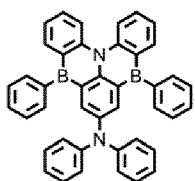
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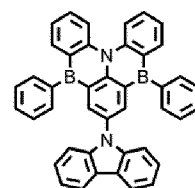
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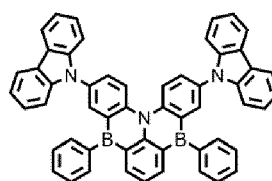
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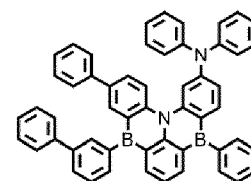
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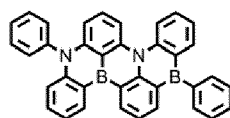
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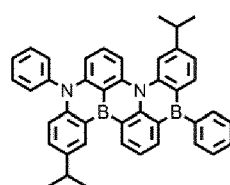
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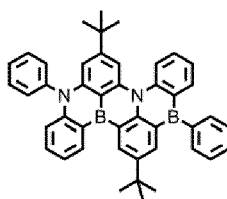
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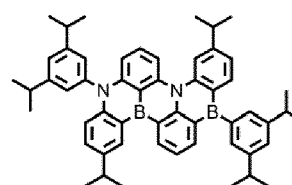
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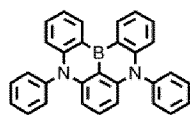
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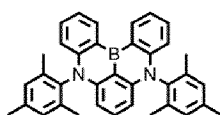
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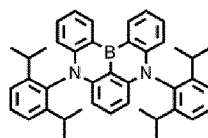




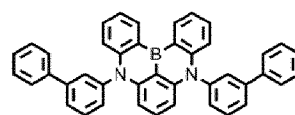
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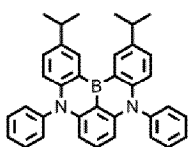
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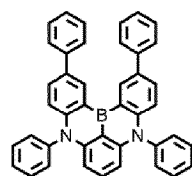
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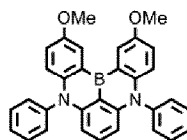
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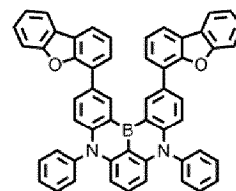
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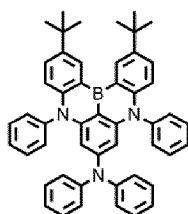
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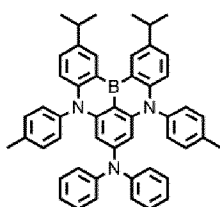
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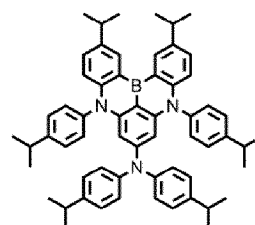
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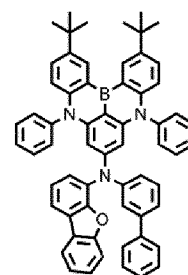
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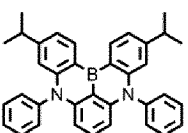
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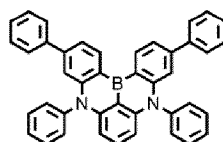
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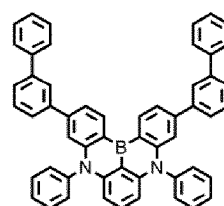
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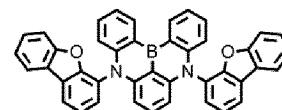
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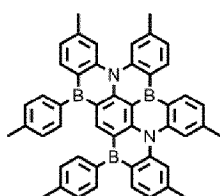
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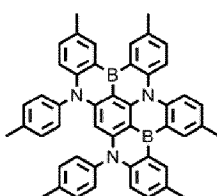
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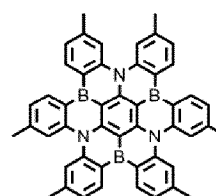
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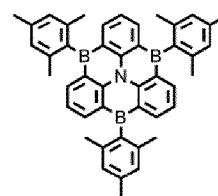
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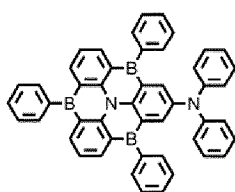
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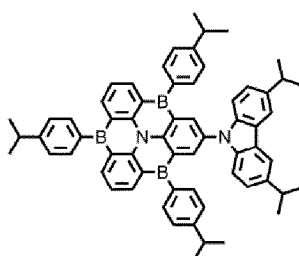
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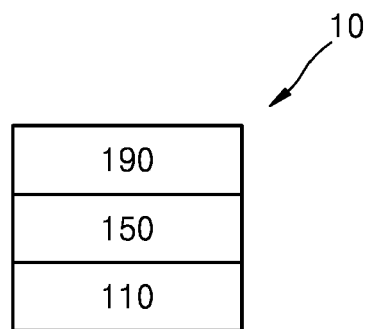
14. An organic light-emitting device according to any one of claims 1 to 13, wherein:

the third compound is a thermally activated delayed fluorescence (TADF) emitter; and/or  
the third compound has a maximum emission wavelength in a range of about 450 nm to about 650 nm; and/or  
the organic light-emitting device emits delayed fluorescence in a range of about 450 nm to about 650 nm; and/or  
the first electrode is an anode,  
the second electrode is a cathode,  
the organic layer further comprises a hole transport region between the first electrode and the emission layer  
and/or an electron transport region between the emission layer and the second electrode,  
the hole transport region comprises a hole injection layer, a hole transport layer, an emission auxiliary layer,  
an electron blocking layer, or any combination thereof, and  
the electron transport region comprises a hole blocking layer, an electron transport layer, an electron injection  
layer, or any combination thereof.

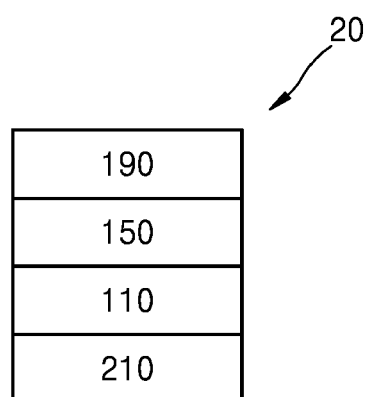
15. A display apparatus comprising:

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

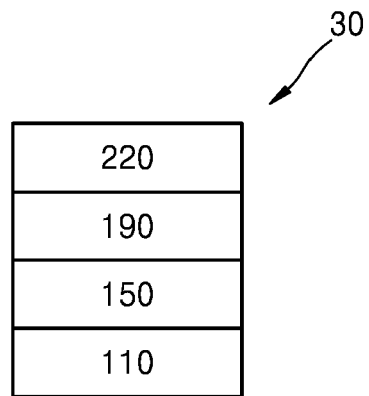
**FIG. 1**



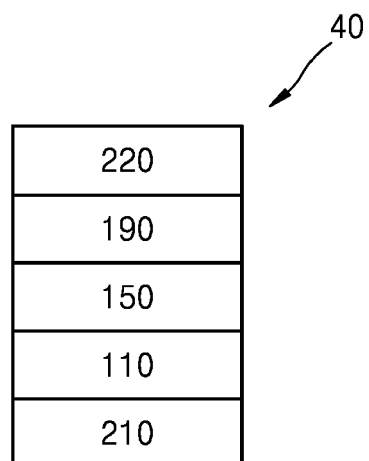
**FIG. 2**



**FIG. 3**



**FIG. 4**





## EUROPEAN SEARCH REPORT

Application Number  
EP 19 19 5101

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 2018/301629 A1 (HATAKEYAMA TAKUJI [JP] ET AL) 18 October 2018 (2018-10-18) * paragraph [0418] - paragraph [0547]; claims 1-9; compounds (1-441); (3-6); ET-6 *	1,10,11,15 2-9, 12-14	INV. H01L51/54
A	----- WO 2018/150832 A1 (KWANSEI GAKUIN EDUCATIONAL FOUND [JP]; JNC CORP [JP]) 23 August 2018 (2018-08-23) * claims 1-12; figure 1 * & US 2019/312207 A1 (HATAKEYAMA TAKUJI [JP] ET AL) 10 October 2019 (2019-10-10) * paragraph [0421] - paragraph [0439]; claims 1-10 *	1-15	
A	----- WO 2017/188111 A1 (KWANSEI GAKUIN EDUCATIONAL FOUND [JP]; JNC CORP [JP]) 2 November 2017 (2017-11-02) * claims 1-10; figure 1 *	1-15	
A,P	& US 2019/207112 A1 (HATAKEYAMA TAKUJI [JP] ET AL) 4 July 2019 (2019-07-04) * paragraph [0189] - paragraph [0559]; compounds (1-1153) *	1-15	TECHNICAL FIELDS SEARCHED (IPC) H01L
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 March 2020	Examiner Königstein, C
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

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

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.  
The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

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专利名称(译)	有机电致发光装置及其显示单元		
公开(公告)号	<a href="#">EP3686947A1</a>	公开(公告)日	2020-07-29
申请号	EP2019195101	申请日	2019-09-03
[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 SEULONG NAIJO TSUYOSHI BAE SUNGSOO		
发明人	KIM, SEULONG NAIJO, TSUYOSHI BAE, SUNGSOO LEE, DONGCHAN		
IPC分类号	H01L51/54		
CPC分类号	H01L51/0052 H01L51/0058 H01L51/006 H01L51/0061 H01L51/0067 H01L51/0072 H01L51/008 H01L51/5012 H01L27/3241 H01L51/0054 H01L51/0056 H01L51/0065 H01L51/0068 H01L51/0073 H01L51/0074 H01L51/0094 H01L51/5056 H01L51/5072 H01L51/5092 H01L51/5096		
优先权	1020190008342 2019-01-22 KR		
外部链接	<a href="#">Espacenet</a>		

# 摘要(译)

提供一种有机发光装置和包括该有机发光装置的显示装置。该有机发光器件包括:第一电极;以及第二电极。第二电极;第一电极和第二电极之间的有机层,其中有机层包括发射层,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,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。

**FIG. 1**

