



(11) **EP 3 561 894 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:  
**30.10.2019 Bulletin 2019/44**

(51) Int Cl.:  
**H01L 51/54 (2006.01)**

(21) Application number: **19170211.7**

(22) Date of filing: **18.04.2019**

(84) Designated Contracting States:  
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB  
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO  
PL PT RO RS SE SI SK SM TR**  
Designated Extension States:  
**BA ME**  
Designated Validation States:  
**KH MA MD TN**

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(30) Priority: **27.04.2018 KR 20180049403**

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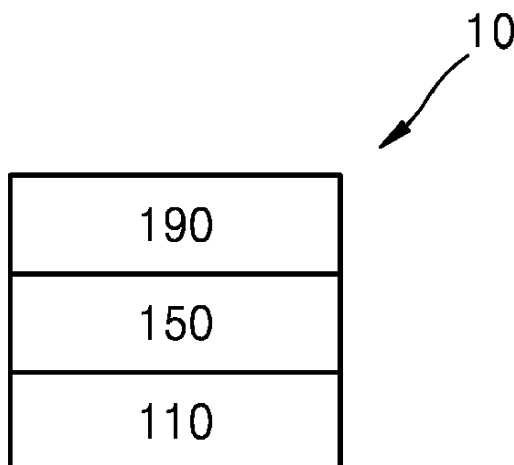
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(54) **DIAMINE COMPOUND AND ORGANIC LIGHT-EMITTING DEVICE INCLUDING THE SAME**

(57) Provided are a diamine compound including a naphthyl-phenyl linker and a 2-carbazoyl group and an organic light-emitting device 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 and including an emission layer, wherein the organic layer includes the diamine compound including the naphthyl-phenyl linker and the 2-carbazoyl group.

**FIG. 1**



**EP 3 561 894 A1**

## Description

## BACKGROUND

## 5 1. Field

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

## 10 2. Description of the Related Art

[0002] Organic light-emitting devices are self-emission devices, 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.

15 [0003] An example of such organic light-emitting devices may include a first electrode disposed on a substrate, and a hole transport region, an emission layer, an electron transport region, and a second electrode, which are sequentially disposed 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.  
20 These excitons transit (e.g., transition or relax) from an excited state to a ground state, thereby generating light.

## SUMMARY

25 [0004] Aspects of embodiments of the present disclosure provide a diamine compound and an organic light-emitting device 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.

30 [0006] An aspect of an embodiment provides an organic light-emitting device including: a first electrode; a second electrode; an organic layer between the first electrode and the second electrode and including an emission layer, wherein the organic layer includes a diamine compound including a naphthyl-phenyl linker and a 2-carbazolyl group.

[0007] In one embodiment, the first electrode is an anode, the second electrode is a cathode, the organic layer further includes a hole transport region between the first electrode and the emission layer, and the hole transport region includes the diamine compound.

35 [0008] In one embodiment, the hole transport region may include at least one of a hole injection layer and a hole transport layer, and at least one of the hole injection layer and the hole transport layer may include the diamine compound.

[0009] In one embodiment, the hole transport region may include a p-dopant, and the p-dopant may have a lowest unoccupied molecular orbital (LUMO) energy level of about -3.5 eV or less.

[0010] Another aspect of an embodiment provides a diamine compound represented by Formula 1:

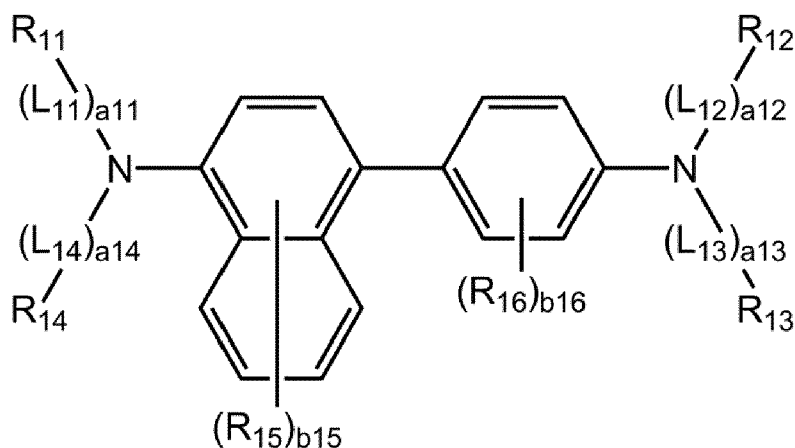
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Formula 1

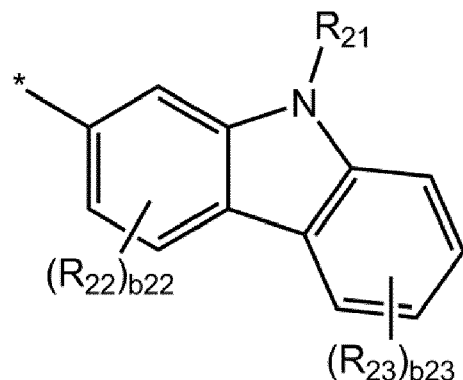
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## Formula 2



In Formula 1,

$L_{11}$  to  $L_{14}$  are each independently selected from a single bond, a substituted or unsubstituted  $C_5$ - $C_{60}$  carbocyclic group, and a substituted or unsubstituted  $C_1$ - $C_{60}$  heterocyclic group,

$a_{11}$  to  $a_{14}$  are each independently selected from 0, 1, 2, and 3,

$R_{11}$  to  $R_{14}$  are each independently selected from a group represented by Formula 2, 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  $C_1$ - $C_{60}$  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 of  $R_{11}$  to  $R_{14}$  is a group represented by Formula 2,

$R_{15}$ ,  $R_{16}$ , and  $R_{21}$  to  $R_{23}$  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 substituted or unsubstituted  $C_1$ - $C_{60}$  alkyl group, a substituted or unsubstituted  $C_2$ - $C_{60}$  alkenyl group, a substituted or unsubstituted  $C_2$ - $C_{60}$  alkynyl group, a substituted or unsubstituted  $C_1$ - $C_{60}$  alkoxy group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkenyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkenyl group, a substituted or unsubstituted  $C_6$ - $C_{60}$  aryl group, a substituted or unsubstituted  $C_6$ - $C_{60}$  aryloxy group, a substituted or unsubstituted  $C_6$ - $C_{60}$  arylthio group, a substituted or unsubstituted  $C_1$ - $C_{60}$  heteroaryl group, a substituted or unsubstituted  $C_1$ - $C_{60}$  heteroaryloxy group, a substituted or unsubstituted  $C_1$ - $C_{60}$  heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, -Si( $Q_1$ )( $Q_2$ )( $Q_3$ ), -B( $Q_1$ )( $Q_2$ ), -N( $Q_1$ )( $Q_2$ ), -P( $Q_1$ )( $Q_2$ ), -C(=O)( $Q_1$ ), -S(=O)( $Q_1$ ), -S(=O)<sub>2</sub>( $Q_1$ ), -P(=O)( $Q_1$ )( $Q_2$ ), and -P(=S)( $Q_1$ )( $Q_2$ ),

$b_{15}$  is selected from 1, 2, 3, 4, 5, and 6,

$b_{16}$  and  $b_{23}$  are each independently selected from 1, 2, 3, and 4,

$b_{22}$  is selected from 1, 2, and 3,

$Q_1$  to  $Q_3$  are each independently selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $C_1$ - $C_{60}$  alkyl group, a  $C_2$ - $C_{60}$  alkenyl group, a  $C_2$ - $C_{60}$  alkynyl group, a  $C_1$ - $C_{60}$  alkoxy group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_1$ - $C_{10}$  heterocycloalkyl group, a  $C_3$ - $C_{10}$  cycloalkenyl group, a  $C_1$ - $C_{10}$  heterocycloalkenyl group, a  $C_6$ - $C_{60}$  aryl group, a  $C_1$ - $C_{60}$  heteroaryl group, a  $C_1$ - $C_{60}$  heteroaryloxy group, a  $C_1$ - $C_{60}$  heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a  $C_1$ - $C_{60}$  alkyl group substituted with at least one selected from deuterium, -F, and a cyano group, a  $C_6$ - $C_{60}$  aryl group substituted with at least one selected from deuterium, -F, and a cyano group, a biphenyl group, and a terphenyl group, and

\* indicates a binding site to a neighboring atom.

**[0011]** At least some of the above and other features of the present invention are set out in the claims.

#### BRIEF DESCRIPTION OF THE DRAWINGS

**[0012]** These and/or other aspects of embodiments of the present disclosure 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.

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## DETAILED DESCRIPTION

**[0013]** The subject matter of the present disclosure will now be described more fully with reference to embodiments. The subject matter of the disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the subject matter of the disclosure to those skilled in the art. Features of embodiments of the present disclosure, and how to achieve them, will become apparent by reference to the embodiments that will be described herein in more detail, together with the accompanying drawings. The subject matter of the present disclosure may, however, be embodied in many different forms and should not be limited to the embodiments.

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**[0014]** Hereinafter, embodiments are described in more detail by referring to the attached drawings, and in the drawings, like reference numerals denote like elements, and a redundant explanation thereof will not be provided herein.

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**[0015]** 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.

**[0016]** It will be further understood that the terms "comprises" and/or "comprising" 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.

20

**[0017]** 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.

25

**[0018]** Sizes of components in the drawings may be exaggerated for convenience of explanation. In other words, since 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.

**[0019]** An organic light-emitting device according to an embodiment includes: a first electrode; a second electrode; an organic layer between the first electrode and the second electrode and including an emission layer, wherein the organic layer includes a diamine compound including a naphthyl-phenyl linker and a 2-carbazolyl group.

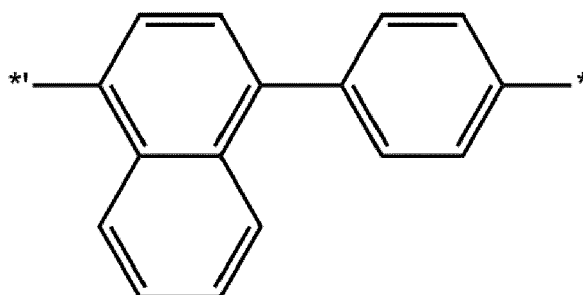
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**[0020]** As used herein, the term "diamine compound" refers to a compound including two amino groups. For example, the diamine compound essentially includes a first amino group and a second amino group.

**[0021]** As used herein, the term "naphthyl-phenyl linker" refers to a divalent group having a structure in which a set or arbitrary carbon atom in a naphthalene group is linked to a set or arbitrary carbon atom in a benzene group. For example, the naphthyl-phenyl linker may be represented by Formula 1A, but embodiments of the present disclosure are not limited thereto. The naphthyl-phenyl linker may include other constitutional isomers of Formula 1A:

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Formula 1A



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In Formula 1A,

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\* indicates a binding site to a nitrogen atom of the first amino group, and \*' indicates a binding site to a nitrogen atom of the second amino group; or

\* indicates a binding site to a nitrogen atom of the second amino group, and \*' indicates a binding site to a nitrogen atom of the first amino group, and

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any hydrogen or an arbitrary hydrogen in Formula 1A may be replaced with a substituent.

**[0022]** As used herein, the term "2-carbazolyl group" refers to a monovalent group in which the second carbon of the

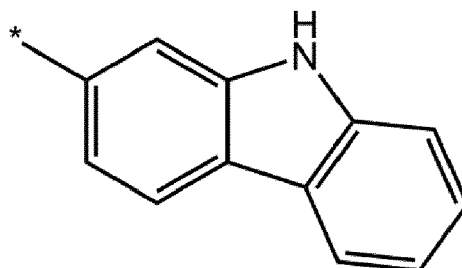
carbazole is directly linked to the nitrogen atom of the first amino group or the second amino group of the diamine compound, or linked thereto via an arbitrary divalent group. For example, the 2-carbazolyl group may be represented by Formula 2A:

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Formula 2A

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In Formula 2A,

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\* indicates a binding site to a nitrogen atom of the diamine compound, and any hydrogen or an arbitrary hydrogen in Formula 2A may be further replaced with a substituent.

**[0023]** For example, the diamine compound may include a naphthyl-phenyl linker between two amino groups, and at least one substituent of the two amino groups may be a 2-carbazolyl group. For example, the diamine compound may include a naphthyl-phenyl linker between the first amino group and the second amino group, and at least one substituent of the first amino group and the second amino group may be a 2-carbazolyl group.

25

**[0024]** For example, 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 the hole transport region may include the diamine compound, but embodiments of the present disclosure are not limited thereto.

**[0025]** For example, the hole transport region may include at least one of a hole injection layer and a hole transport layer, and at least one of the hole injection layer and hole transport layer may include the diamine compound, but embodiments of the present disclosure are not limited thereto.

30

**[0026]** In one embodiment, the hole transport region may include a p-dopant, and the p-dopant may have a lowest unoccupied molecular orbital (LUMO) energy level of about -3.5 eV or less, but embodiments of the present disclosure are not limited thereto.

**[0027]** In one embodiment, the diamine compound may be represented by Formula 1.

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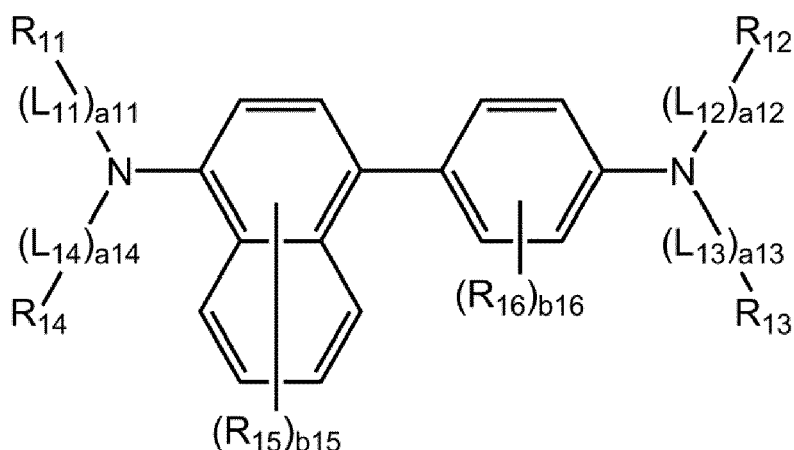
**[0028]** In one or more embodiments, the diamine compound may be represented by Formula 1, and at least one of  $R_{11}$  to  $R_{14}$  is a group represented by Formula 2:

Formula 1

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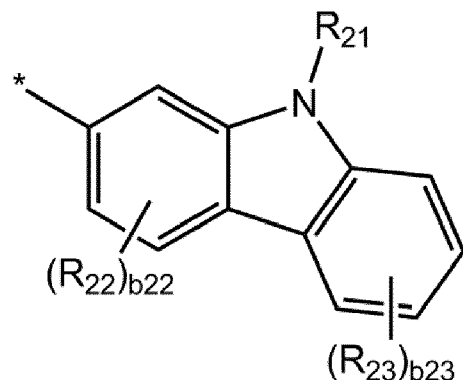
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Formula 2



For example, in Formula 1,  $R_{11}$  may be a group represented by Formula 2;

$R_{12}$  may be a group represented by Formula 2;

$R_{11}$  and  $R_{12}$  may each be a group represented by Formula 2;

$R_{11}$  and  $R_{14}$  may each be a group represented by Formula 2;

$R_{11}$ ,  $R_{12}$ , and  $R_{14}$  may each be a group represented by Formula 2;

$R_{11}$ ,  $R_{12}$ , and  $R_{13}$  may each be a group represented by Formula 2; or

$R_{11}$ ,  $R_{12}$ ,  $R_{13}$ , and  $R_{14}$  may each be a group represented by Formula 2, but embodiments of the present disclosure are not limited thereto.

**[0029]** In more detail, in Formula 1,  $R_{11}$  may be a group represented by Formula 2; or  $R_{12}$  may be a group represented by Formula 2, but embodiments of the present disclosure are not limited thereto.

**[0030]** For example, when  $R_{11}$  is a group represented by Formula 2,  $(L_{11})_{a11}$  may be a single bond (*i.e.*  $a_{11}$  is 0 or  $a_{11}$  is 1 and  $L_{11}$  is a single bond). For example, when  $R_{12}$  is a group represented by Formula 2,  $(L_{12})_{a12}$  may be a single bond (*i.e.*  $a_{12}$  is 0 or  $a_{12}$  is 1 and  $L_{12}$  is a single bond). For example, when  $R_{13}$  is a group represented by Formula 2,  $(L_{13})_{a13}$  may be a single bond (*i.e.*  $a_{13}$  is 0 or  $a_{13}$  is 1 and  $L_{13}$  is a single bond). For example, when  $R_{14}$  is a group represented by Formula 2,  $(L_{14})_{a14}$  may be a single bond (*i.e.*  $a_{14}$  is 0 or  $a_{14}$  is 1 and  $L_{14}$  is a single bond).

**[0031]** In Formula 1,  $L_{11}$  to  $L_{14}$  are each independently selected from a single bond, a substituted or unsubstituted  $C_5$ - $C_{60}$  carbocyclic group, and a substituted or unsubstituted  $C_1$ - $C_{60}$  heterocyclic group.

**[0032]** For example, in Formula 1,  $L_{11}$  to  $L_{14}$  may each independently be selected from a single bond, a substituted or unsubstituted  $C_5$ - $C_{30}$  carbocyclic group, and a substituted or unsubstituted  $C_1$ - $C_{20}$  heterocyclic group. For example, in Formula 1,  $L_{11}$  to  $L_{14}$  may each independently be selected from a single bond, a substituted or unsubstituted  $C_6$ - $C_{25}$  carbocyclic group, and a substituted or unsubstituted  $C_4$ - $C_{20}$  heterocyclic group.

**[0033]** For example, in Formula 1,  $L_{11}$  to  $L_{14}$  may each independently be selected from:

a single bond, 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; and

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, 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  $C_1$ - $C_{20}$  (*e.g.*  $C_1$ - $C_{10}$ ) alkyl group, a  $C_1$ - $C_{20}$  (*e.g.*  $C_1$ - $C_{10}$ ) 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 thiophenyl group, a furanyl group, a silolyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a ben-

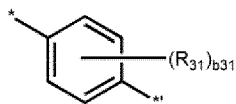
zocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group,  $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$ ,  $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$ , and  $-\text{B}(\text{Q}_{31})(\text{Q}_{32})$ , and

$\text{Q}_{31}$  to  $\text{Q}_{33}$  may each independently be selected from a  $\text{C}_1\text{-C}_{60}$  (e.g.  $\text{C}_1\text{-C}_{20}$ ) alkyl group, a phenyl group, a biphenyl group, and a terphenyl group, but embodiments of the present disclosure are not limited thereto.

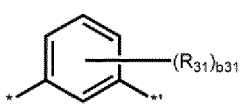
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**[0034]** In one embodiment, in Formula 1,  $\text{L}_{11}$  to  $\text{L}_{14}$  may each independently be selected from a single bond and groups represented by Formulae 3-1 to 3-41, but embodiments of the present disclosure are not limited thereto:

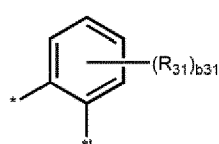
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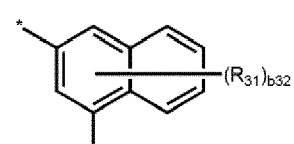
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3-2

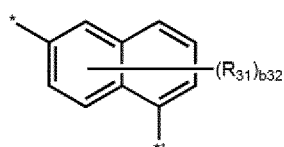


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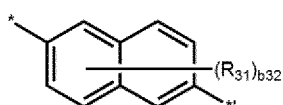


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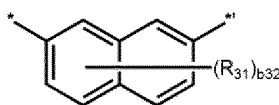
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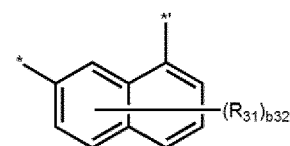
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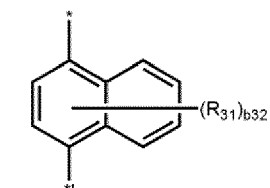
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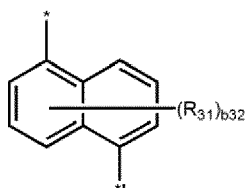
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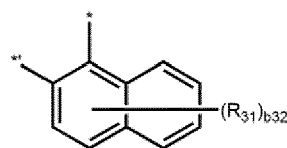
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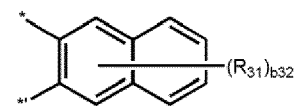
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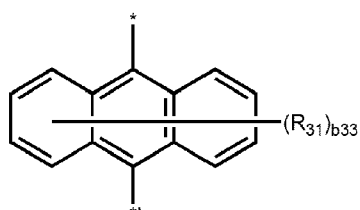


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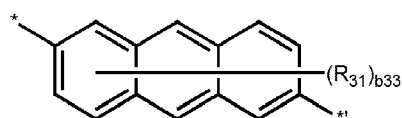


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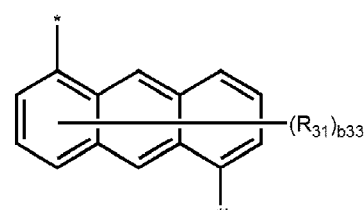
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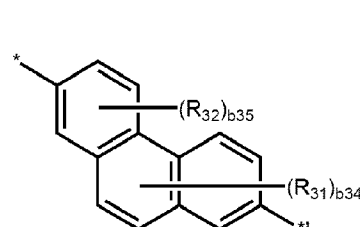


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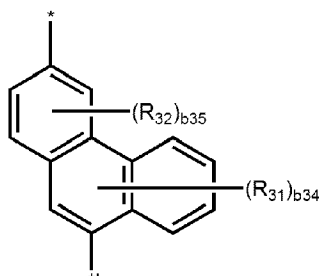


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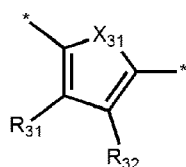
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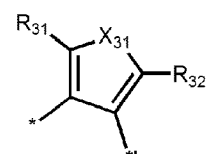
3-16



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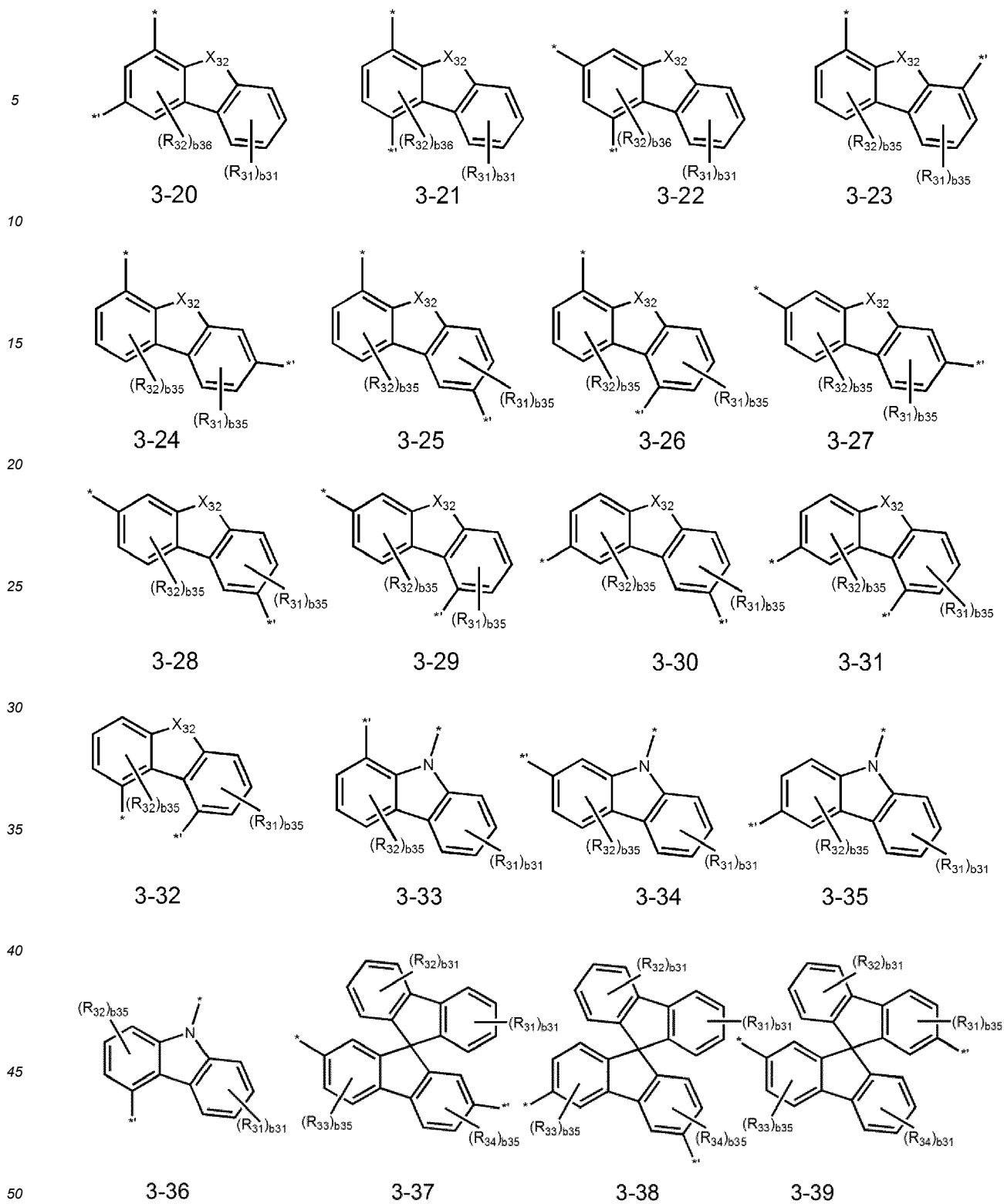


3-18



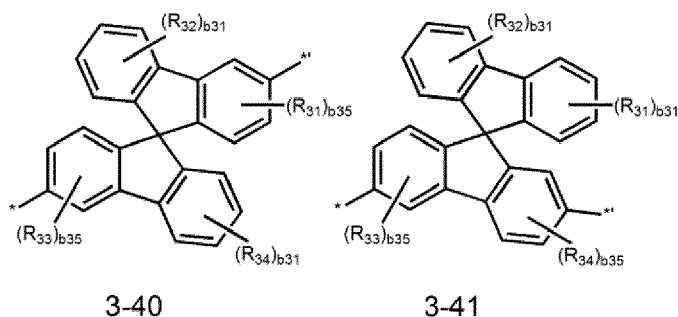
3-19

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In Formulae 3-1 to 3-41,

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$X_{31}$  is selected from O and S,

$X_{32}$  is selected from O, S, N( $R_{33}$ ), and C( $R_{33}$ )( $R_{34}$ ),

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$R_{31}$  to  $R_{34}$  are each independently selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $C_1$ - $C_{20}$  (e.g.  $C_1$ - $C_{10}$ ) alkyl group, a  $C_1$ - $C_{20}$  (e.g.  $C_1$ - $C_{10}$ ) 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 thiophenyl group, a furanyl group, a silolyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, -Si( $Q_{31}$ )( $Q_{32}$ )( $Q_{33}$ ), -N( $Q_{31}$ )( $Q_{32}$ ), and -B( $Q_{31}$ )( $Q_{32}$ ),

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$Q_{31}$  to  $Q_{33}$  are each independently selected from a  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) alkyl group, a phenyl group, a biphenyl group, and a terphenyl group,

$b_{31}$  is selected from 1, 2, 3, and 4,

$b_{32}$  is selected from 1, 2, 3, 4, 5, and 6,

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$b_{33}$  is selected from 1, 2, 3, 4, 5, 6, 7, and 8,

$b_{34}$  is selected from 1, 2, 3, 4, and 5,

$b_{35}$  is selected from 1, 2, and 3,

$b_{36}$  is selected from 1 and 2, and

\* and \*\* each indicate a binding site to a neighboring atom.

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**[0035]** In Formula 1,  $a_{11}$  indicates the repeating number of  $L_{11}$ , and is selected from 0, 1, 2, and 3. Likewise, in Formula 1,  $a_{12}$  to  $a_{14}$  indicate the repeating number of  $L_{12}$  to  $L_{14}$ , respectively, and  $a_{12}$  to  $a_{14}$  are each independently selected from 0, 1, 2, and 3.

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**[0036]** For example, in Formula 1,  $a_{11}$  to  $a_{14}$  may each independently be selected from 0 and 1, but embodiments of the present disclosure are not limited thereto.

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**[0037]** In Formula 1,  $R_{11}$  to  $R_{14}$  are each independently selected from a group represented by Formula 2, 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  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{30}$ ) aryl group, a substituted or unsubstituted  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, wherein at least one selected from  $R_{11}$  to  $R_{14}$  may be a group represented by Formula 2.

**[0038]** For example, in Formula 1,  $R_{11}$  to  $R_{14}$  may each independently be selected from:

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a group represented by Formula 2, 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 pentalenyl group, an indenyl group, a naphthyl group, an azulenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a

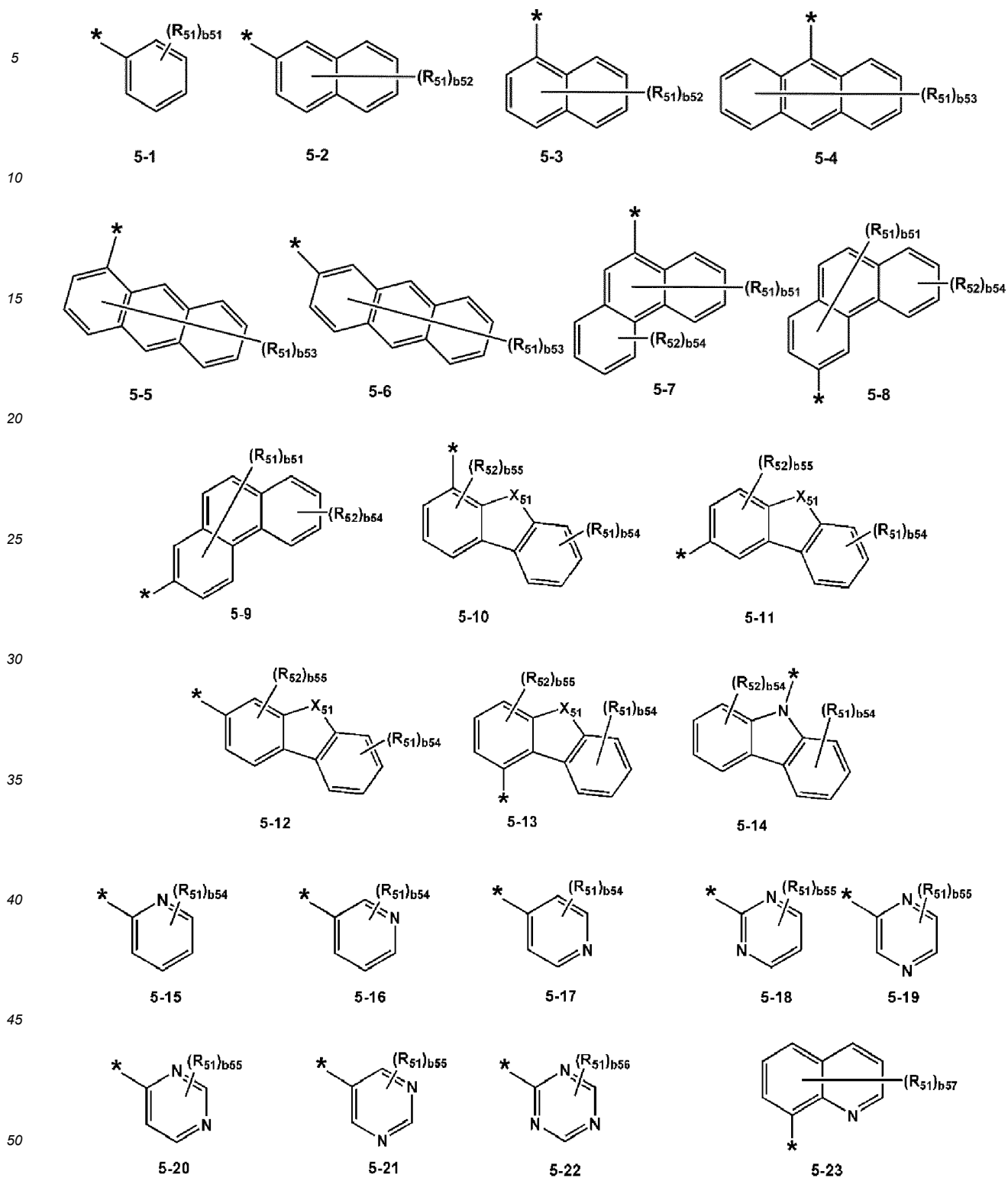
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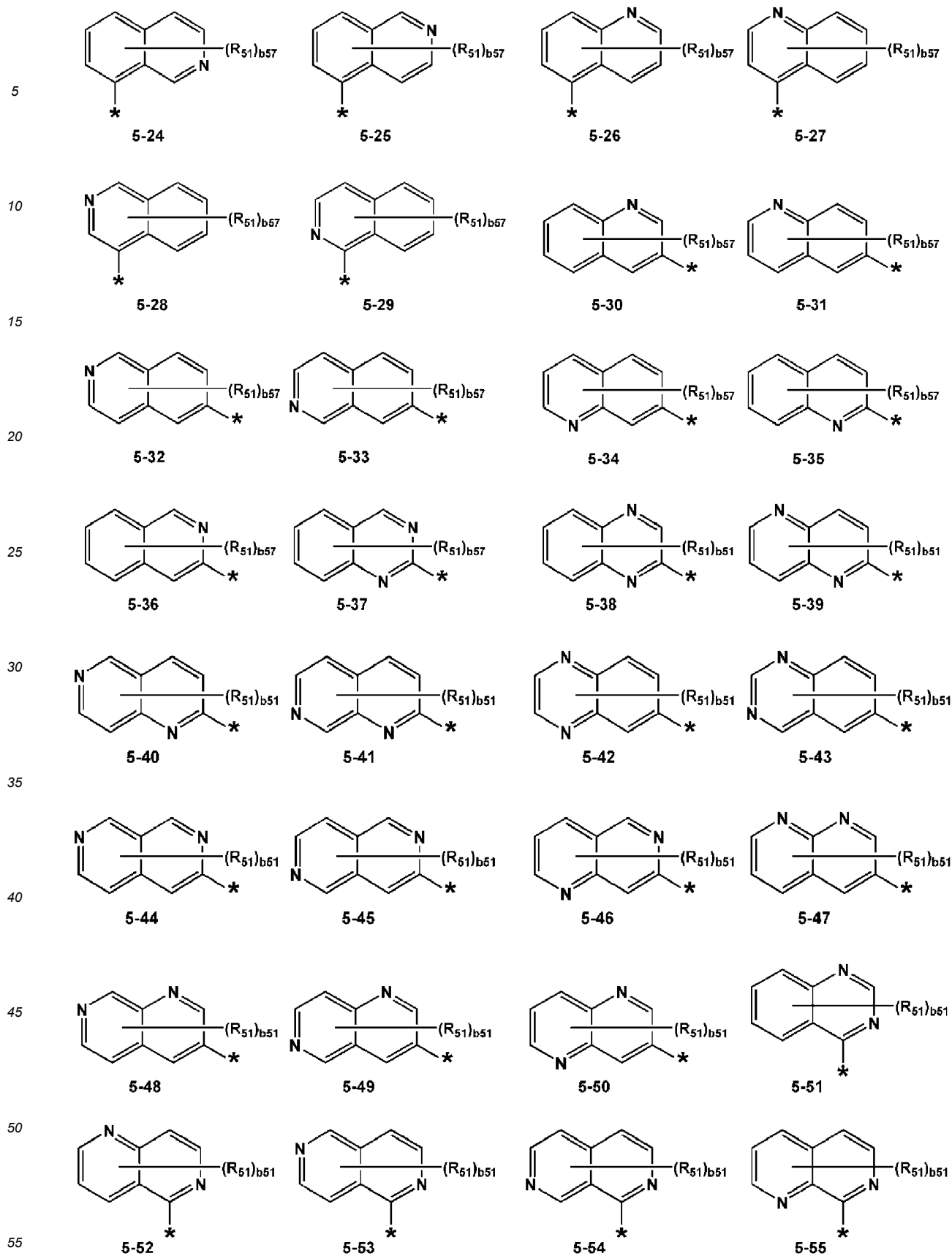
phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quinazolinyl group, a benzoquinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl group; and

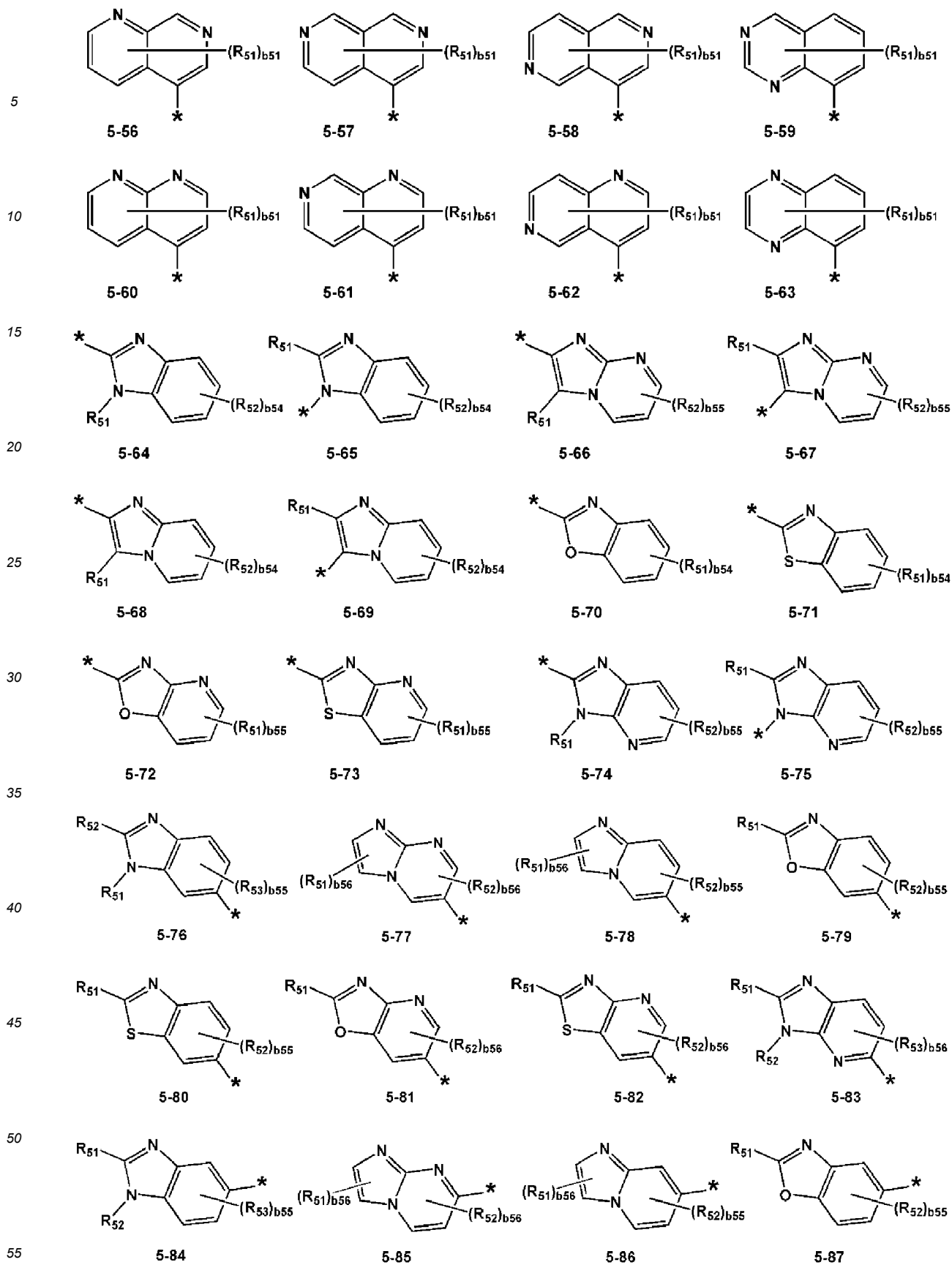
a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, a purinyl group, a quinolyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quinazolinyl group, a benzoquinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl 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> (e.g. C<sub>1</sub>-C<sub>10</sub>) alkyl group, a C<sub>1</sub>-C<sub>20</sub> (e.g. C<sub>1</sub>-C<sub>10</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 pentalenyl group, an indenyl group, a naphthyl group, an azulenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, a purinyl group, a quinolyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quinazolinyl group, a benzoquinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl group, wherein at least one selected from R<sub>11</sub> to R<sub>14</sub> is a group represented by Formula 2, but embodiments of the present disclosure are not limited thereto.

**[0039]** In one embodiment, in Formula 1, R<sub>11</sub> to R<sub>14</sub> may each independently be selected from a group represented by Formula 2 and groups represented by Formulae 5-1 to 5-138, but embodiments of the present disclosure are not

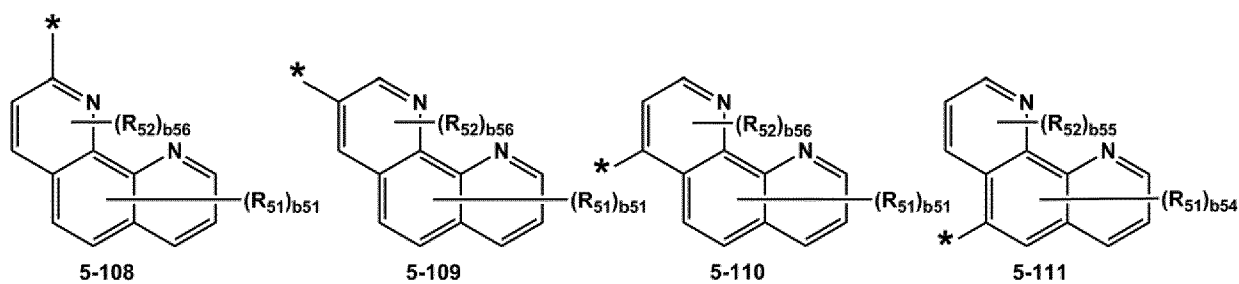
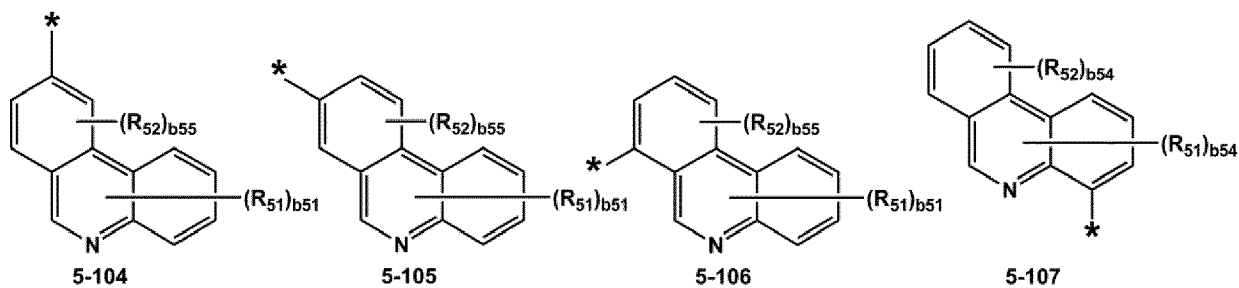
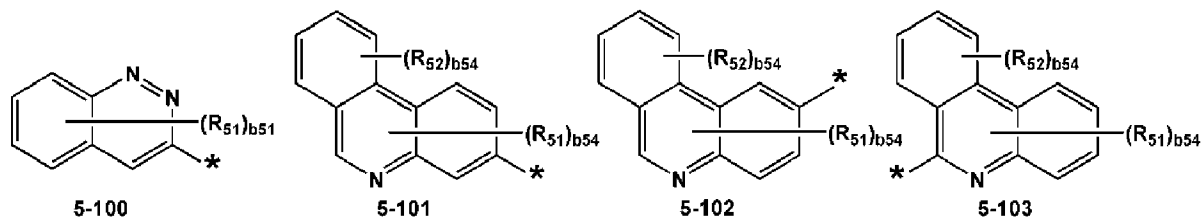
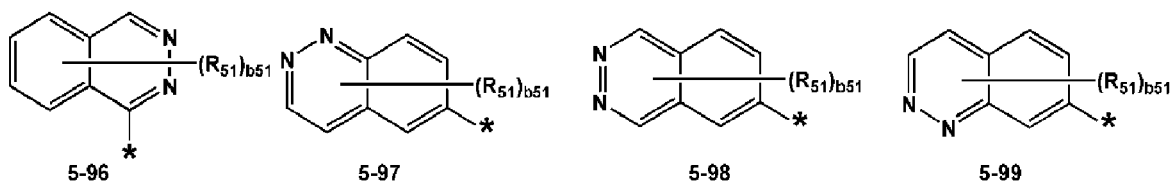
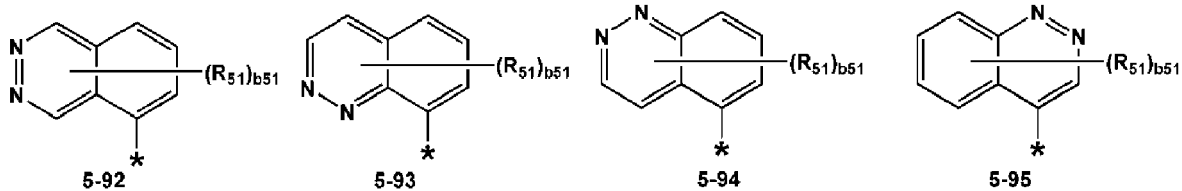
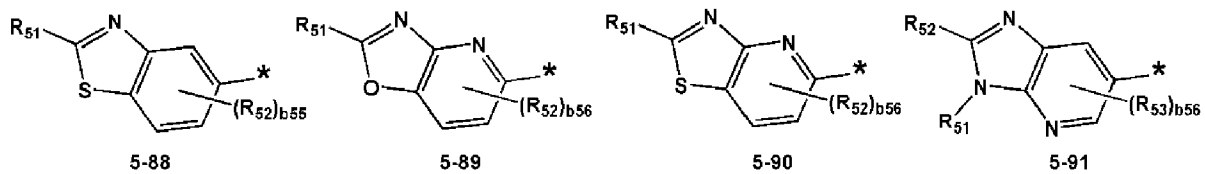
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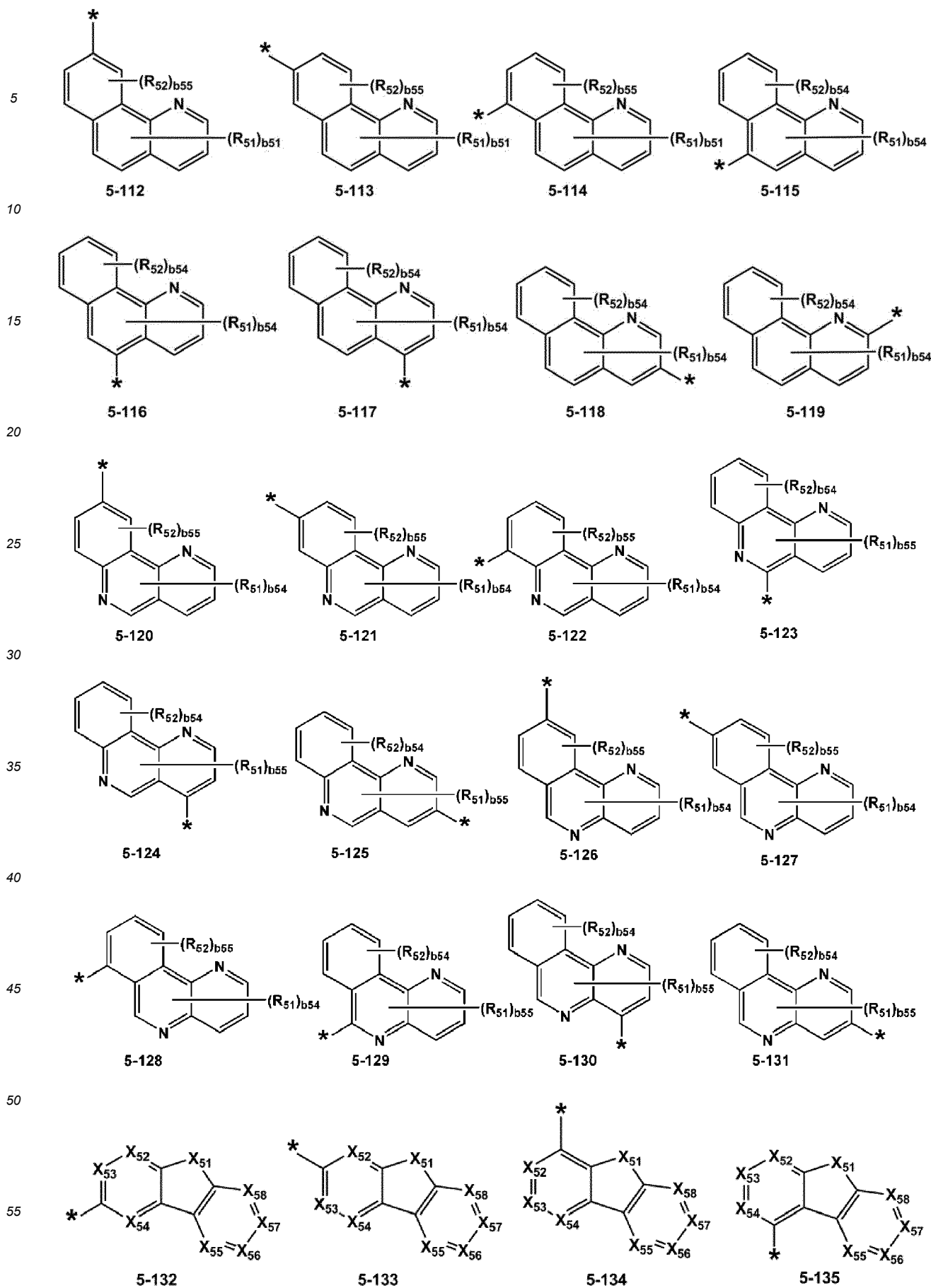




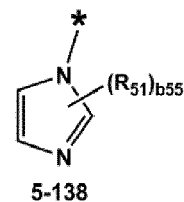
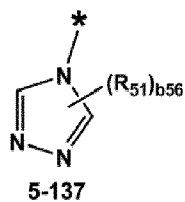
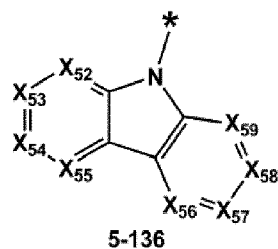


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10 In Formulae 5-1 to 5-138,

$X_{51}$  is selected from O, S, N( $R_{51}$ ), and C( $R_{51}$ )( $R_{60}$ ),

$X_{52}$  is N or C( $R_{52}$ ),

$X_{53}$  is N or C( $R_{53}$ ),

15  $X_{54}$  is N or C( $R_{54}$ ),

$X_{55}$  is N or C( $R_{55}$ ),

$X_{56}$  is N or C( $R_{56}$ ),

$X_{57}$  is N or C( $R_{57}$ ),

$X_{58}$  is N or C( $R_{58}$ ),

20  $X_{59}$  is N or C( $R_{59}$ ),

$R_{51}$  to  $R_{60}$  are each independently selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $C_1$ - $C_{20}$  (e.g.  $C_1$ - $C_{10}$ ) alkyl group, a  $C_1$ - $C_{20}$  (e.g.  $C_1$ - $C_{10}$ ) 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 thiophenyl group, a furanyl group, a silolyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, -Si( $Q_{31}$ )( $Q_{32}$ )( $Q_{33}$ ), -N( $Q_{31}$ )( $Q_{32}$ ), -B( $Q_{31}$ )( $Q_{32}$ ), -C(=O)( $Q_{31}$ ), -S(=O)( $Q_{31}$ ), -S(=O)<sub>2</sub>( $Q_{31}$ ), -P(=O)( $Q_{31}$ )( $Q_{32}$ ), and -P(=S)( $Q_{31}$ )( $Q_{32}$ ),

30  $Q_{31}$  to  $Q_{33}$  are each independently selected from a  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) alkyl group, a phenyl group, a biphenyl group, and a terphenyl group,

b51 is selected from 1, 2, 3, 4, and 5,

b52 is selected from 1, 2, 3, 4, 5, 6, and 7,

b53 is selected from 1, 2, 3, 4, 5, 6, 7, 8, and 9,

35 b54 is selected from 1, 2, 3, and 4,

b55 is selected from 1, 2, and 3,

b56 is selected from 1 and 2,

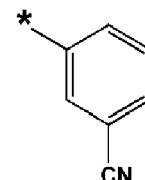
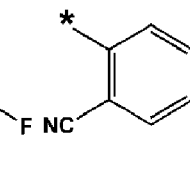
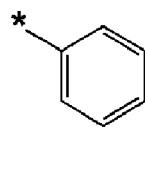
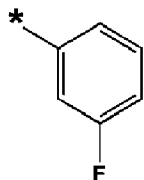
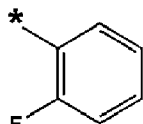
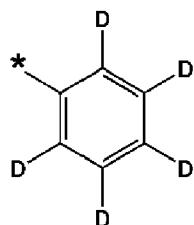
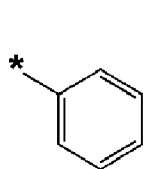
b57 is selected from 1, 2, 3, 4, 5, and 6, and

\* indicates a binding site to a neighboring atom.

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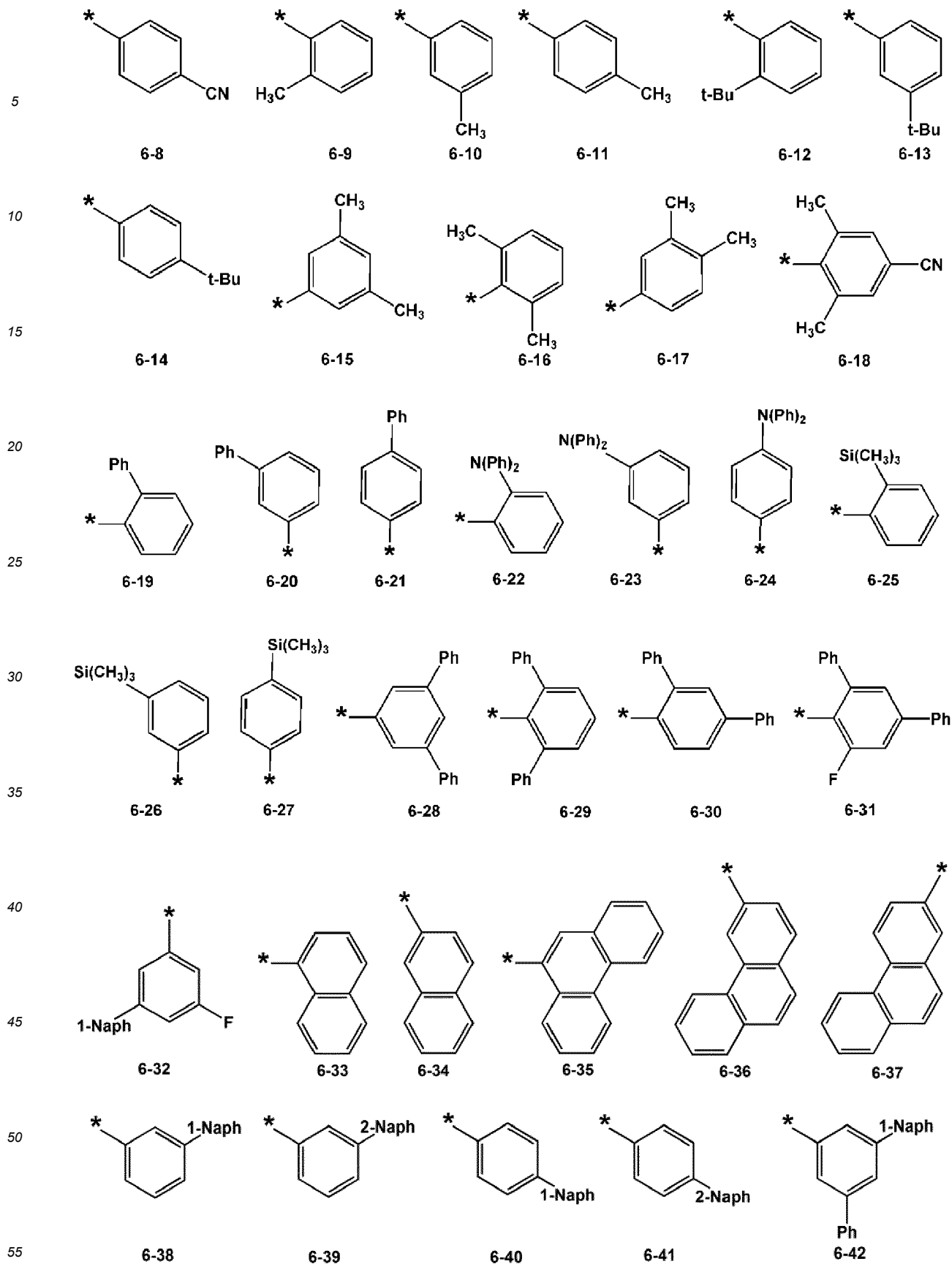
[0040] In one embodiment, in Formula 1,  $R_{11}$  to  $R_{14}$  may each independently be selected from a group represented by Formula 2 and groups represented by Formulae 6-1 to 6-257, but embodiments of the present disclosure are not limited thereto:

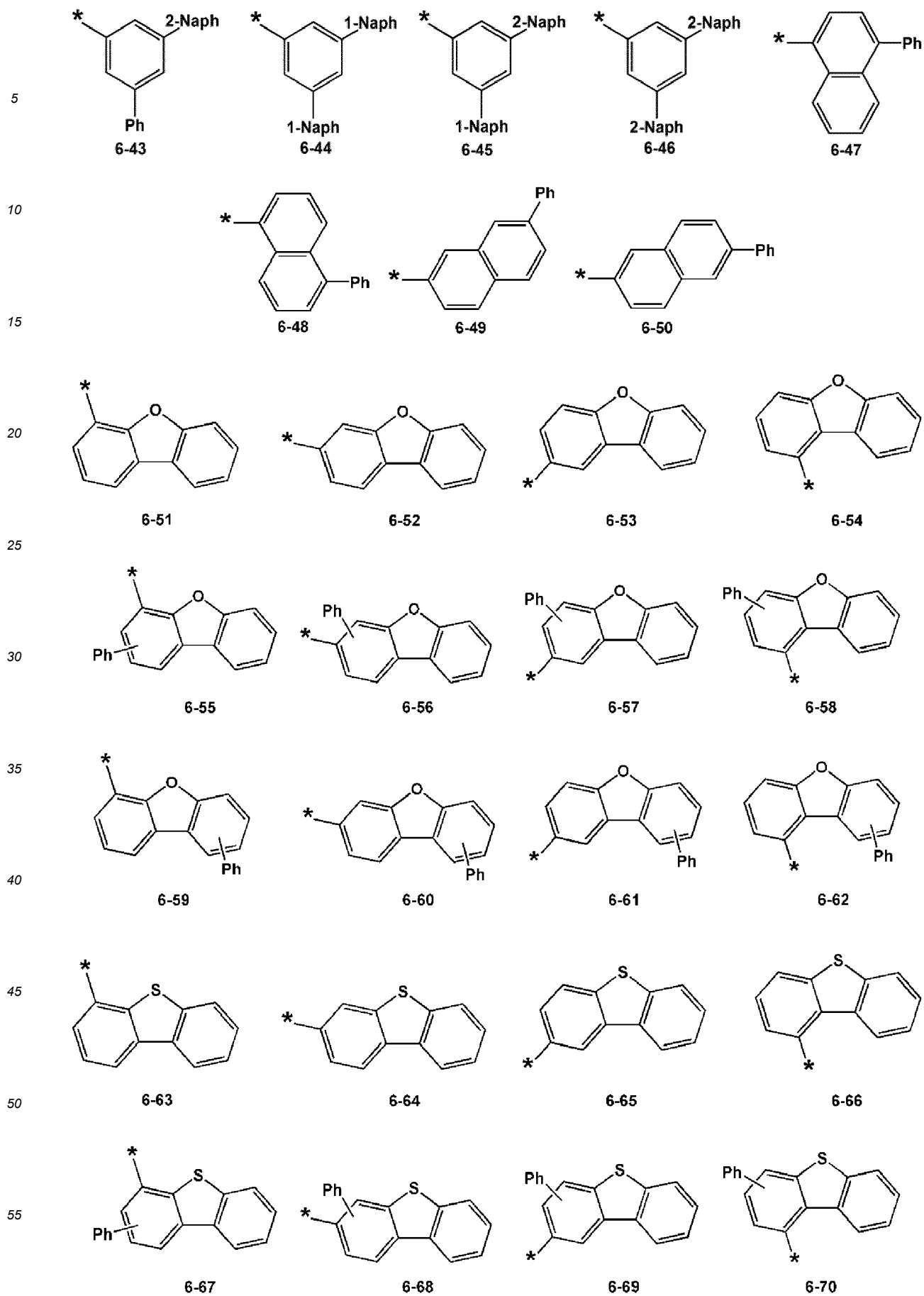
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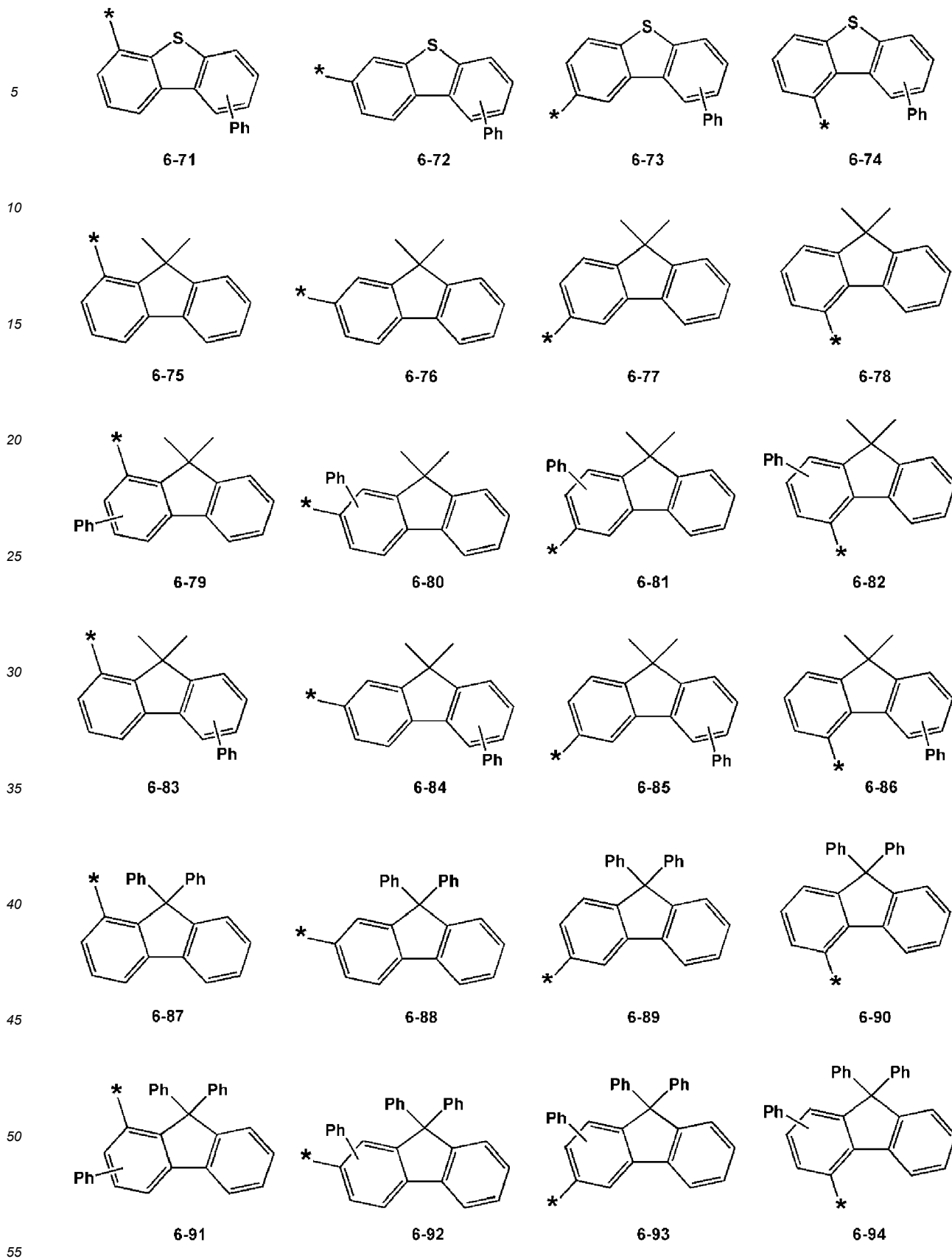


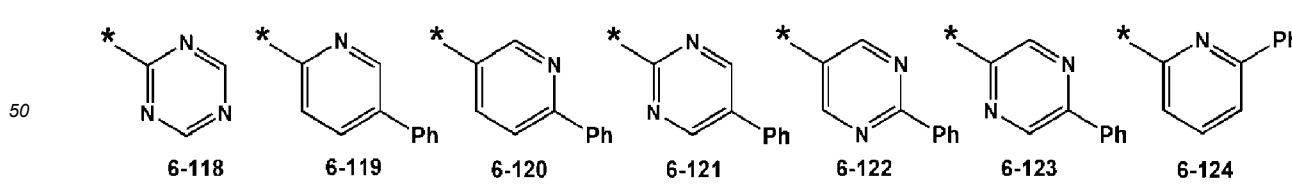
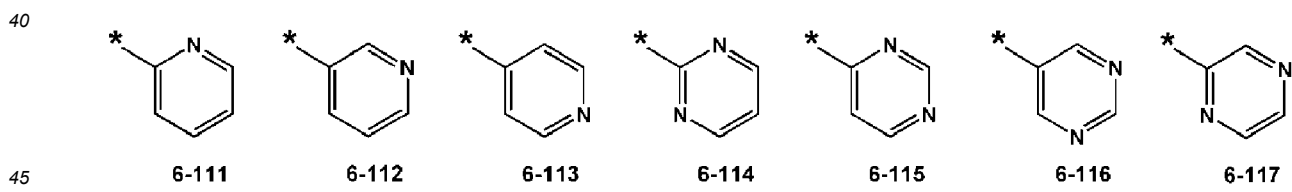
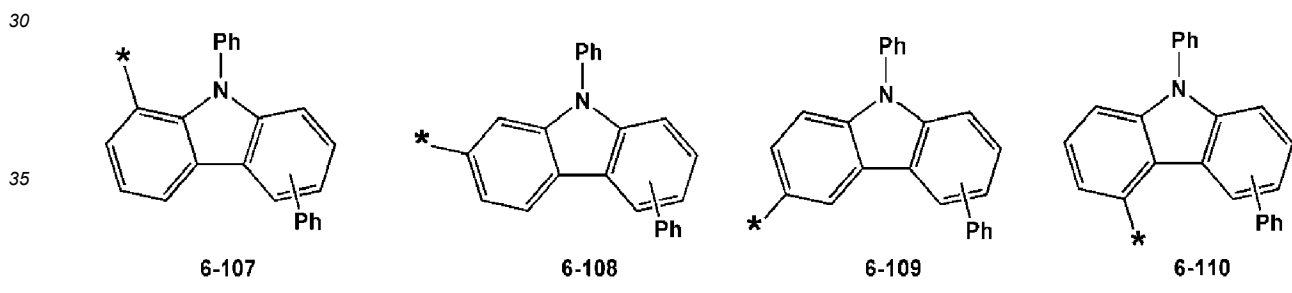
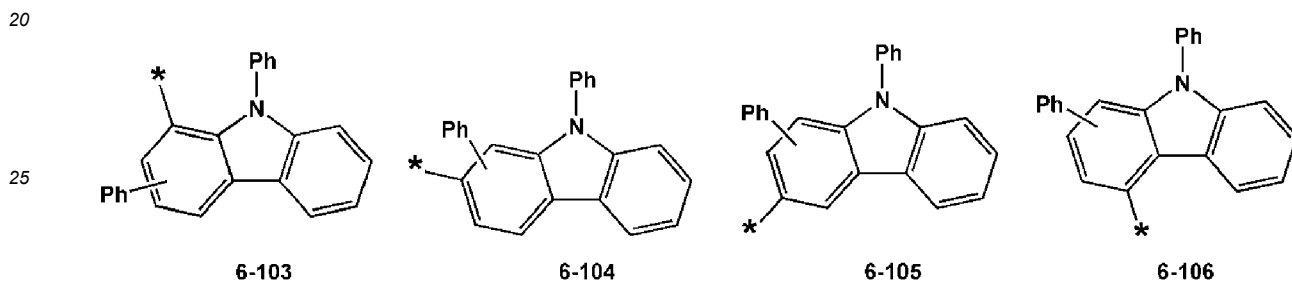
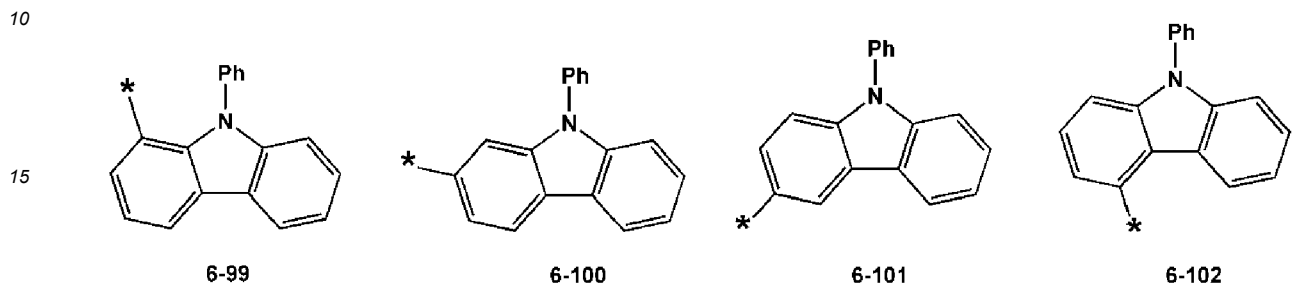
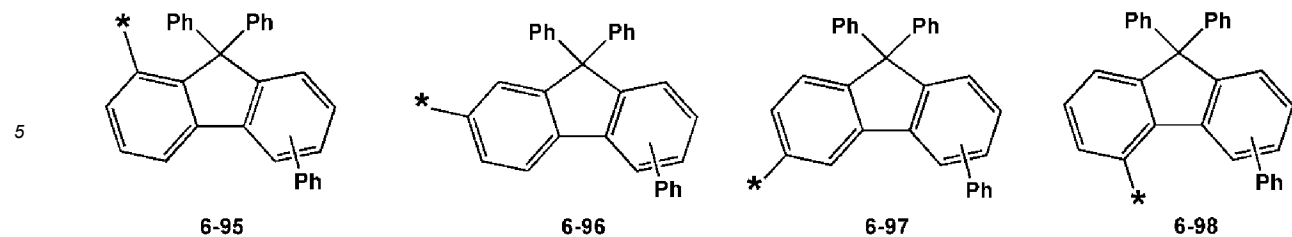
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EP 3 561 894 A1



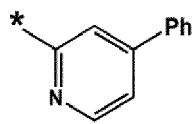




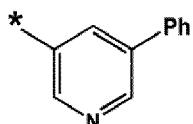


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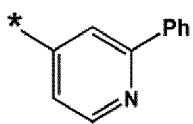
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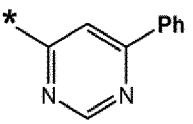
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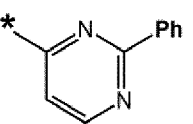
6-126



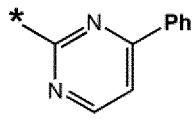
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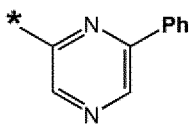
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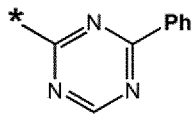
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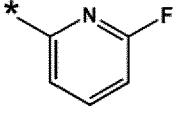
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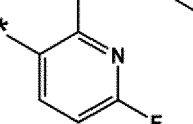
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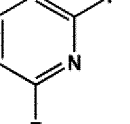
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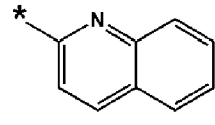
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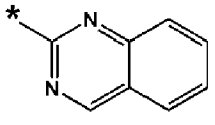
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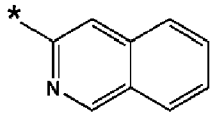
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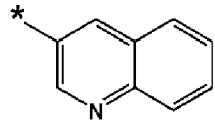
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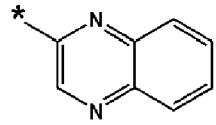
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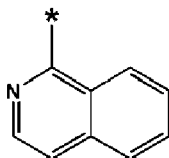
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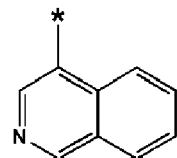
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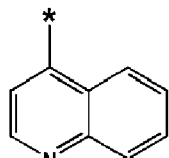
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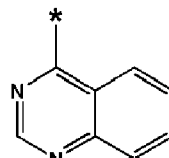
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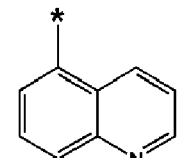
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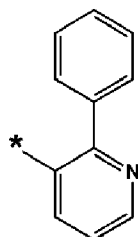
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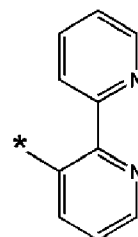
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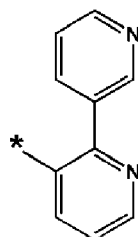
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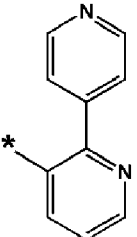
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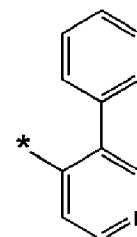
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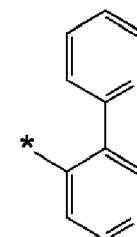
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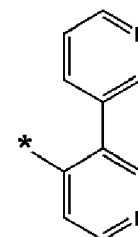
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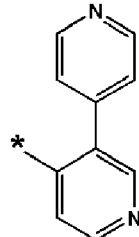
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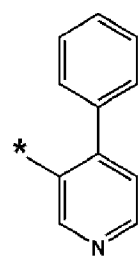
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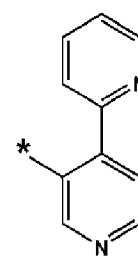
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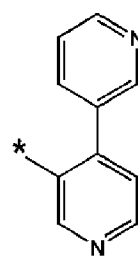
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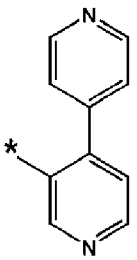
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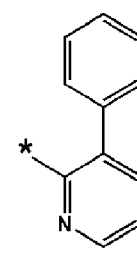
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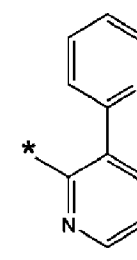
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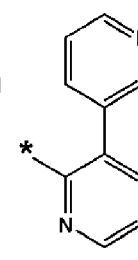
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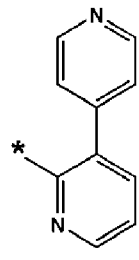
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6-159

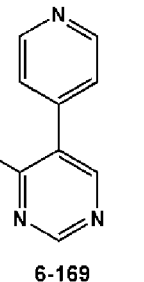
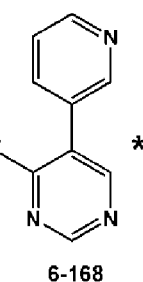
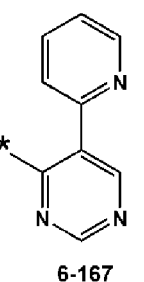
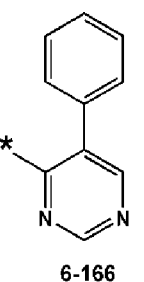
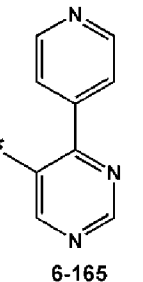
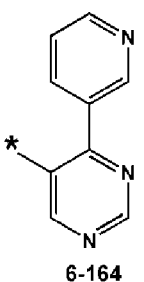
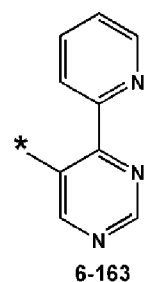
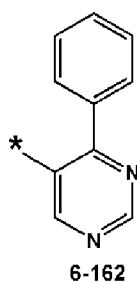


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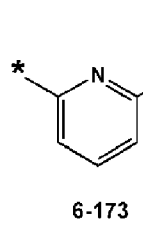
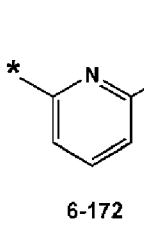
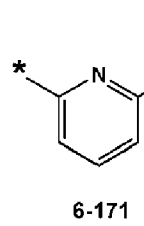
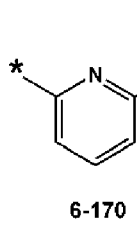
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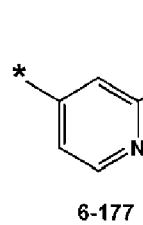
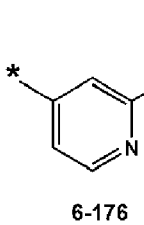
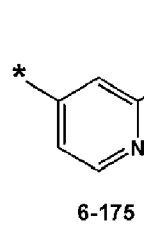
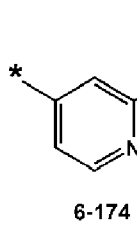
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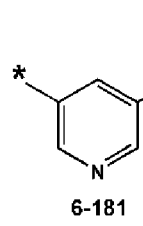
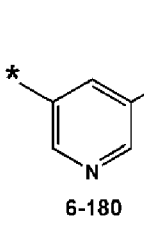
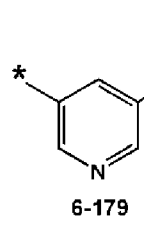
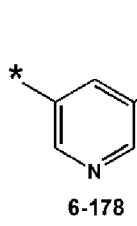
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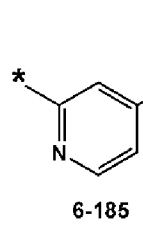
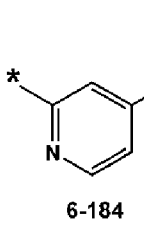
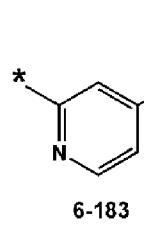
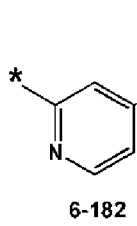
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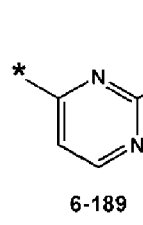
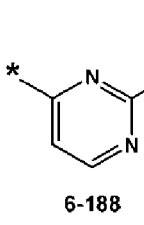
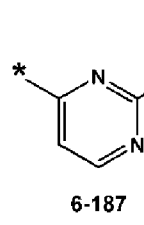
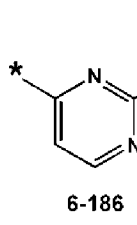


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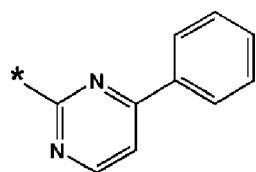


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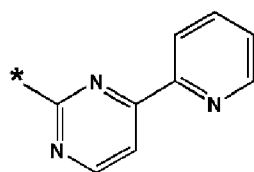


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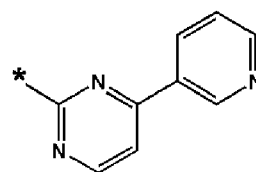
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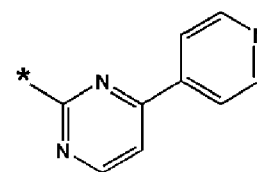
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6-191

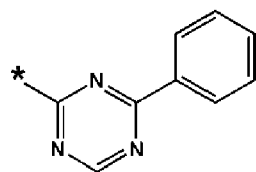


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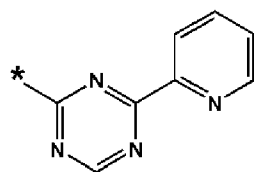


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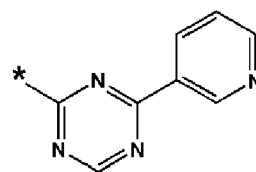
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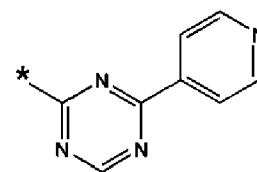
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6-195

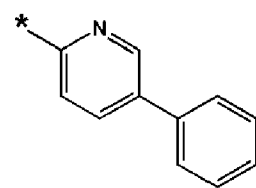


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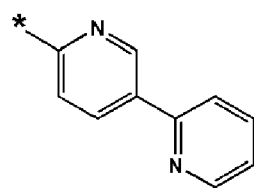


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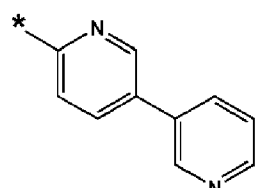
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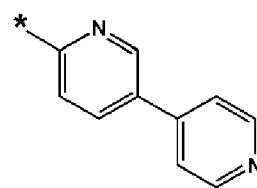
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6-199

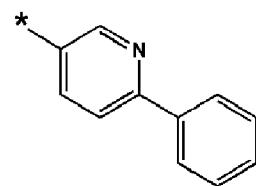


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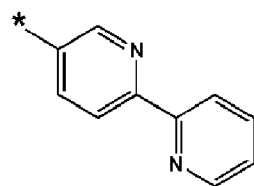


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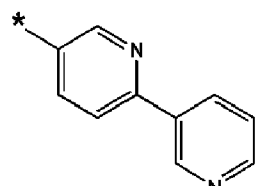
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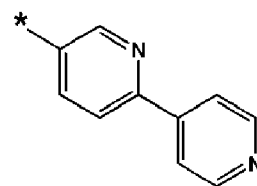
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6-203

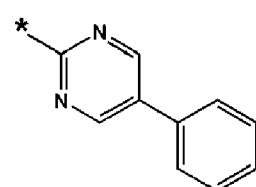


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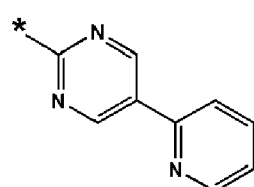


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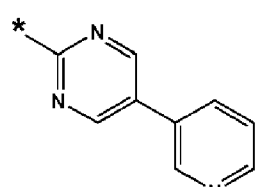
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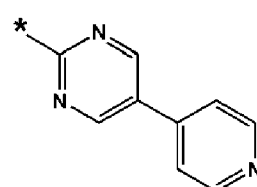
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6-207

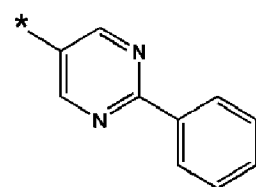


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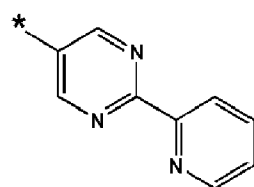


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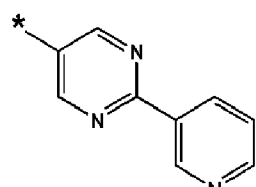
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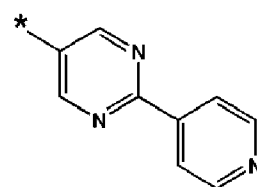
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6-211



6-212

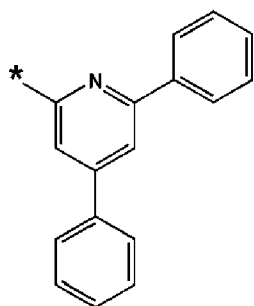


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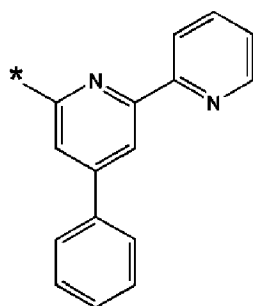
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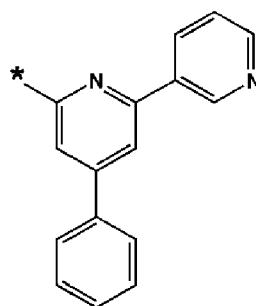
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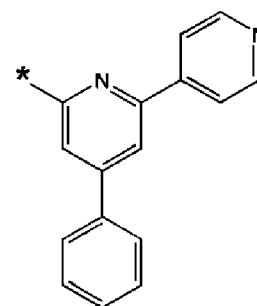
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6-215



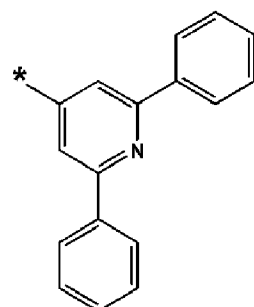
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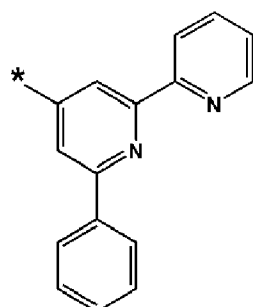
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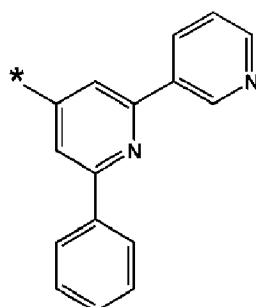
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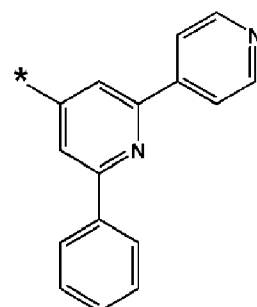
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6-219



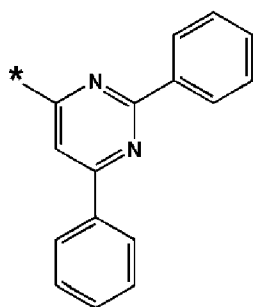
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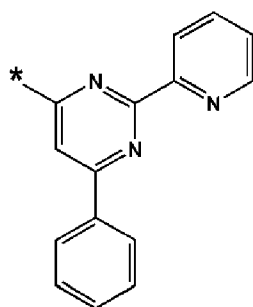
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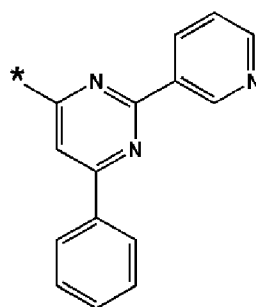
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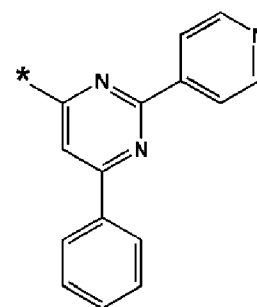
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6-223



6-224

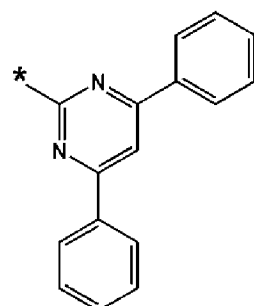


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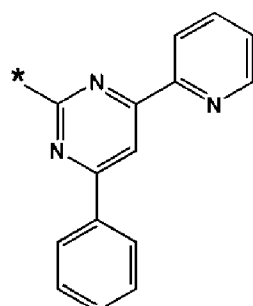
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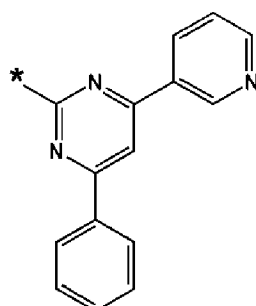
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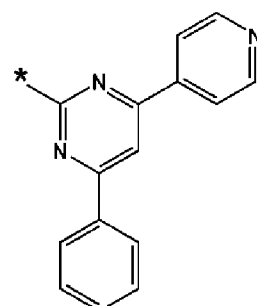
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6-227



6-228



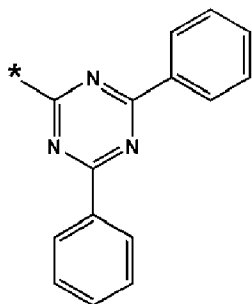
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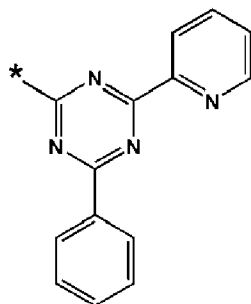
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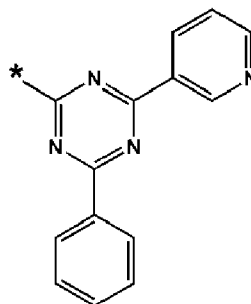
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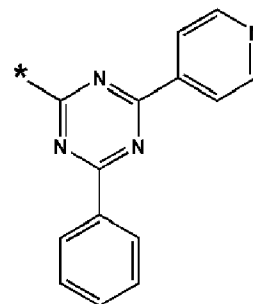
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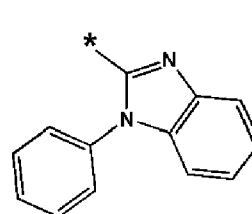
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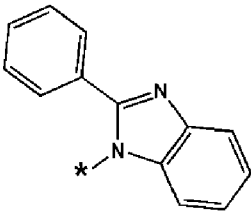
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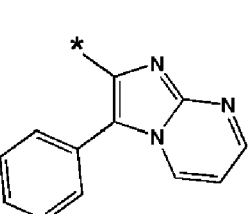
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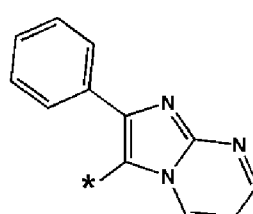
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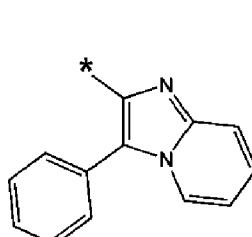
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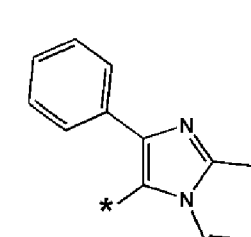
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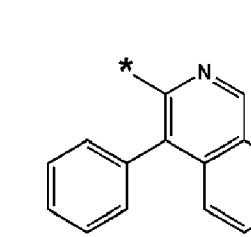
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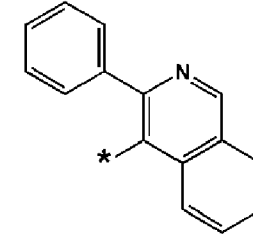
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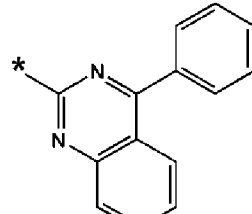
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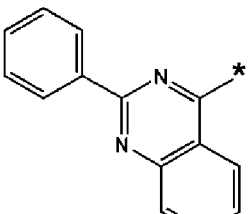
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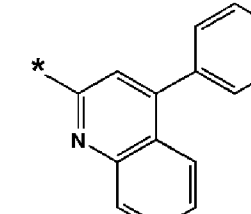
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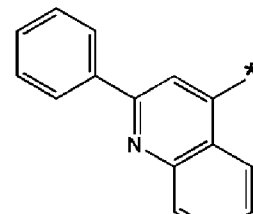
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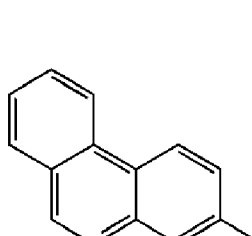
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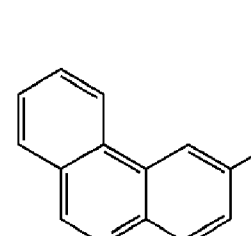
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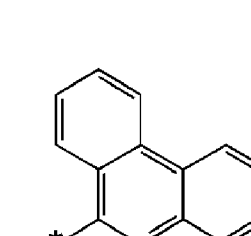
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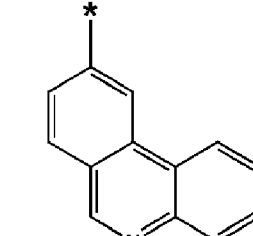
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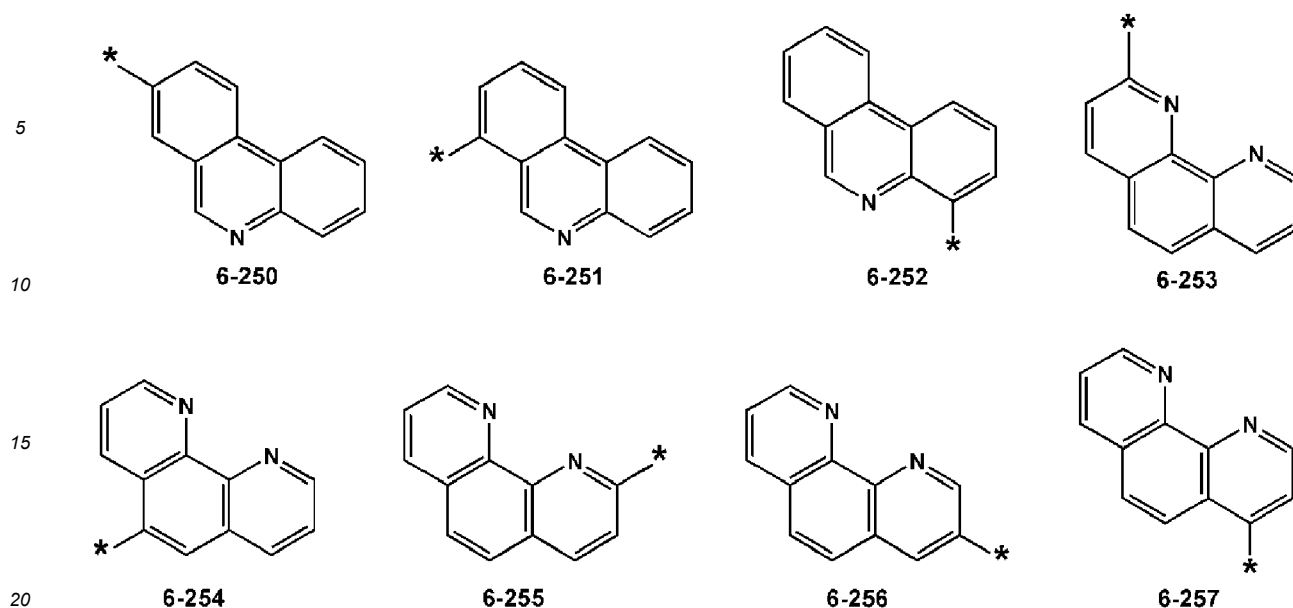
6-247



6-248



6-249



In Formulae 6-1 to 6-257,

- "t-Bu" indicates a tert-butyl group,  
 "Ph" indicates a phenyl group,  
 "1-Naph" indicates a 1-naphthyl group,  
 "2-Naph" indicates a 2-naphthyl group, and  
 \* indicates a binding site to a neighboring atom.

**[0041]** In one embodiment, in Formula 1,  $R_{11}$  to  $R_{14}$  may each independently be selected from a group represented by Formula 2 and groups represented by Formulae 6-1 to 6-110, but embodiments of the present disclosure are not limited thereto.

**[0042]** In Formulae 1 and 2,  $R_{15}$ ,  $R_{16}$ , and  $R_{21}$  to  $R_{23}$  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 substituted or unsubstituted  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) alkyl group, a substituted or unsubstituted  $C_2$ - $C_{60}$  (e.g.  $C_2$ - $C_{20}$ ) alkenyl group, a substituted or unsubstituted  $C_2$ - $C_{60}$  (e.g.  $C_2$ - $C_{20}$ ) alkynyl group, a substituted or unsubstituted  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) alkoxy group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkenyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkenyl group, a substituted or unsubstituted  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{30}$ ) aryl group, a substituted or unsubstituted  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{30}$ ) aryloxy group, a substituted or unsubstituted  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{30}$ ) arylthio group, a substituted or unsubstituted  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heteroaryl group, a substituted or unsubstituted  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heteroaryloxy group, a substituted or unsubstituted  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heteroarylthio group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, -Si( $Q_1$ )( $Q_2$ )( $Q_3$ ), -B( $Q_1$ )( $Q_2$ ), -N( $Q_1$ )( $Q_2$ ), -P( $Q_1$ )( $Q_2$ ), -C(=O)( $Q_1$ ), -S(=O)( $Q_1$ ), -S(=O)<sub>2</sub>( $Q_1$ ), -P(=O)( $Q_1$ )( $Q_2$ ), and -P(=S)( $Q_1$ )( $Q_2$ ), and

**[0043]**  $Q_1$  to  $Q_3$  are each independently selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) alkyl group, a  $C_2$ - $C_{60}$  (e.g.  $C_2$ - $C_{20}$ ) alkenyl group, a  $C_2$ - $C_{60}$  (e.g.  $C_2$ - $C_{20}$ ) alkynyl group, a  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) alkoxy group, a  $C_3$ - $C_{10}$  cycloalkyl group, a  $C_1$ - $C_{10}$  heterocycloalkyl group, a  $C_3$ - $C_{10}$  cycloalkenyl group, a  $C_1$ - $C_{10}$  heterocycloalkenyl group, a  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{30}$ ) aryl group, a  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heteroaryl group, a  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heteroaryloxy group, a  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heteroarylthio group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) alkyl group substituted with at least one selected from deuterium, -F, and a cyano group, a  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{30}$ ) aryl group substituted with at least one selected from deuterium, -F, and a cyano group, a biphenyl group, and a terphenyl group.

**[0044]** For example, in Formulae 1 and 2,  $R_{15}$ ,  $R_{16}$ , and  $R_{21}$  to  $R_{23}$  may each independently be selected from:

- hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano group, a  $C_1$ - $C_{20}$  (e.g.  $C_1$ - $C_{10}$ ) alkyl group, and a  $C_1$ - $C_{20}$  (e.g.  $C_1$ - $C_{10}$ ) alkoxy group;

a C<sub>1</sub>-C<sub>20</sub> (e.g. C<sub>1</sub>-C<sub>10</sub>) alkyl group and a C<sub>1</sub>-C<sub>20</sub> alkoxy group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a cyano group, a phenyl group, and a biphenyl 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 pentalenyl group, an indenyl group, a naphthyl group, an azulenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quinazoliny group, a benzoquinazoliny group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl 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 pentalenyl group, an indenyl group, a naphthyl group, an azulenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quinazoliny group, a benzoquinazoliny group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl 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 cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quinazoliny group, a benzoquinazoliny group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a

dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-

bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, an indolocarbazolyl group, -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)(Q<sub>31</sub>), -S(=O)<sub>2</sub>(Q<sub>31</sub>), -P(=O)(Q<sub>31</sub>)(Q<sub>32</sub>), and -P(=S)(Q<sub>31</sub>)(Q<sub>32</sub>); and

-Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>), -N(Q<sub>1</sub>)(Q<sub>2</sub>), -B(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  
 Q<sub>1</sub> to Q<sub>3</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 monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, but embodiments of the present disclosure are not limited thereto.

**[0045]** In one embodiment, in Formulae 1 and 2, R<sub>15</sub>, R<sub>16</sub>, and R<sub>21</sub> to R<sub>23</sub> may each independently be selected from:

hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano group, and a C<sub>1</sub>-C<sub>20</sub> (e.g. C<sub>1</sub>-C<sub>10</sub>) alkyl group;  
 a C<sub>1</sub>-C<sub>20</sub> (e.g. C<sub>1</sub>-C<sub>10</sub>) alkyl group substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, and a cyano group;

groups represented by Formulae 5-1 to 5-138; and

-Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>), -N(Q<sub>1</sub>)(Q<sub>2</sub>), -B(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>), but embodiments of the present disclosure are not limited thereto.

**[0046]** In one embodiment, in Formulae 1 and 2, R<sub>15</sub>, R<sub>16</sub>, and R<sub>21</sub> to R<sub>23</sub> may each independently be selected from:

hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano group, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, and a tert-butyl 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, and a tert-butyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, and a cyano group; and

groups represented by Formulae 6-1 to 6-257, but embodiments of the present disclosure are not limited thereto.

**[0047]** In one embodiment, in Formulae 1 and 2, R<sub>15</sub>, R<sub>16</sub>, R<sub>22</sub>, and R<sub>23</sub> may each independently be selected from:

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

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, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I and a cyano group, but embodiments of the present disclosure are not limited thereto.

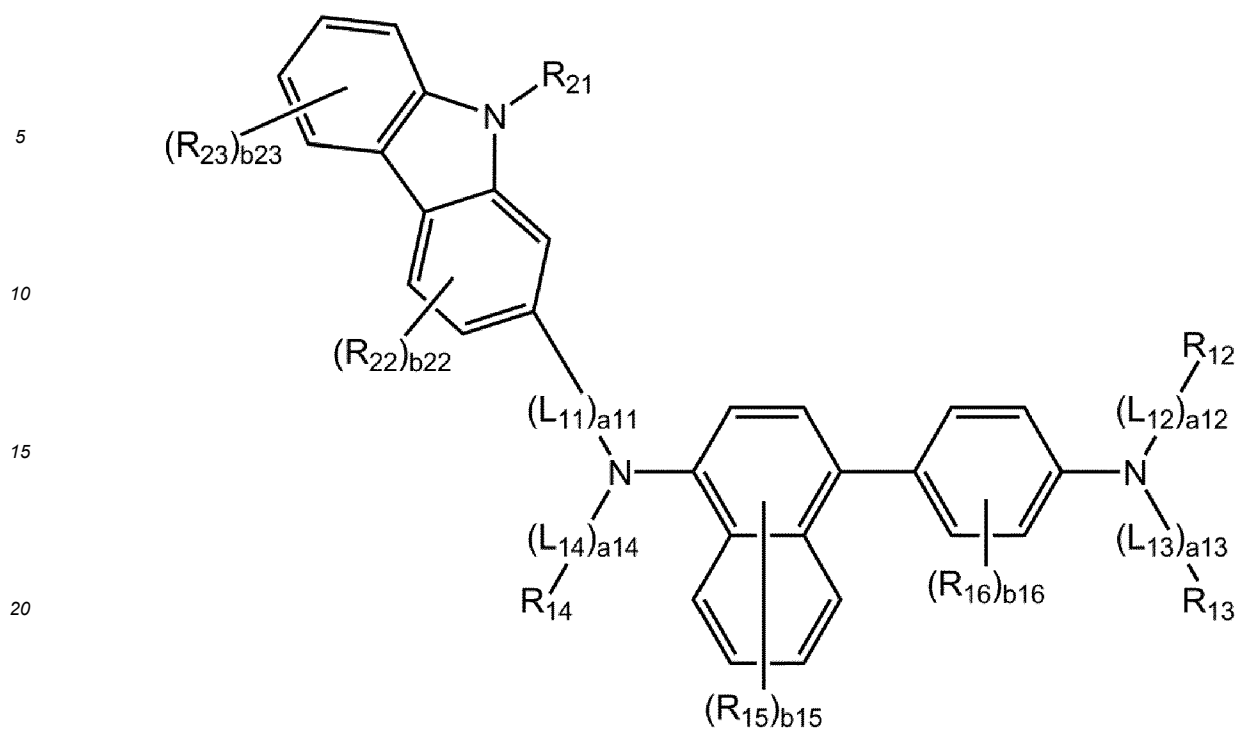
**[0048]** In Formula 1, b15 indicates the number of substituent(s) for R<sub>15</sub>, and is selected from 1, 2, 3, 4, 5, and 6.

**[0049]** In Formula 1, b16 indicates the number of substituent(s) for R<sub>16</sub>, and is selected from 1, 2, 3, and 4.

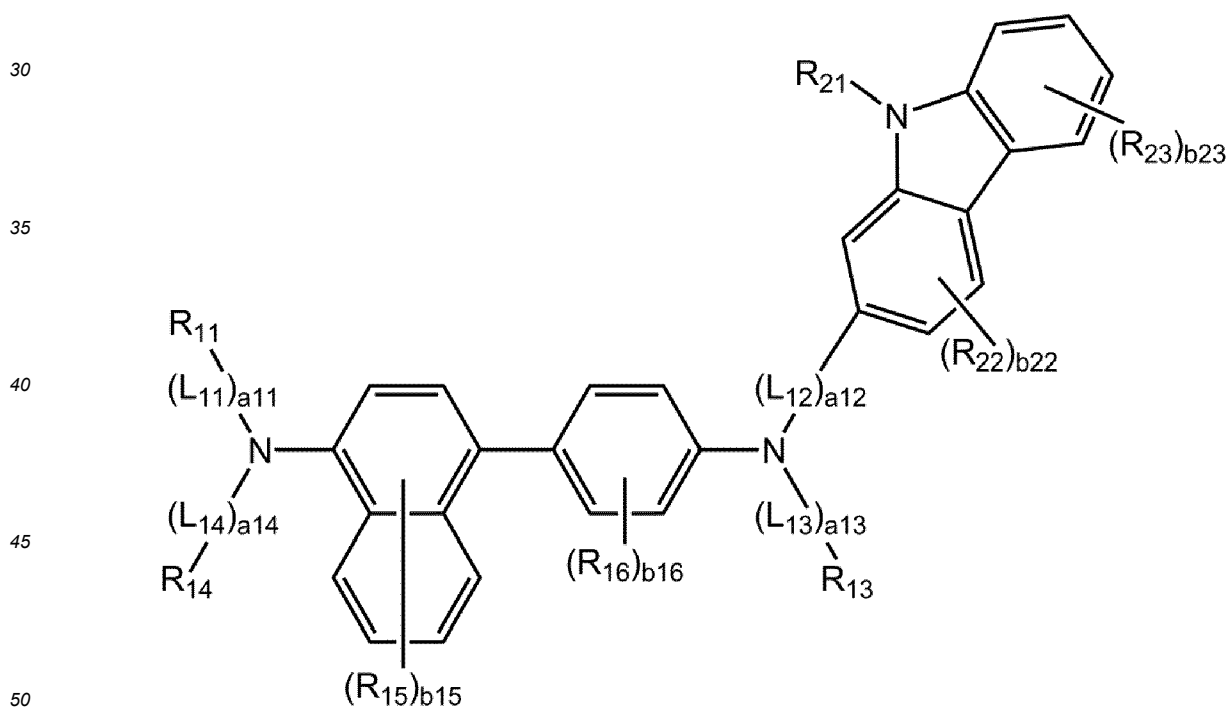
**[0050]** In Formula 2, b22 indicates the number of substituent(s) for R<sub>22</sub>, and is selected from 1, 2, and 3.

**[0051]** In Formula 2, b23 indicates the number of substituent(s) for R<sub>23</sub>, and is selected from 1, 2, 3, and 4.

**[0052]** In one embodiment, the diamine compound represented by Formula 1 may be represented by one selected from Formulae 1-1 and 1-2, but embodiments of the present disclosure are not limited thereto:



1-1



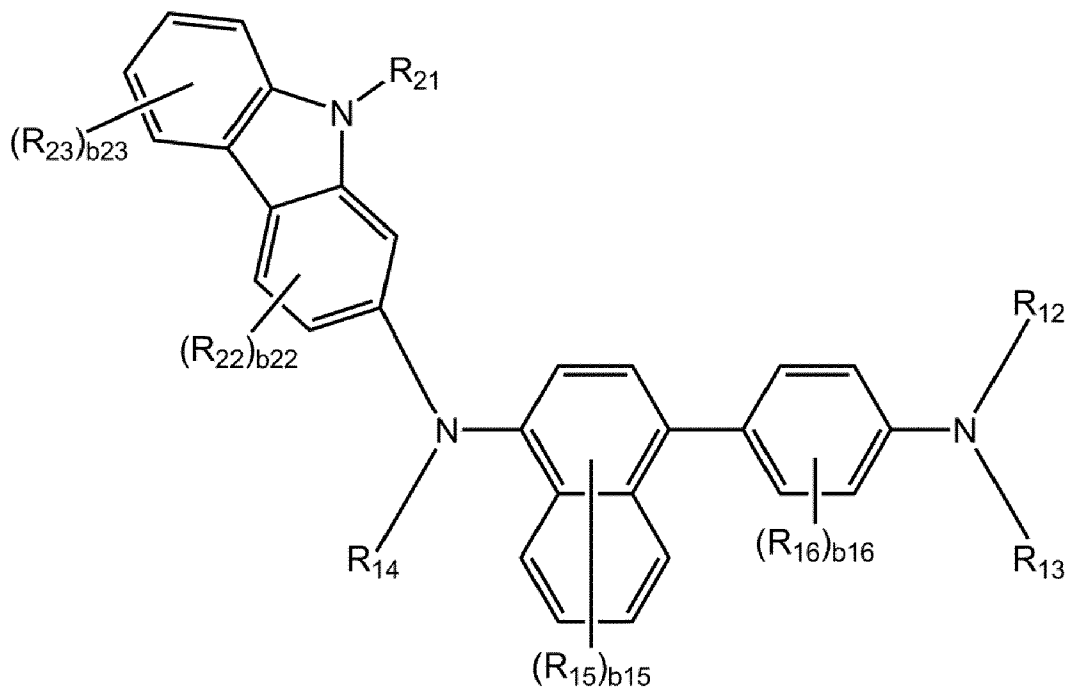
1-2

55 In Formulae 1-1 and 1-2,

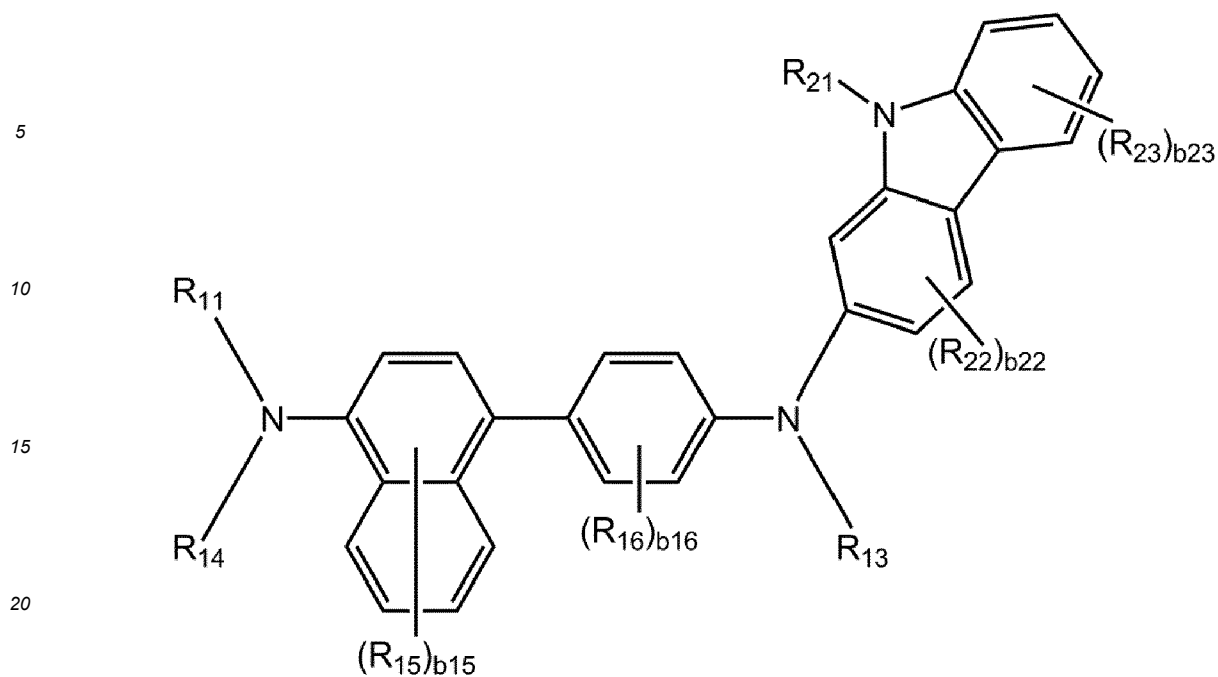
L<sub>11</sub> to L<sub>14</sub>, a<sub>11</sub> to a<sub>14</sub>, R<sub>15</sub>, R<sub>16</sub>, b<sub>15</sub>, and b<sub>16</sub> are respectively the same as described in Formula 1,  
 R<sub>21</sub> to R<sub>23</sub>, b<sub>22</sub>, and b<sub>23</sub> are respectively the same as described in Formula 2, and

R<sub>11</sub> to R<sub>14</sub> are each independently 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>30</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.

[0053] In one or more embodiments, the diamine compound represented by Formula 1 may be represented by one selected from Formulae 1-11 and 1-12, but embodiments of the present disclosure are not limited thereto:



1-11



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1-12

In Formulae 1-11 and 1-12,

R<sub>15</sub>, R<sub>16</sub>, b<sub>15</sub>, and b<sub>16</sub> are respectively the same as described in Formula 1,

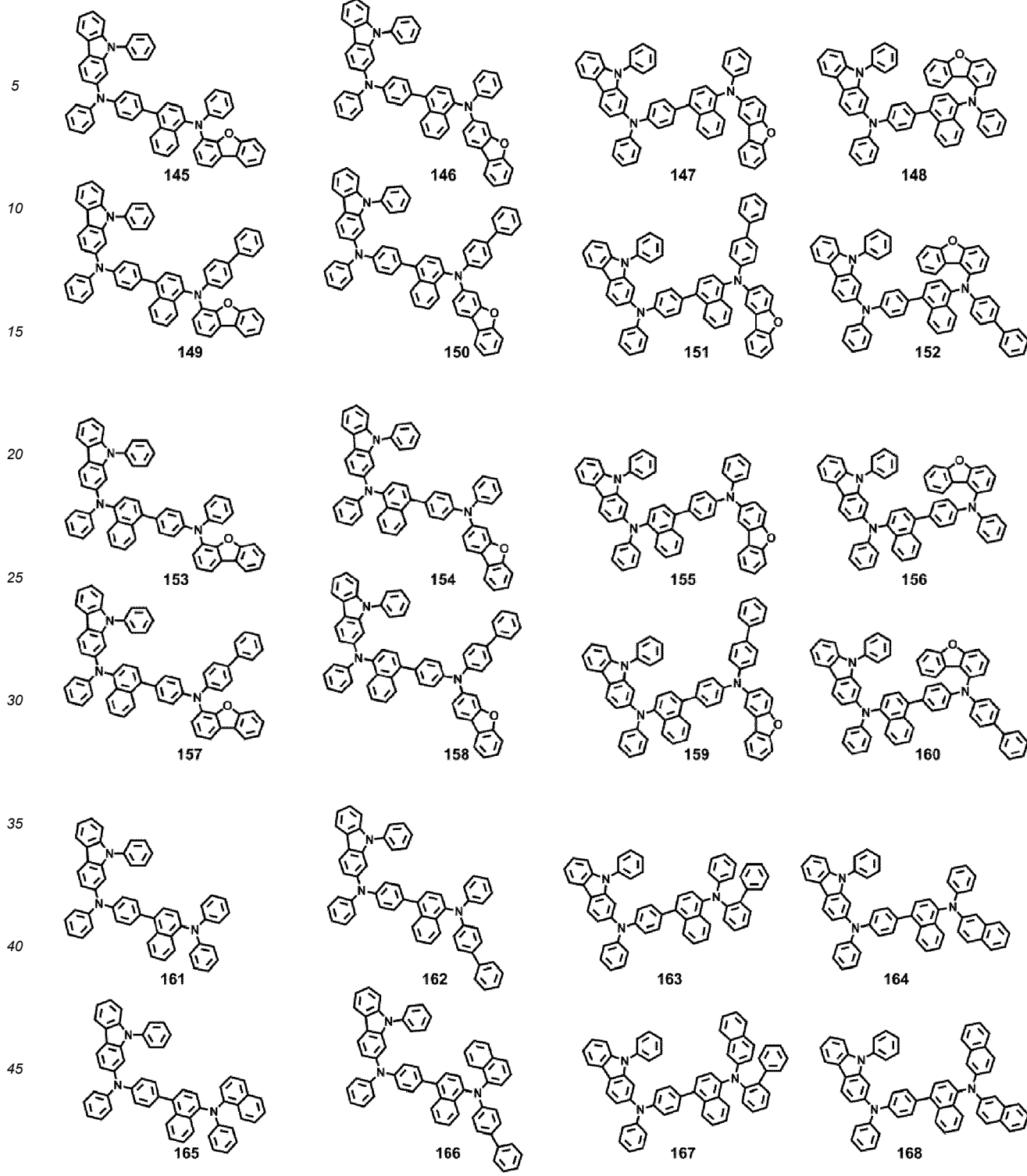
R<sub>21</sub> to R<sub>23</sub>, b<sub>22</sub>, and b<sub>23</sub> are respectively the same as described in Formula 2, and

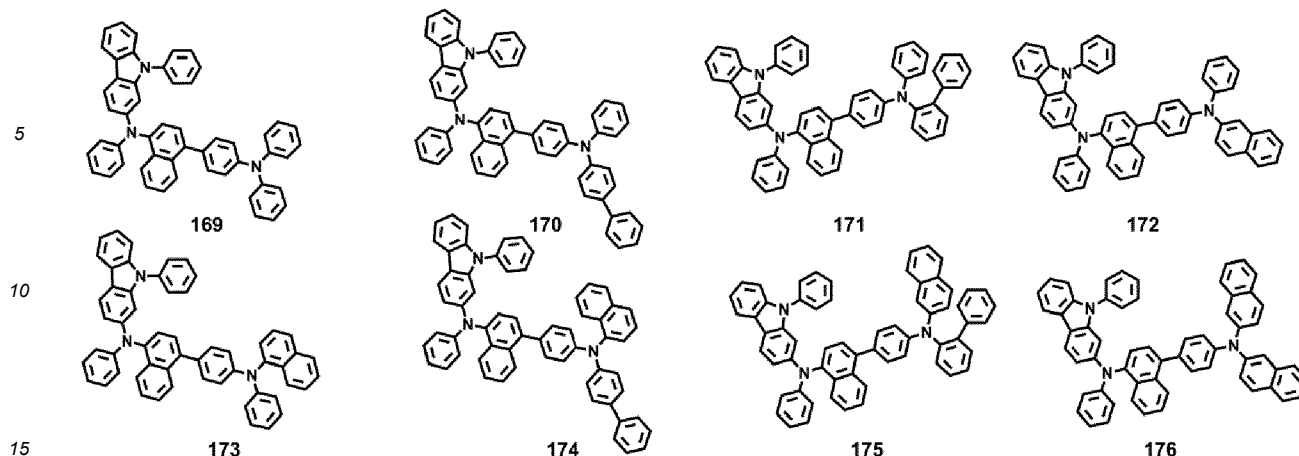
R<sub>11</sub> to R<sub>14</sub> are each independently selected from a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl 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>30</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.

**[0054]** For example, in Formulae 1-11 and 1-12, R<sub>15</sub>, R<sub>16</sub>, R<sub>22</sub>, and R<sub>23</sub> may each independently be selected from:

hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano group, a methyl group, an ethyl group, an n-propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a sec-butyl group, and a tert-butyl group; and 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, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I and a cyano group, but embodiments of the present disclosure are not limited thereto.

**[0055]** In more detail, the diamine compound represented by Formula 1 may be selected from Compounds 145 to 176, but embodiments of the present disclosure are not limited thereto:





[0056] While the present disclosure is not limited by any particular mechanism or theory, it is believed that since the diamine compound represented by Formula 1 includes the 2-carbazolyl group, the glass transition temperature and/or the melting point of the diamine compound may be improved. Therefore, an organic light-emitting device including the diamine compound represented by Formula 1 may exhibit long lifespan characteristics, improved storage stability, and/or improved reliability.

[0057] In addition, it is believed that since the diamine compound represented by Formula 1 includes the 2-carbazolyl group, the hole injection and/or the mobility of the diamine compound are improved. Therefore, the light-emitting region of the organic light-emitting device including the diamine compound may be widened, thereby delaying or reducing the deterioration of the organic light-emitting device.

[0058] Additionally, it is believed that since the diamine compound represented by Formula 1 includes the naphthyl-phenyl linker, a plane including two amino groups as a substrate may have a tilted structure. Therefore, when the diamine compound is deposited, the diamine compound tends to be densely stacked, thereby improving charge mobility. Therefore, the organic light-emitting device including the diamine compound represented by Formula 1 may have low driving voltage and high efficiency characteristics.

[0059] The diamine compound represented by Formula 1 may be synthesized by using any suitable organic synthesis method available in the art. Methods of synthesizing the diamine compound may be readily recognized by those of skill in the art by referring to Examples provided below.

[0060] The diamine compound represented by Formula 1 may be used between a pair of electrodes of an organic light-emitting device.

[0061] The expression "(an organic layer) includes at least one diamine compound," as used herein, may include a case in which "(an organic layer) includes identical diamine compounds represented by Formula 1" and a case in which "(an organic layer) includes two or more different diamine compounds represented by Formula 1".

[0062] For example, the organic layer may include, as the diamine compound, Compound 1 only. In this regard, Compound 1 may exist in a hole transport layer of the organic light-emitting device. In one or more embodiments, the organic layer may include, as the diamine compound, Compound 1 and Compound 2. In one or more embodiments, Compound 1 and Compound 2 may both exist in an identical layer (for example, Compound 1 and Compound 2 may both exist in a hole transport layer), or may exist in different layers (for example, Compound 1 may exist in a hole transport layer and Compound 2 may exist in a hole injection layer).

[0063] The organic layer includes i) a hole transport region that is disposed between the first electrode (anode) and the emission layer and includes at least one of a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer, and ii) an electron transport region that is disposed between the emission layer and the second electrode (cathode) and includes at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer. For example, the hole transport region of the organic light-emitting device may include at least one of the diamine compound represented by Formula 1.

[0064] The term "organic layer," as used herein, refers to a single layer and/or a plurality of layers disposed between the first electrode and the second electrode of the organic light-emitting device. A material included in the "organic layer" is not limited to an organic material. For example, the organic layer may include an inorganic material in addition to an organic material.

#### Description of FIG. 1

[0065] 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.

**[0066]** 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.

#### 5 **First electrode 110**

**[0067]** In FIG. 1, a substrate may be additionally disposed under the first electrode 110 or above the second electrode 190. The substrate may be a glass substrate or a plastic substrate, each having excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water resistance.

10 **[0068]** 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.

**[0069]** 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 (SnO<sub>2</sub>), zinc oxide (ZnO), and any combinations thereof, but embodiments of the present disclosure are not limited thereto. In one or more embodiments, when the first electrode 110 is a semi-transmissive electrode or a reflectable electrode, a material for forming 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.

20 **[0070]** 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.

#### 25 **Organic layer 150**

**[0071]** The organic layer 150 is disposed on the first electrode 110. The organic layer 150 may include an emission layer.

**[0072]** 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.

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#### **Hole transport region in organic layer 150**

**[0073]** 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.

35

**[0074]** 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.

**[0075]** 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.

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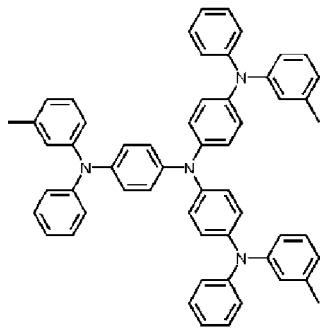
**[0076]** The electron transport region may further include the diamine compound.

**[0077]** The hole transport region may further include, in addition to the diamine compound, at least one selected from TDATA, 2-TNATA, NPB(NPD),  $\beta$ -NPB, TPD, Spiro-TPD, Spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201, and a compound represented by Formula 202:

50

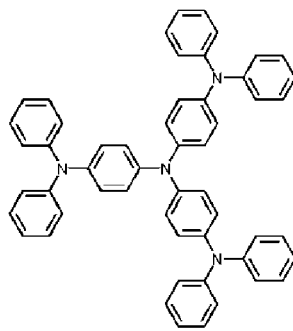
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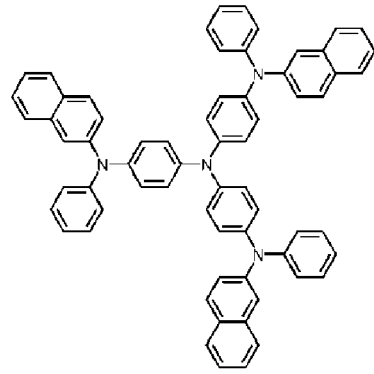


**m-MTDATA**

10

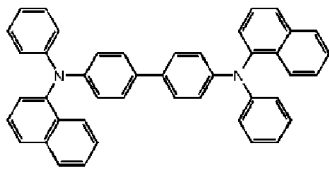


**TDATA**



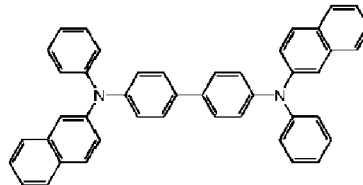
**2-TNATA**

15

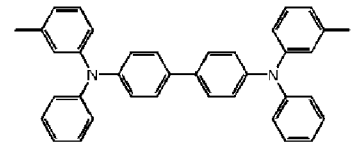


**NPB**

20

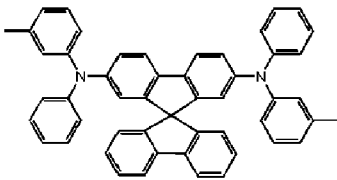


**β-NPB**



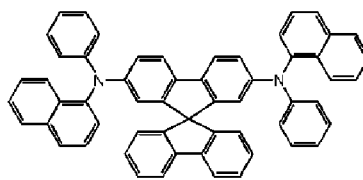
**TPD**

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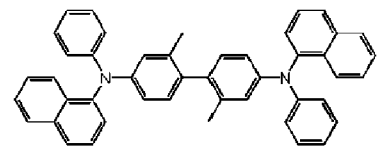


**Spiro-TPD**

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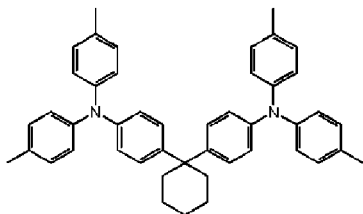


**Spiro-NPB**



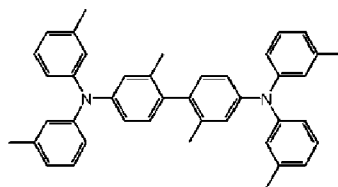
**methylated NPB**

35



**TAPC**

40



**HMTPD**

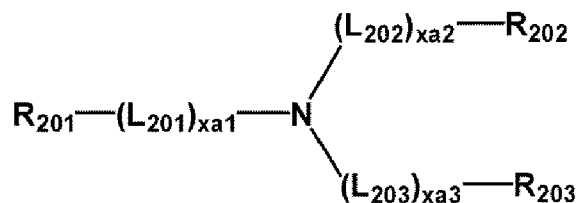
Formula 201

45

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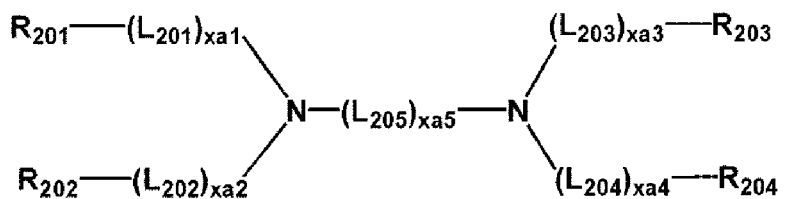
5



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Formula 202

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In Formulae 201 and 202,

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$\text{L}_{201}$  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

25

divalent non-aromatic condensed heteropolycyclic group;

$\text{L}_{205}$  may be selected from  $^*\text{-O-}^*$ ,  $^*\text{-S-}^*$ ,  $^*\text{-N}(\text{Q}_{201})\text{-}^*$ , 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

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divalent non-aromatic condensed heteropolycyclic group,

$x_{a1}$  to  $x_{a4}$  may each independently be an integer of 0 to 3,

$x_{a5}$  may be an integer of 1 to 10, and

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$\text{R}_{201}$  to  $\text{R}_{204}$  and  $\text{Q}_{201}$  may each independently be 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.

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**[0078]** 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.

45

**[0079]** In one embodiment, in Formulae 201 and 202,

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

50

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacacenylene 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

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a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexaceny-  
 5 nylene group, a pentacenylenylene group, a rubicenylenylene group, a coronenylenylene group, an ovalenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, and a pyridinylenylene group,  
 10 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,  
 15 an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), and -N(Q<sub>31</sub>)(Q<sub>32</sub>), and Q<sub>31</sub> to Q<sub>33</sub> may each independently be selected from a C<sub>1</sub>-C<sub>10</sub> alkyl group, a C<sub>1</sub>-C<sub>10</sub> alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

**[0080]** In one or more embodiments, xa1 to xa4 may each independently be 0, 1, or 2.

**[0081]** In one or more embodiments, xa5 may be 1, 2, 3, or 4.

**[0082]** In one or more embodiments, R<sub>201</sub> to R<sub>204</sub> and Q<sub>201</sub> may each independently be selected from:

a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group; and  
 30 a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group, each substituted  
 35 with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C<sub>1</sub>-C<sub>10</sub> alkyl group, a phenyl group substituted with -F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), and -N(Q<sub>31</sub>)(Q<sub>32</sub>), and Q<sub>31</sub> to Q<sub>33</sub> may respectively be the same as described above.

**[0083]** In one or more embodiments, in Formula 201, at least one selected from R<sub>201</sub> to R<sub>203</sub> may each independently be selected from:

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

a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a 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.

**[0084]** In one or more embodiments, in Formula 202, i) R<sub>201</sub> and R<sub>202</sub> may be linked each other via a single bond, and/or ii) R<sub>203</sub> and R<sub>204</sub> may be linked each other via a single bond.

**[0085]** 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:

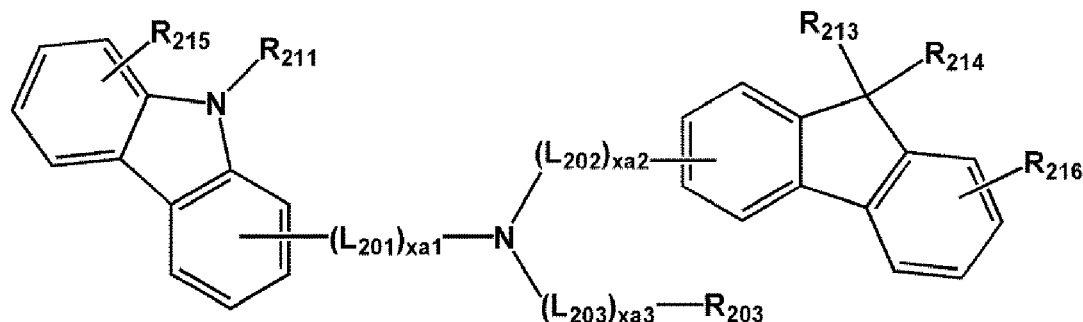
a carbazolyl group; and

a carbazolyl group substituted 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.

**[0086]** The compound represented by Formula 201 may be represented by Formula 201A:

Formula 201A



**[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:

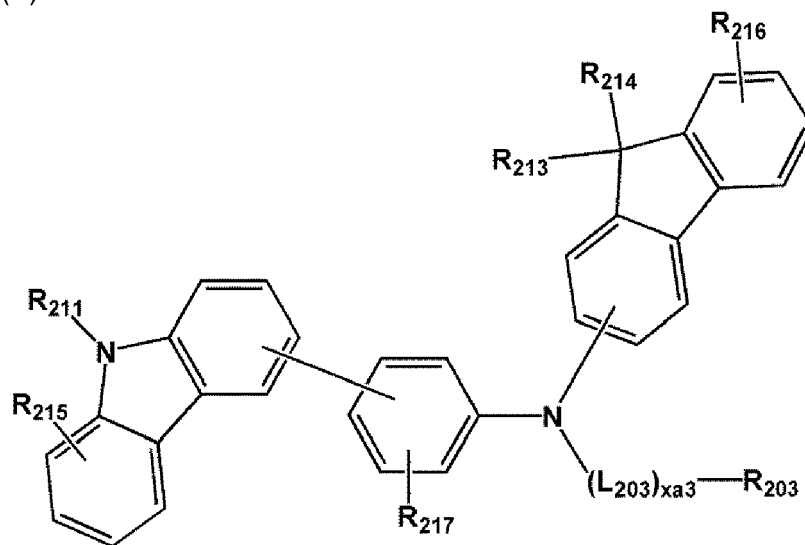
Formula 201A(1)

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[0088] 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:

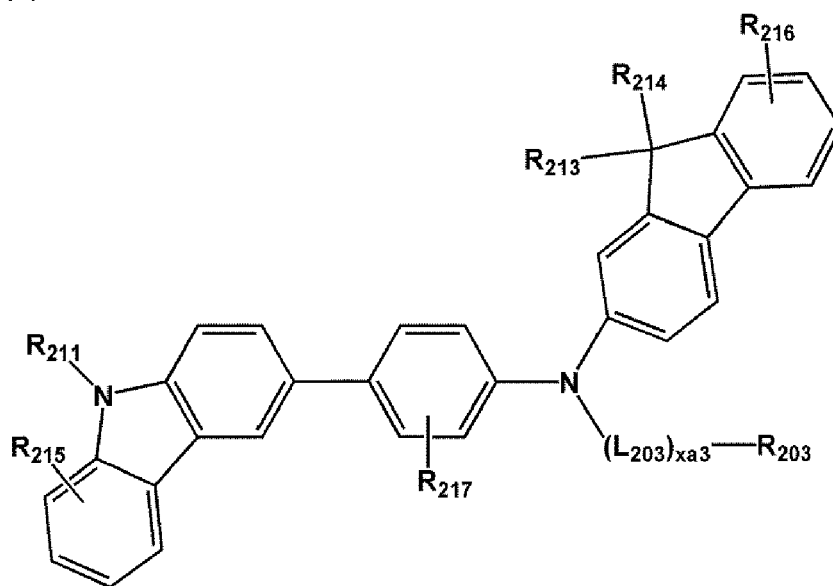
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Formula 201A-1

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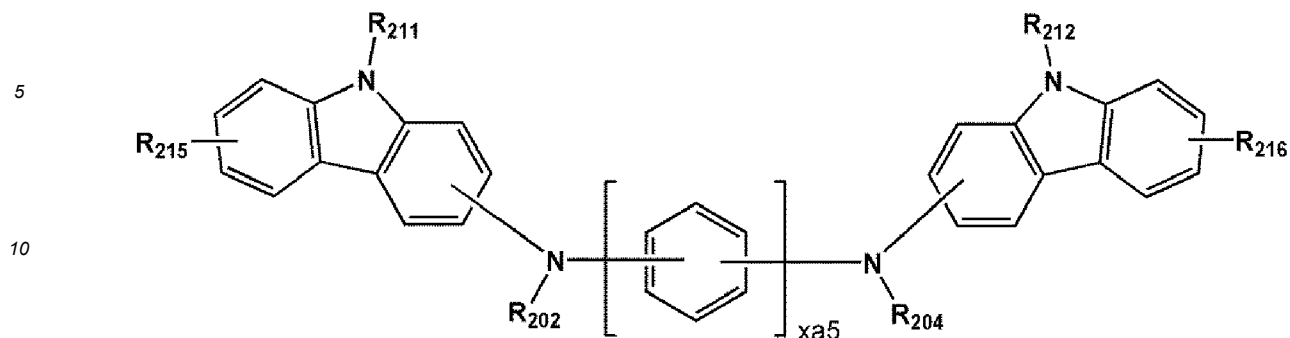
45

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

50

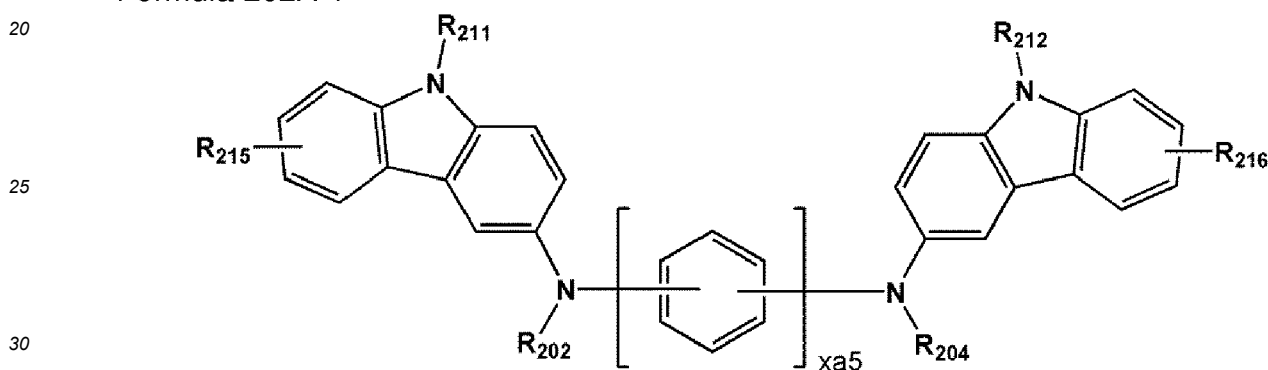
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Formula 202A



15 **[0090]** In one or more embodiments, the compound represented by Formula 202 may be represented by Formula 202A-1:

Formula 202A-1



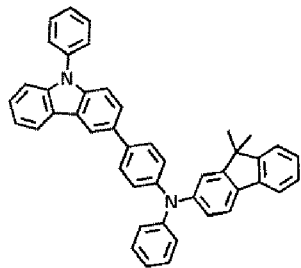
In Formulae 201A, 201A(1), 201A-1, 202A, and 202A-1,

35  $L_{201}$  to  $L_{203}$ ,  $xa1$  to  $xa3$ ,  $xa5$ , and  $R_{202}$  to  $R_{204}$  may respectively be the same as described above,  $R_{211}$  and  $R_{212}$  may respectively be the same as described 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  $C_1$ - $C_{10}$  alkyl group, a phenyl group substituted with -F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group.

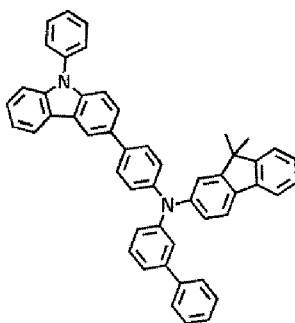
50 **[0091]** The hole transport region may include at least one compound selected from Compounds HT1 to HT39, but embodiments of the present disclosure are not limited thereto:

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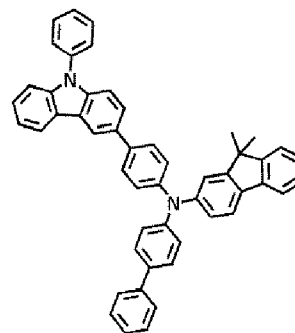
5



HT1

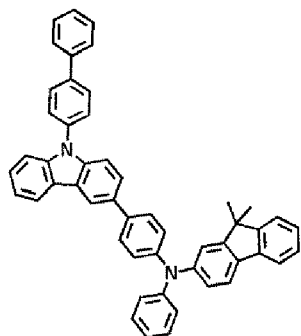


HT2

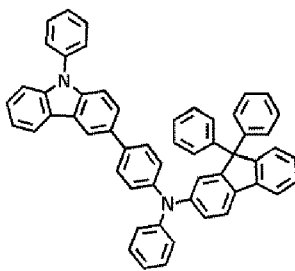


HT3

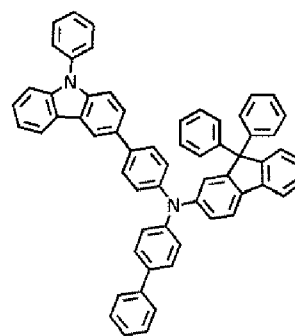
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HT4

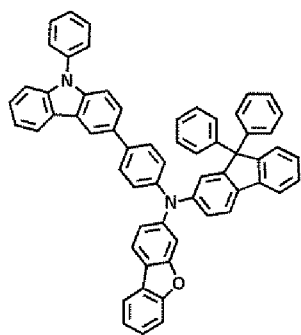


HT5

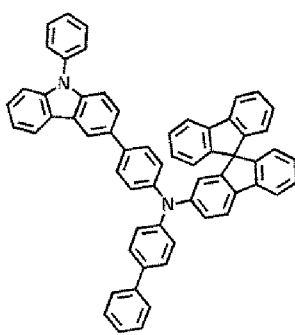


HT6

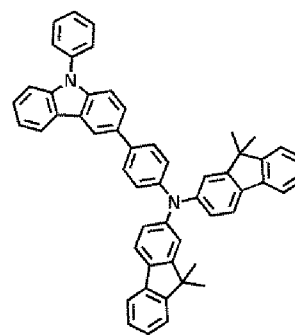
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HT7

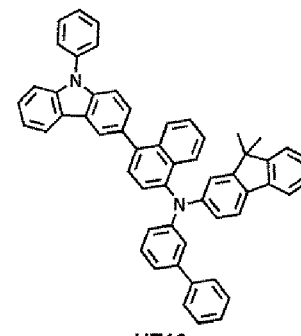


HT8

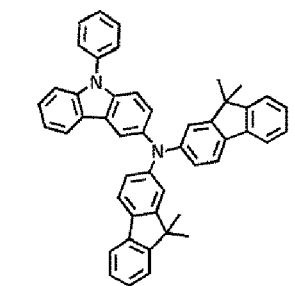


HT9

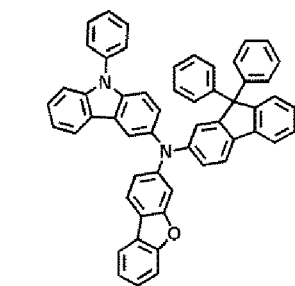
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HT10



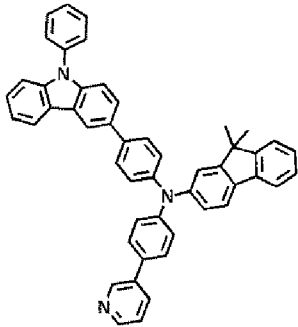
HT11



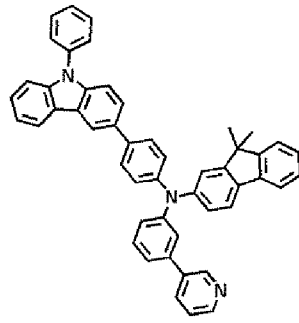
HT12

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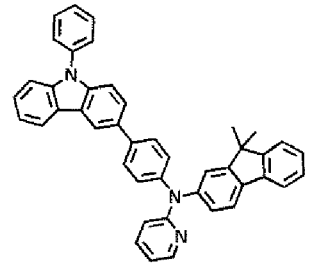
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HT13

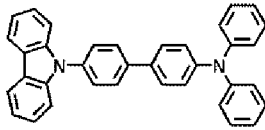


HT14

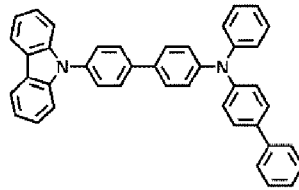


HT15

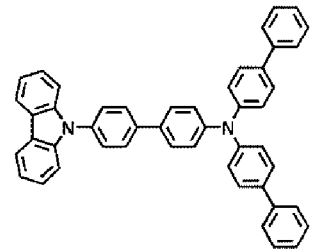
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HT16



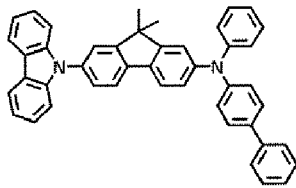
HT17



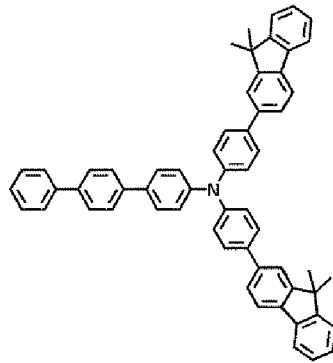
HT18

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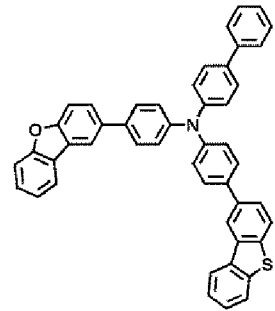
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HT19



HT20

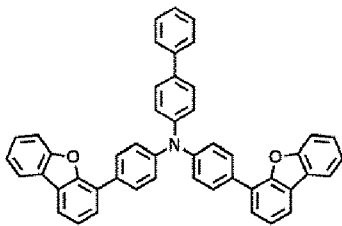


HT21

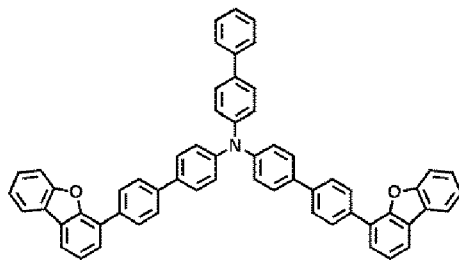
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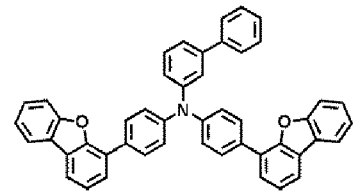
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HT22



HT23

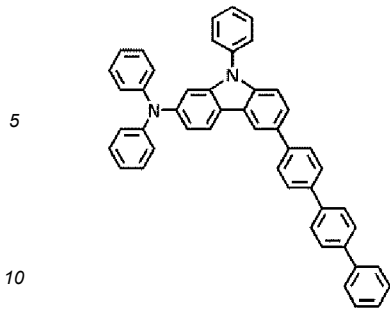


HT24

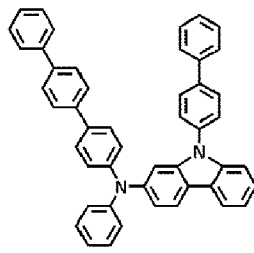
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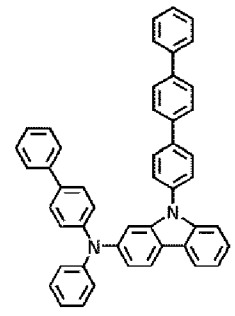
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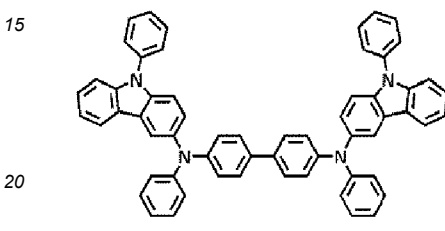
HT25



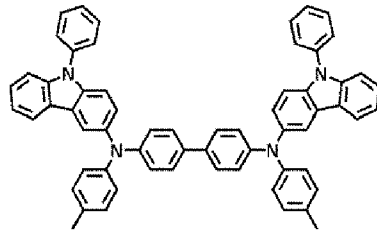
HT26



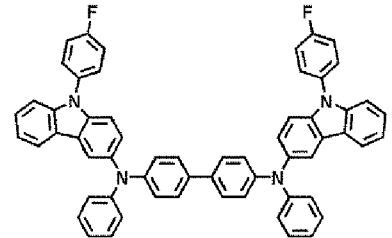
HT27



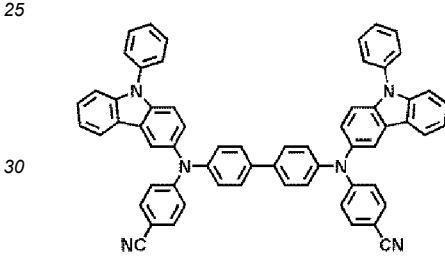
HT28



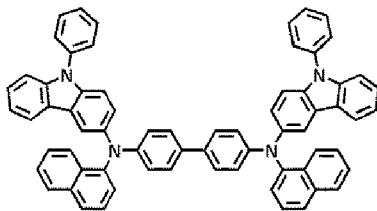
HT29



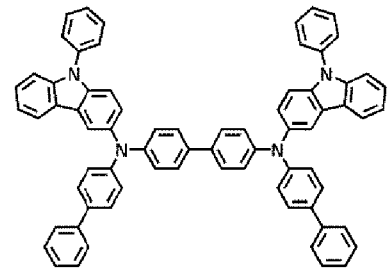
HT30



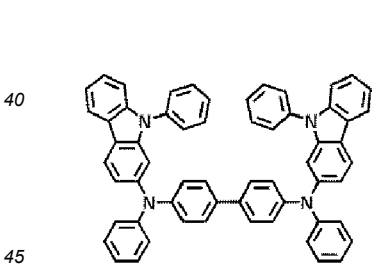
HT31



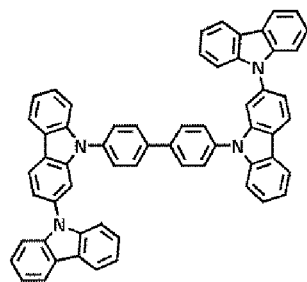
HT32



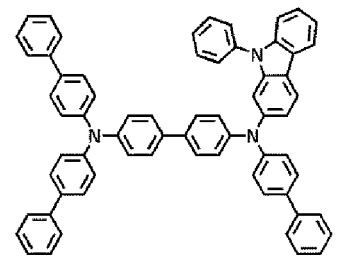
HT33



HT34



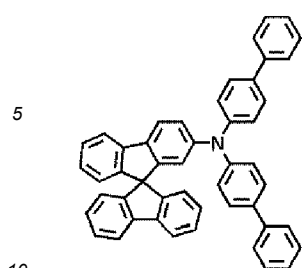
HT35



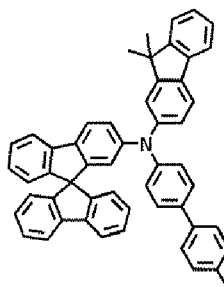
HT36

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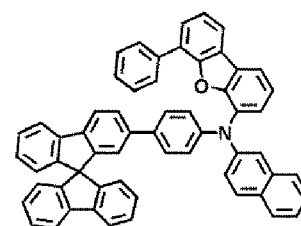
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HT37



HT38



HT39

15 [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 500 Å to about 700 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 100 Å to about 1,000 Å, about 100 Å to about 800 Å, about 100 Å to about 500 Å, or about 200 Å to about 400 Å. When the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are within the foregoing ranges, suitable or satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

25 [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.

#### 30 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.

35 [0096] In one embodiment, the p-dopant may have a lowest unoccupied molecular orbital (LUMO) energy level 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:

40 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

45 a compound represented by Formula 221 below,

but embodiments of the present disclosure are not limited thereto:

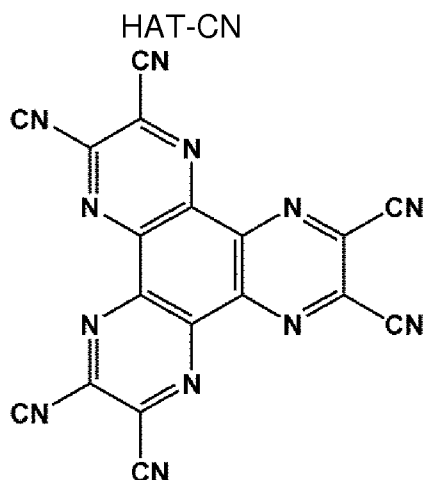
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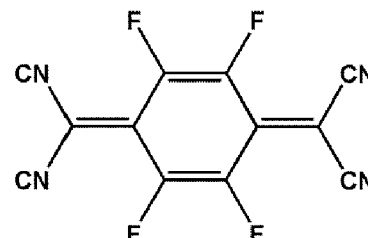
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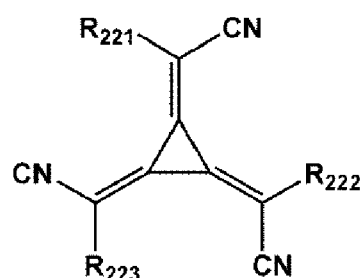
F4-TCNQ



Formula 221

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In Formula 221,

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$R_{221}$  to  $R_{223}$  may each independently be selected from a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  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  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{32}$ ) aryl group, a substituted or unsubstituted  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, wherein at least one selected from  $R_{221}$  to  $R_{223}$  may each independently be selected from a cyano group, -F, -Cl, -Br, -I, a  $C_1$ - $C_{20}$  alkyl group substituted with -F, a  $C_1$ - $C_{20}$  alkyl group substituted with -Cl, a  $C_1$ - $C_{20}$  alkyl group substituted with -Br, and a  $C_1$ - $C_{20}$  alkyl group substituted with -I.

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#### Emission layer in organic layer 150

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**[0099]** 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.

45

**[0100]** The emission layer may include a host and a dopant. The dopant may include at least one selected from a phosphorescent dopant and a fluorescent dopant.

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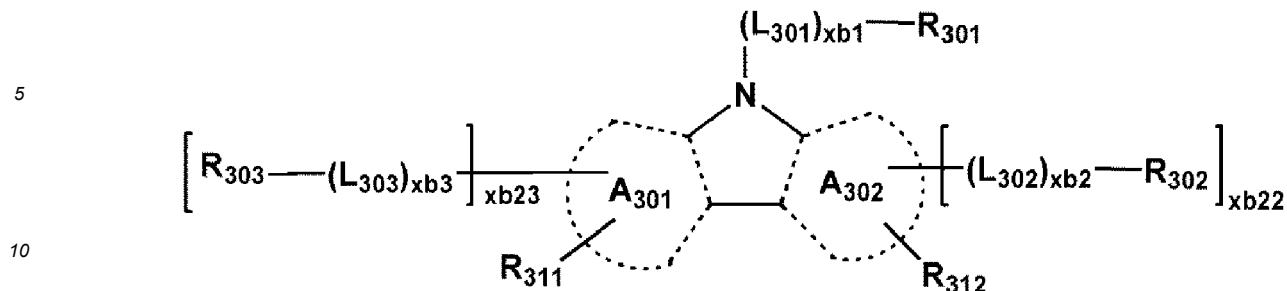
**[0101]** An amount of the dopant in the emission layer may be in a range of about 0.01 parts by weight to about 15 parts by weight based on 100 parts by weight of the host, but embodiments of the present disclosure are not limited thereto.

**[0102]** 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.

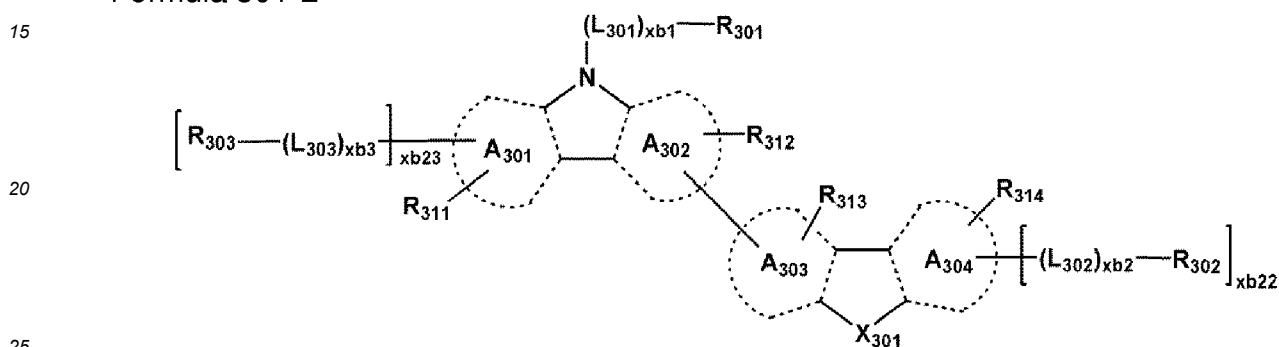
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Formula 301-1



Formula 301-2



In Formulae 301-1 and 301-2,

30 A301 to A304 may each independently be selected from a benzene group, a naphthalene group, a phenanthrene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a pyridine group, a pyrimidine group, an indene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, an indole group, a carbazole group, a benzocarbazole group, a dibenzocarbazole group, a furan group, a benzofuran group, a dibenzofuran group, a naphthofuran group, a benzonaphthofuran group, a dinaphthofuran group, a thiophene group, a benzothiophene group, a dibenzothiophene group, a naphthothiophene group, a benzonaphthothiophene group, and a dinaphthothiophene group,

35 X<sub>301</sub> may be O, S, or N-[(L<sub>304</sub>)<sub>xb4</sub>-R<sub>304</sub>].

R<sub>311</sub> to R<sub>314</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, a naphthyl group -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>),

40 xb22 and xb23 may each independently be 0, 1, or 2,

L<sub>301</sub>, xb1, R<sub>301</sub>, and Q<sub>31</sub> to Q<sub>33</sub> may respectively be same as described above,

L<sub>302</sub> to L<sub>304</sub> may respectively be same as described in connection with L<sub>301</sub>,

45 xb2 to xb4 may respectively be same as described in connection with xb1, and

R<sub>302</sub> to R<sub>304</sub> may respectively be same as described in connection with R<sub>301</sub>.

[0108] For example, L<sub>301</sub> to L<sub>304</sub> in Formulae 301, 301-1, and 301-2 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.

[0109] For example, in Formulae 301, 301-1, and 301-2, L<sub>301</sub> to L<sub>304</sub> may each independently be selected from:

55 a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylene group,

an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene 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 anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene 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 hexacenylyl group, a pentacenylyl 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 quinoxalinylyl 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, an azacarbazolyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), -N(O<sub>31</sub>)(O<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>31</sub> to Q<sub>33</sub> may respectively be the same as described above.

**[0110]** As another example, R<sub>301</sub> to R<sub>304</sub> in Formulae 301, 301-1, and 301-2 may each independently 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 substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>10</sub>) alkyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>10</sub>) alkenyl group, a substituted or unsubstituted C<sub>2</sub>-C<sub>60</sub> (e.g. C<sub>2</sub>-C<sub>10</sub>) alkynyl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> (e.g. C<sub>1</sub>-C<sub>10</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>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>301</sub>)(Q<sub>302</sub>)(Q<sub>303</sub>), -N(Q<sub>301</sub>)(Q<sub>302</sub>), -B(Q<sub>301</sub>)(Q<sub>302</sub>), -C(=O)(Q<sub>301</sub>), -S(=O)<sub>2</sub>(Q<sub>301</sub>), and -P(=O)(Q<sub>301</sub>)(Q<sub>302</sub>), but embodiments are not limited thereto.

**[0111]** In one embodiment, in Formulae 301, 301-1, and 301-2, R<sub>301</sub> to R<sub>304</sub> may each independently be selected from:

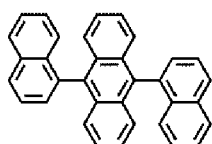
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenylyl 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 quinoxalinylyl 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, an azacarbazolyl group, -Si(Q<sub>301</sub>)(Q<sub>302</sub>)(Q<sub>303</sub>), -N(Q<sub>301</sub>)(Q<sub>302</sub>), -B(Q<sub>301</sub>)(Q<sub>302</sub>), -C(=O)(Q<sub>301</sub>), -S(=O)<sub>2</sub>(Q<sub>301</sub>), and -P(=O)(Q<sub>301</sub>)(Q<sub>302</sub>), but embodiments are not limited thereto.

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 quinazoliny 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

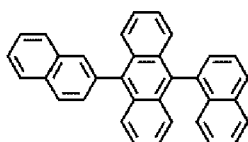
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazoliny group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazoliny 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, an azacarbazolyl group, -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>31</sub> to Q<sub>33</sub> may respectively be the same as described above.

**[0112]** In one embodiment, the host may include an alkaline earth metal complex. For example, the host may include a complex selected from a Be complex (for example, Compound H55), a Mg complex, and a Zn complex. For example, the host may be selected from a Be complex (for example, Compound H55), a Mg complex, and a Zn complex.

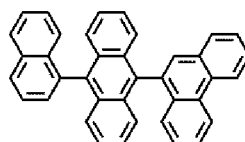
**[0113]** The host may include at least one selected from 9,10-di-(2-naphthyl)anthracene (ADN), 2-methyl-9,10-bis(naphthalen-2-yl)anthracene (MADN), 9,10-di-(2-naphthyl)-2-t-butyl-anthracene (TBADN), 4,4'-bis(N-carbazolyl)-1,1'-biphenyl (CBP), 1,3-di-9-carbazolylbenzene (mCP), 1,3,5-tri(carbazol-9-yl)benzene (TCP), and Compounds H1 to H55, but embodiments of the present disclosure are not limited thereto:



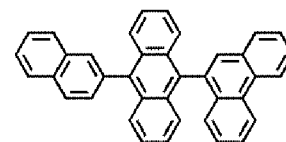
H1



H2

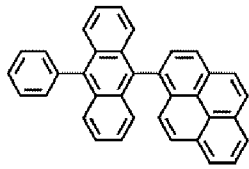


H3

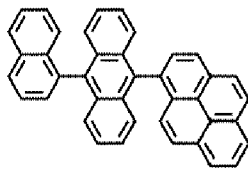


H4

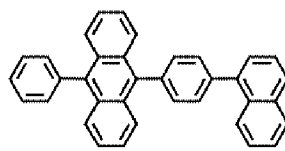
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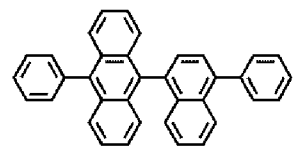
H5



H6

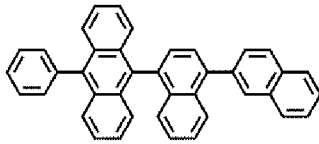


H7

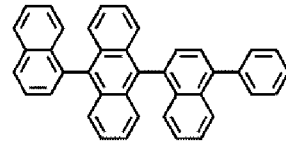


H8

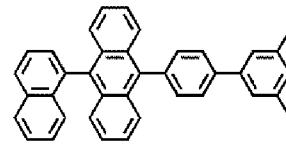
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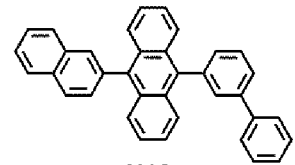
H9



H10



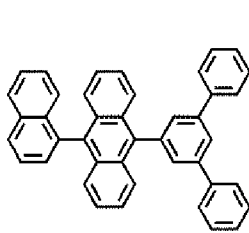
H11



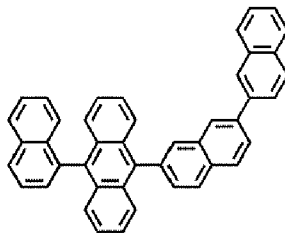
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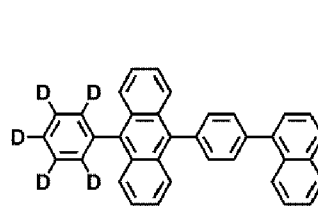
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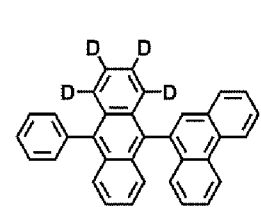
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H14



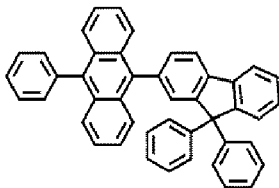
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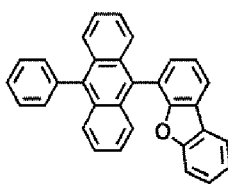
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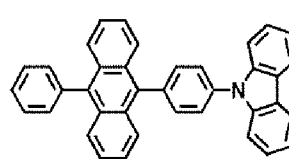
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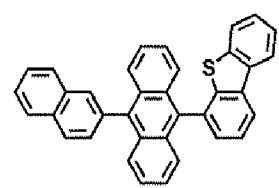
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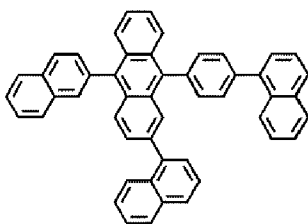
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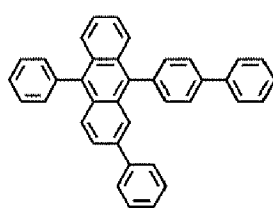
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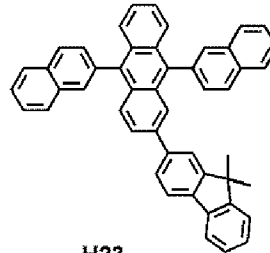
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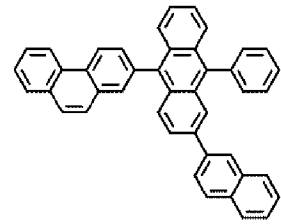
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H22



H23



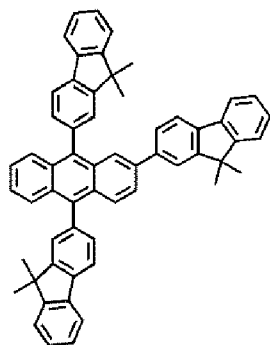
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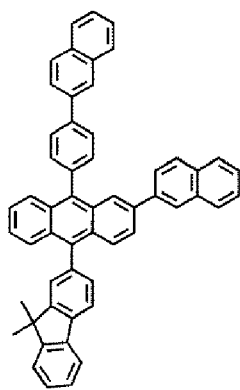
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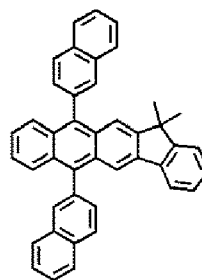
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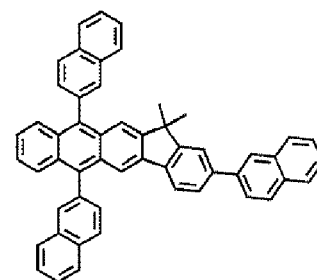
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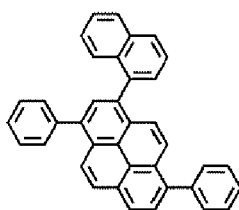
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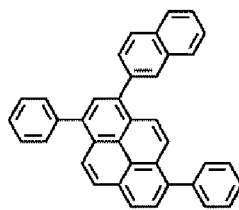
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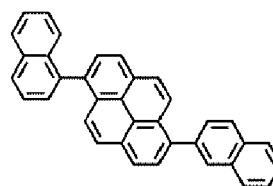
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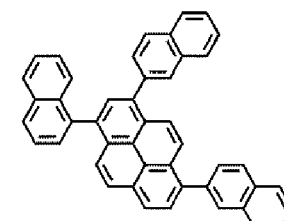
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H30



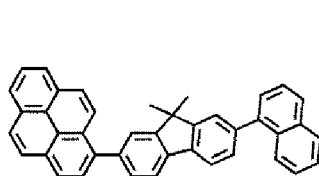
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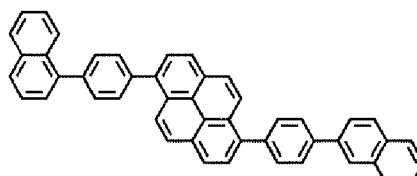
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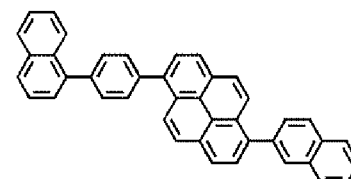
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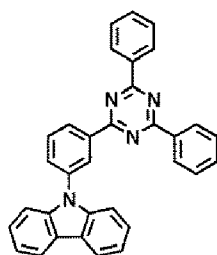
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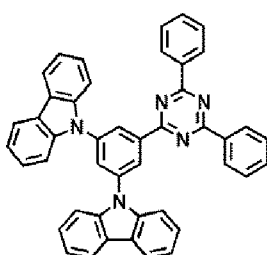
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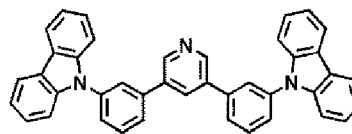
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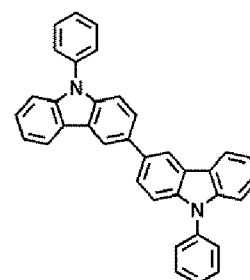
H36



H37



H38



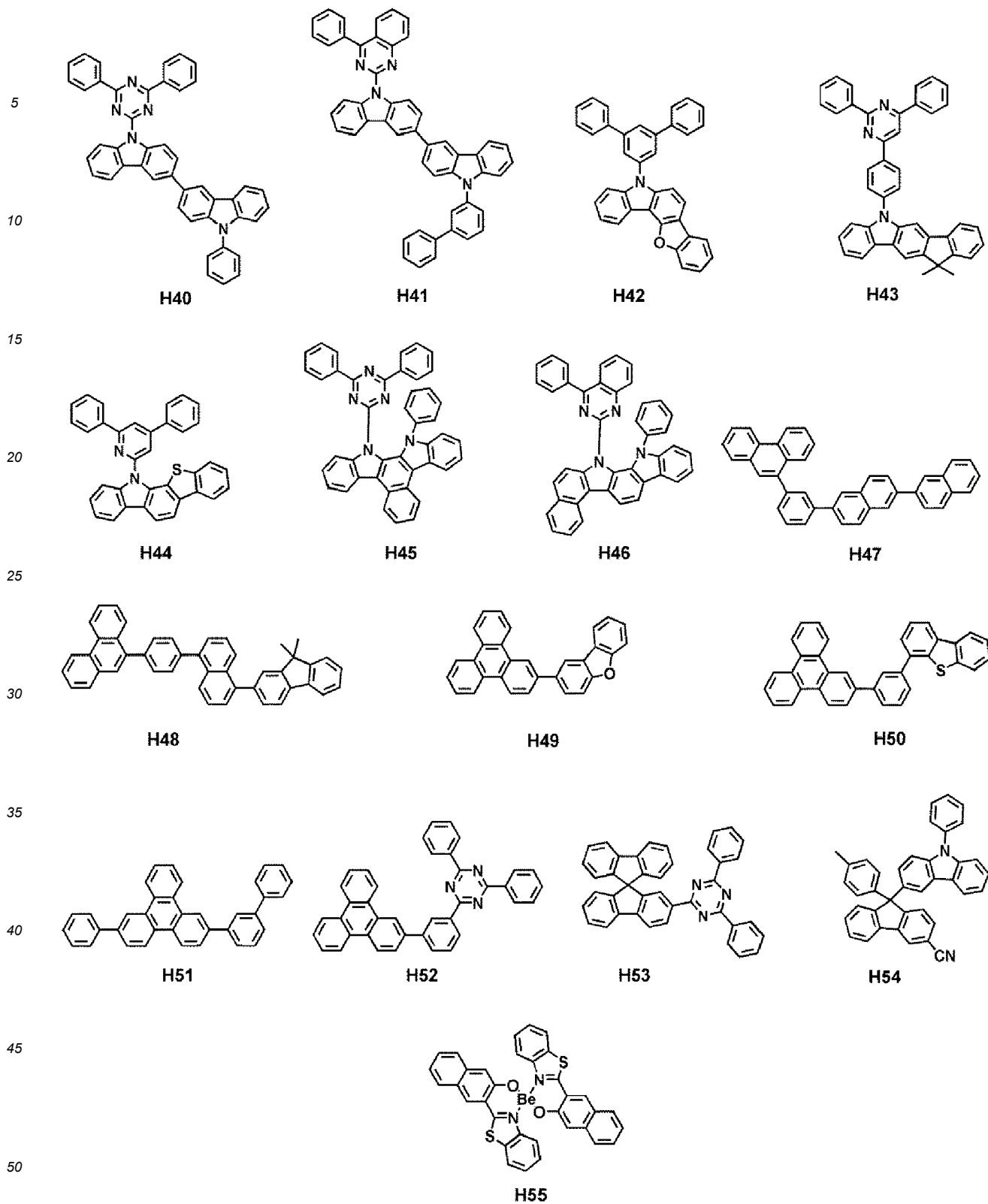
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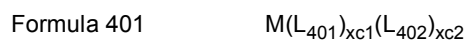
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Phosphorescent dopant included in emission layer in organic layer 150

55 [0114] The phosphorescent dopant may include an organometallic complex represented by Formula 401 below:

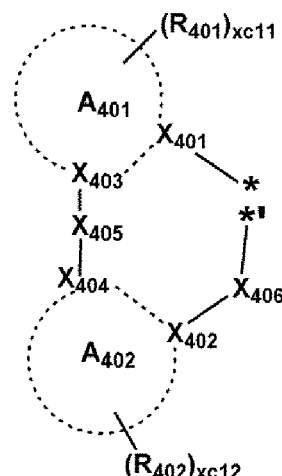


## Formula 402

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In Formulae 401 and 402,

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M may be selected from iridium (Ir), platinum (Pt), palladium (Pd), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), rhodium (Rh), and thulium (Tm),

$L_{401}$  may be selected from ligands represented by Formula 402, and  $xc1$  may be 1, 2, or 3, wherein, when  $xc1$  is two or more, two or more  $L_{401}(S)$  may be identical to or different from each other,

25

$L_{402}$  may be an organic ligand, and  $xc2$  may be an integer of 0 to 4, wherein, when  $xc2$  is two or more, two or more  $L_{402}(s)$  may be identical to or different from each other,

$X_{401}$  to  $X_{404}$  may each independently be nitrogen or carbon,

$X_{401}$  and  $X_{403}$  may be linked via a single bond or a double bond, and  $X_{402}$  and  $X_{404}$  may be linked via a single bond or a double bond,

30

$A_{401}$  and  $A_{402}$  may each independently be a  $C_5$ - $C_{60}$  (e.g.  $C_5$ - $C_{30}$ ) carbocyclic group or a  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heterocyclic group,

$X_{405}$  may be a single bond,  $*-O-*$ ,  $*-S-*$ ,  $*-C(=O)-*$ ,  $*-N(Q_{411})-*$ ,  $*-C(Q_{411})(Q_{412})-*$ ,  $*-C(Q_{411})=C(Q_{412})-*$ ,  $*-C(Q_{411})=*$ , or  $*=C-*$ , wherein  $Q_{411}$  and  $Q_{412}$  may be hydrogen, deuterium, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group,

35

$X_{406}$  may be a single bond, O, or S,

$R_{401}$  and  $R_{402}$  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 substituted or unsubstituted  $C_1$ - $C_{20}$  alkyl group, a substituted or unsubstituted  $C_1$ - $C_{20}$  alkoxy group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkyl group, a substituted or unsubstituted  $C_3$ - $C_{10}$  cycloalkenyl group, a substituted or unsubstituted  $C_1$ - $C_{10}$  heterocycloalkenyl group, a substituted or unsubstituted  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{30}$ ) aryl group, a substituted or unsubstituted  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{30}$ ) aryloxy group, a substituted or unsubstituted  $C_6$ - $C_{60}$  (e.g.  $C_6$ - $C_{30}$ ) arylthio group, a substituted or unsubstituted  $C_1$ - $C_{60}$  (e.g.  $C_1$ - $C_{20}$ ) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,  $-Si(Q_{401})(Q_{402})(Q_{403})$ ,  $-N(Q_{401})(Q_{402})$ ,  $-B(Q_{401})(Q_{402})$ ,  $-C(=O)(Q_{401})$ ,  $-S(=O)_2(Q_{401})$ , and  $-P(=O)(Q_{401})(Q_{402})$ , wherein  $Q_{401}$  to  $Q_{403}$  may each independently be selected from a  $C_1$ - $C_{10}$  alkyl group, a  $C_1$ - $C_{10}$  alkoxy group, a  $C_6$ - $C_{20}$  aryl group, and a  $C_1$ - $C_{20}$  heteroaryl group,  $xc11$  and  $xc12$  may each independently be an integer of 0 to 10, and

45

\* and \*' in Formula 402 each indicate a binding site to M in Formula 401.

50

**[0115]** In one embodiment, in Formula 402,  $A_{401}$  and  $A_{402}$  may each independently be selected from a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, an indene group, a pyrrole group, a thiophene group, a furan(furan) 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 quinoline group, an isoquinoline group, a benzoquinoline group, a quinoxaline group, a quinazoline group, a carbazole group, a benzimidazole group, a benzofuran group, a benzothiophene group, an isobenzothiophene group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a dibenzofuran group, and a dibenzothiophene group.

55

**[0116]** In one or more embodiments, in Formula 402, i)  $X_{401}$  may be nitrogen, and  $X_{402}$  may be carbon, or ii)  $X_{401}$

and  $X_{402}$  may each be nitrogen concurrently (e.g., at the same time).

**[0117]** In one or more embodiments,  $R_{401}$  and  $R_{402}$  in Formula 402 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 hydrazone group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group;

a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazone group, a phenyl group, a naphthyl group, a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, and a norbornenyl group;

a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

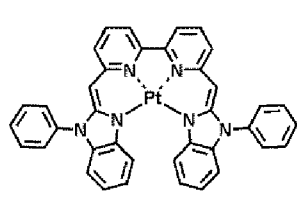
a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazone group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazoliny group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

and  $-Si(Q_{401})(Q_{402})(Q_{403})$ ,  $-N(Q_{401})(Q_{402})$ ,  $-B(Q_{401})(Q_{402})$ ,  $-C(=O)(Q_{401})$ ,  $-S(=O)_2(Q_{401})$ , and  $-P(=O)(Q_{401})(Q_{402})$ , and  $Q_{401}$  to  $Q_{403}$  may each independently be selected from a  $C_1$ - $C_{10}$  alkyl group, a  $C_1$ - $C_{10}$  alkoxy group, a phenyl group, a biphenyl group, and a naphthyl group, but embodiments of the present disclosure are not limited thereto.

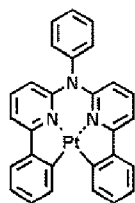
**[0118]** In one or more embodiments, in Formula 401, when  $x_{c1}$  is two or more, two  $A_{401}(s)$  among a plurality of  $L_{401}(s)$  may optionally be linked via a linking group,  $X_{407}$ , or two  $A_{402}(s)$  may optionally be linked via a linking group,  $X_{408}$  (see Compounds PD1 to PD4 and PD7).  $X_{407}$  and  $X_{408}$  may each independently be a single bond,  $^*-O-^*$ ,  $^*-S-^*$ ,  $^*-C(=O)-^*$ ,  $^*-N(Q_{413})-^*$ ,  $^*-C(Q_{413})(Q_{414})-^*$ , or  $^*-C(Q_{413})=C(Q_{414})-^*$  (wherein  $Q_{413}$  and  $Q_{414}$  may each independently be hydrogen, deuterium, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group), but embodiments of the present disclosure are not limited thereto.

**[0119]**  $L_{402}$  in Formula 401 may be a monovalent, divalent, or trivalent organic ligand. For example,  $L_{402}$  may be selected from halogen, diketone (for example, acetylacetonate), carboxylic acid (for example, picolinate),  $-C(=O)$ , isonitrile,  $-CN$ , and phosphorus (for example, phosphine, or phosphite), but embodiments of the present disclosure are not limited thereto.

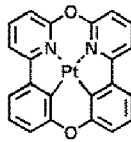
**[0120]** In one or more embodiments, the phosphorescent dopant may be selected from, for example, Compounds PD1 to PD25, but embodiments of the present disclosure are not limited thereto:



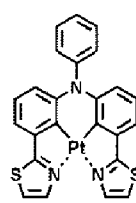
PD1



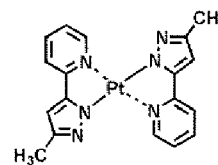
PD2



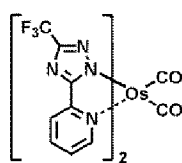
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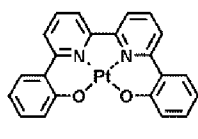
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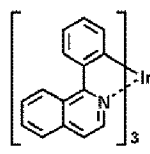
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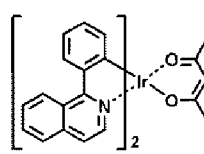
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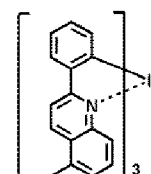
PD7



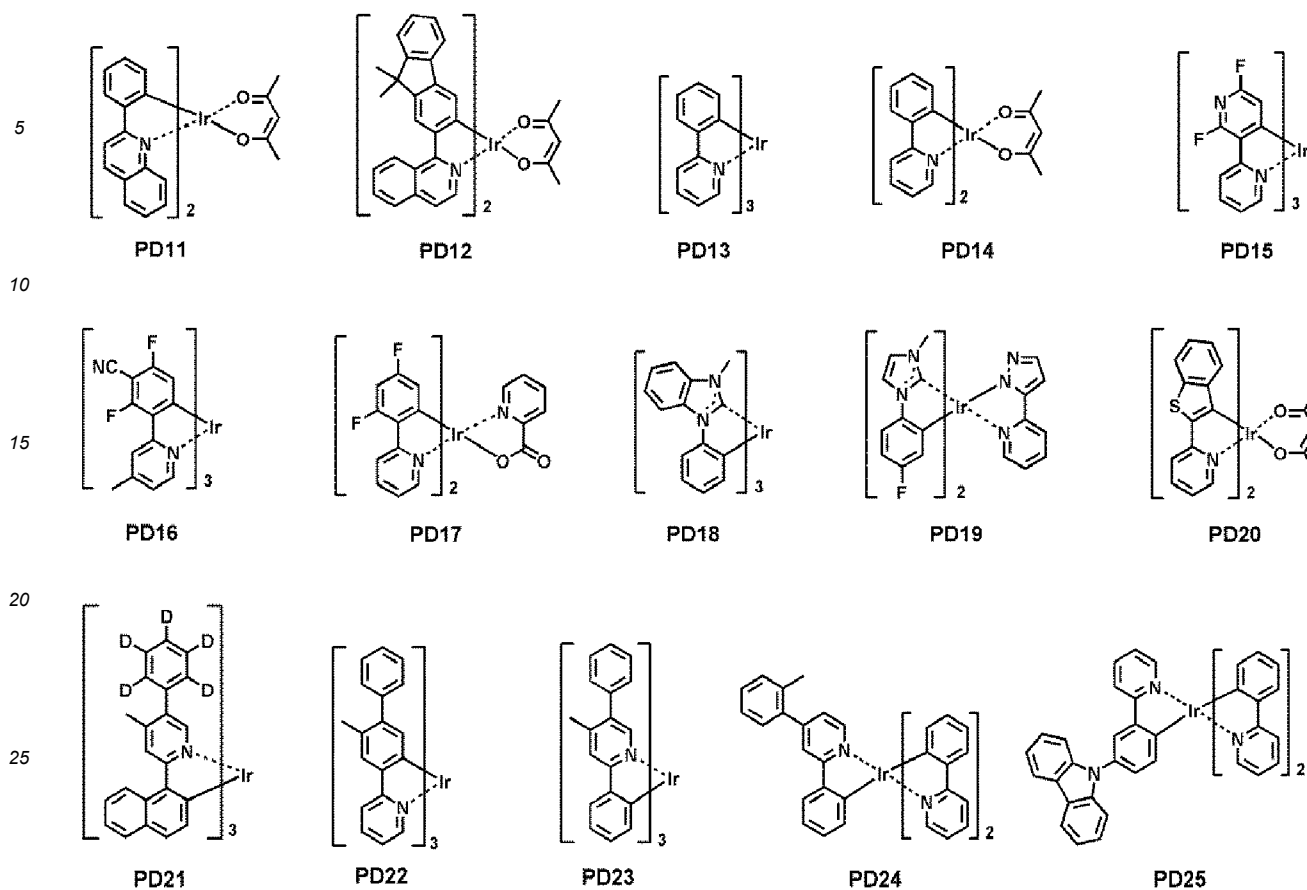
PD8



PD9



PD10

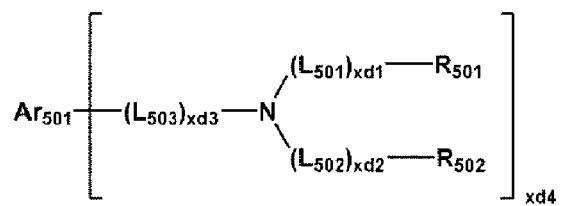


### Fluorescent dopant in emission layer

[0121] The fluorescent dopant may include an arylamine compound or a styrylamine compound.

[0122] The fluorescent dopant may include a compound represented by Formula 501 below.

### Formula 501



45 In Formula 501,

$\text{Ar}_{501}$  may be 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,

50  $\text{L}_{501}$  to  $\text{L}_{503}$  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.  $\text{C}_6\text{-C}_{30}$ ) 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,

55  $\text{xd1}$  to  $\text{xd3}$  may each independently be an integer of 0 to 3,

$\text{R}_{501}$  and  $\text{R}_{502}$  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.  $\text{C}_6\text{-C}_{30}$ )

## EP 3 561 894 A1

aryl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) aryloxy group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub> (e.g. C<sub>6</sub>-C<sub>30</sub>) arylthio 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, and  
5 xd4 may be an integer of 1 to 6.

[0123] For example, Ar<sub>501</sub> may be a substituted or unsubstituted C<sub>5</sub>-C<sub>30</sub> carbocyclic group or a substituted or unsubstituted C<sub>1</sub>-C<sub>20</sub> heterocyclic group, but embodiments are not limited thereto.

[0124] In one embodiment, in Formula 501, Ar<sub>501</sub> may be selected from:

10 a naphthalene group, a heptalene 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, and an indenophenanthrene group; and

15 a naphthalene group, a heptalene 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, and an indenophenanthrene 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, and a naphthyl group.

[0125] In one or more embodiments, in Formula 501, L<sub>501</sub> to L<sub>503</sub> may each independently be selected from:

25 a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylylene group, a fluoranthenylylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylylene group, a hexacenylylene group, a pentacenylylene group, a thiophenylylene group, a furanylylene group, a carbazolylylene group, an indolylylene group, an isoindolylylene group, a benzofuranylylene group, a benzothiophenylylene group, a dibenzofuranylylene group, a dibenzothiophenylylene group, a benzocarbazolylylene group, a dibenzocarbazolylylene group, a dibenzosilolylylene group, and a pyridinylylene group; and

30 a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylylene group, a fluoranthenylylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylylene group, a hexacenylylene group, a pentacenylylene group, a thiophenylylene group, a furanylylene group, a carbazolylylene group, an indolylylene group, an isoindolylylene group, a benzofuranylylene group, a benzothiophenylylene group, a dibenzofuranylylene group, a dibenzothiophenylylene group, a benzocarbazolylylene group, a dibenzocarbazolylylene group, a dibenzosilolylylene group, and a pyridinylylene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a 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, and a pyridinyl group.

[0126] In one or more embodiments, in Formula 501, R<sub>501</sub> and R<sub>502</sub> may each independently be selected from:

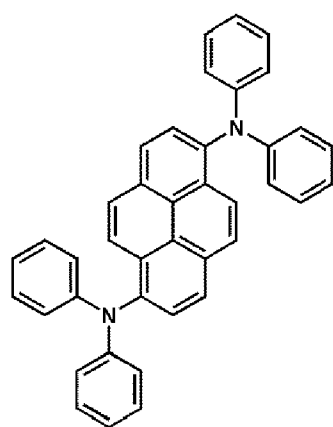
50 a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl 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, and a pyridinyl group; and

55 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

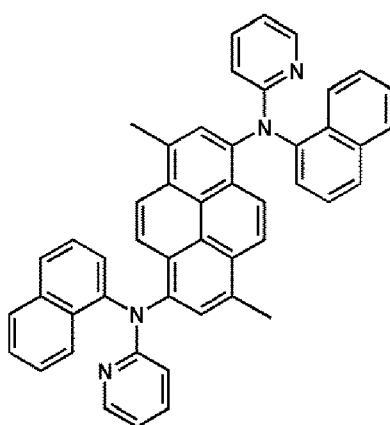
group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and 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 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, and -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</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.

[0127] In one or more embodiments, in Formula 501, xd4 may be two or more, but embodiments of the present disclosure are not limited thereto.

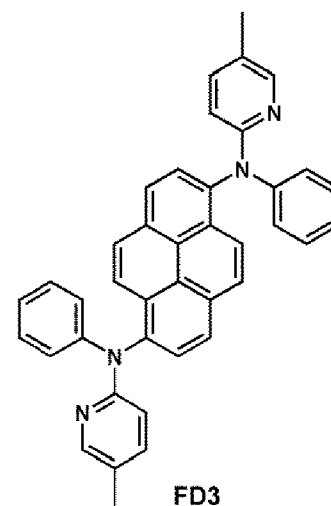
[0128] For example, the fluorescent dopant may be selected from Compounds FD1 to FD22:



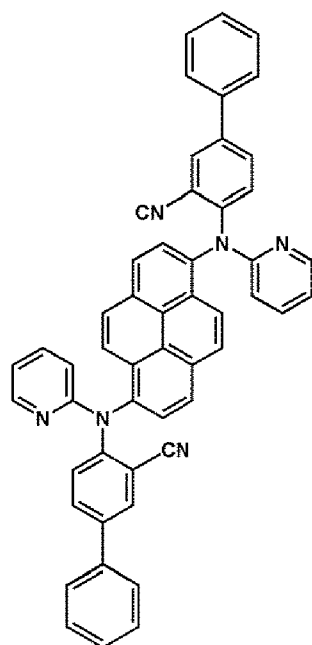
FD1



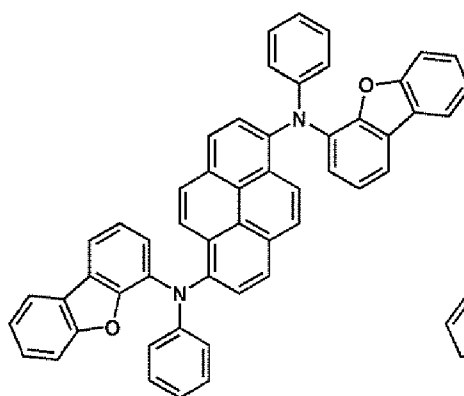
FD2



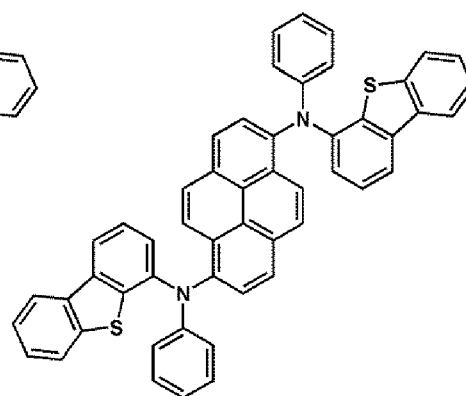
FD3



FD4

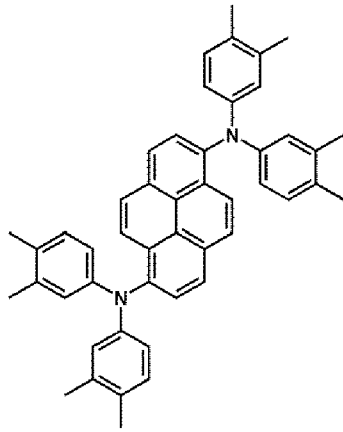


FD5



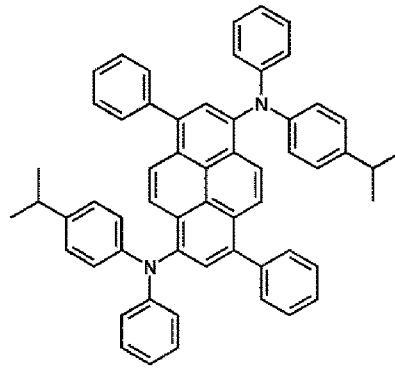
FD6

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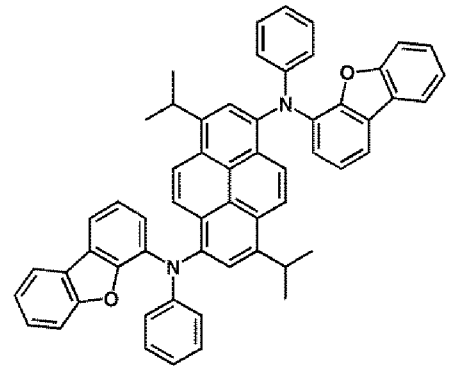
FD7

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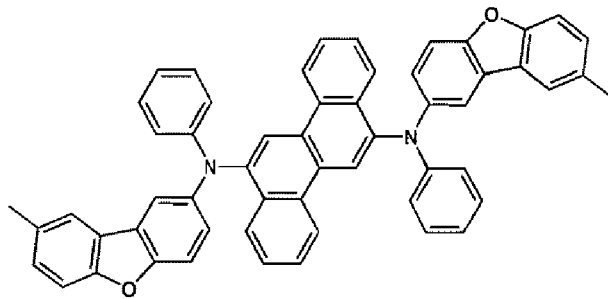
FD8

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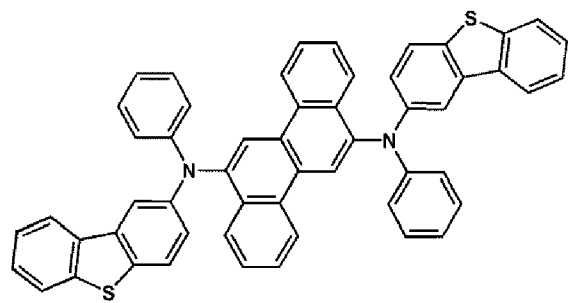
FD9

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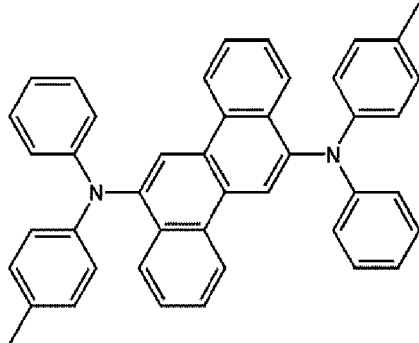
FD10

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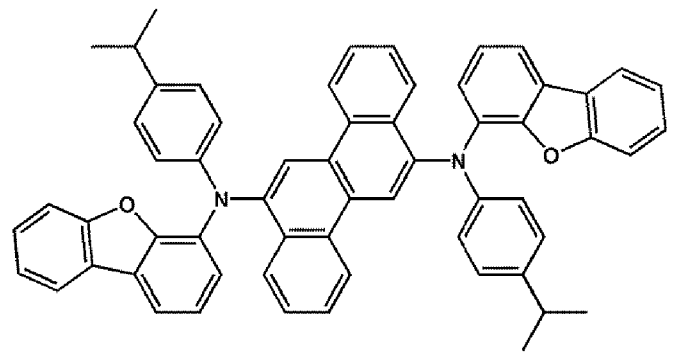
FD11

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FD12

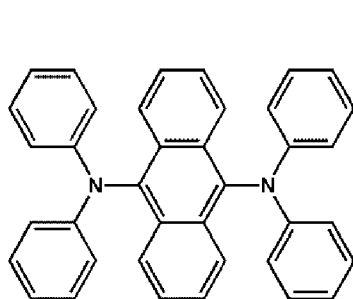
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FD13

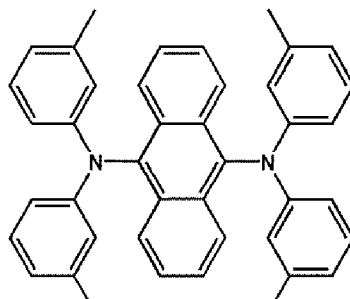
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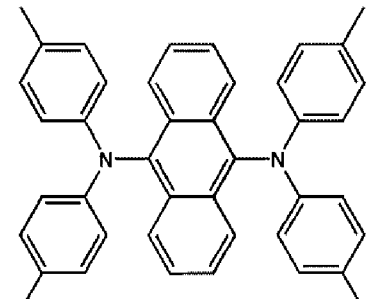
FD14

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FD15

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FD16

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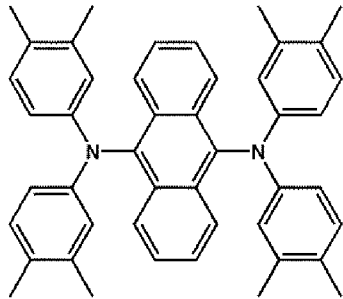
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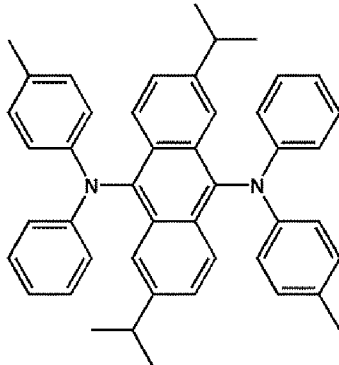
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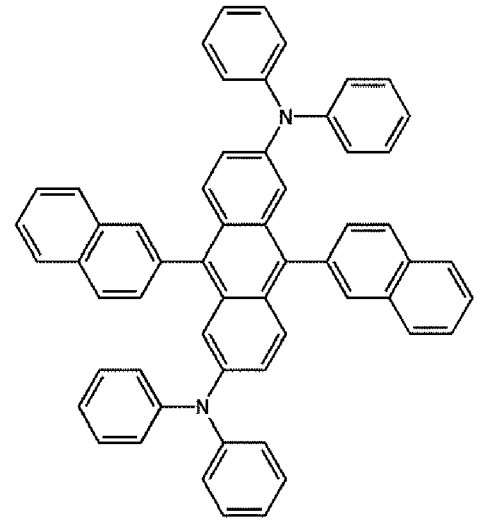
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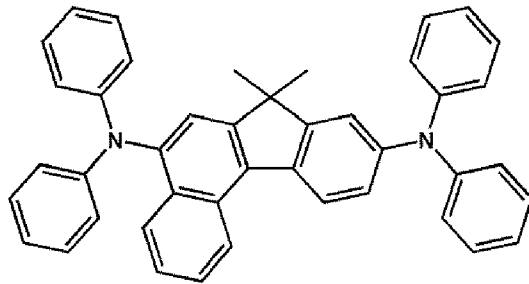
FD17



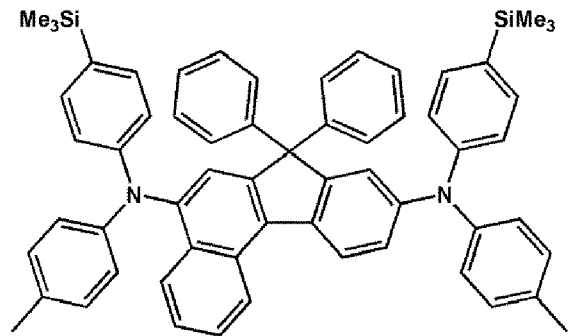
FD18



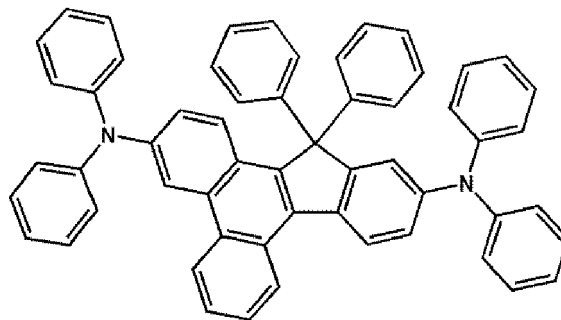
FD19



FD20



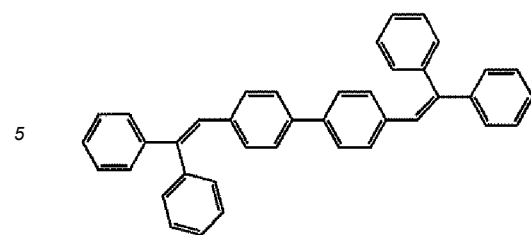
FD21



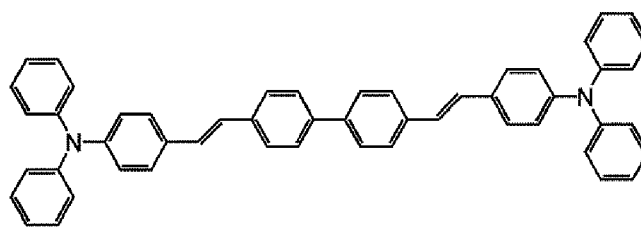
FD22

[0129] In one or more embodiments, the fluorescent dopant may be selected from the following compounds, but  
 50 embodiments of the present disclosure are not limited thereto.

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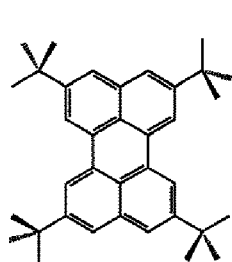


DPVBi

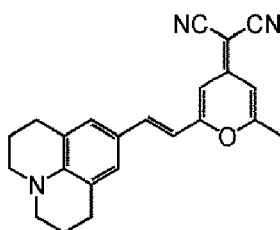


DPAVBi

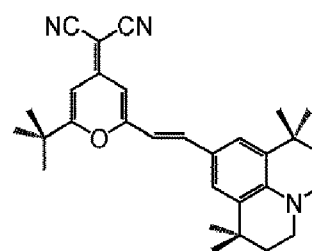
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TBPe



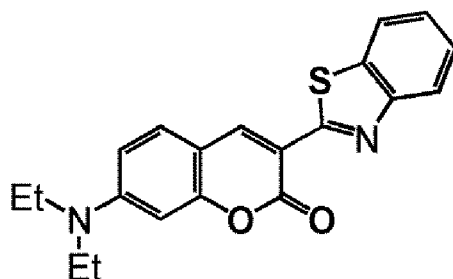
DCM



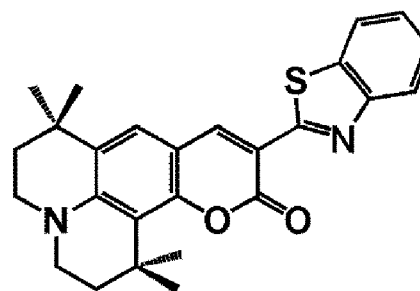
DCJTb

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Coumarin 6



C545T

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35 **Electron transport region in organic layer 150**

[0130] 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.

40 [0131] 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.

45 [0132] 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.

[0133] 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.

[0134] 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.

55 [0135] 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 together with) at least one  $C_5$ - $C_{60}$  (e.g. a  $C_5$ - $C_{30}$ ) carbocyclic group.

**[0136]** 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.

**[0137]** For example, the electron transport region may include a compound represented by Formula 601:



In Formula 601,

$\text{Ar}_{601}$  may be 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,

$\text{xe11}$  may be 1, 2, or 3,

$\text{L}_{601}$  is 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  $\text{C}_6\text{-C}_{60}$  arylene group, a substituted or unsubstituted  $\text{C}_1\text{-C}_{60}$  heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

$\text{xe1}$  may be an integer of 0 to 5,

$\text{R}_{601}$  may 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  $\text{C}_6\text{-C}_{60}$  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,  $-\text{Si}(\text{Q}_{601})(\text{Q}_{602})(\text{Q}_{603})$ ,  $-\text{C}(=\text{O})(\text{Q}_{601})$ ,  $-\text{S}(=\text{O})_2(\text{Q}_{601})$ , and  $-\text{P}(=\text{O})(\text{Q}_{601})(\text{Q}_{602})$ .

$\text{Q}_{601}$  to  $\text{Q}_{603}$  may each independently be a  $\text{C}_1\text{-C}_{10}$  alkyl group, a  $\text{C}_1\text{-C}_{10}$  alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group, and

$\text{xe21}$  may be an integer of 1 to 5.

**[0138]** In one embodiment, at least one of  $\text{Ar}_{601}(\text{S})$  in the number of  $\text{xe11}$  and  $\text{R}_{601}(\text{S})$  in the number of  $\text{xe21}$  may include the  $\pi$  electron-depleted nitrogen-containing ring.

**[0139]** For example,  $\text{Ar}_{601}$  may be a substituted or unsubstituted  $\text{C}_5\text{-C}_{30}$  carbocyclic group or a substituted or unsubstituted  $\text{C}_1\text{-C}_{20}$  heterocyclic group, but embodiments are not limited thereto.

**[0140]** In one embodiment, ring  $\text{Ar}_{601}$  in Formula 601 may be selected from:

a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, an isobenzothiazole group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a thiadiazole group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group; and

a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, an isobenzothiazole group, a benzoxazole group, an

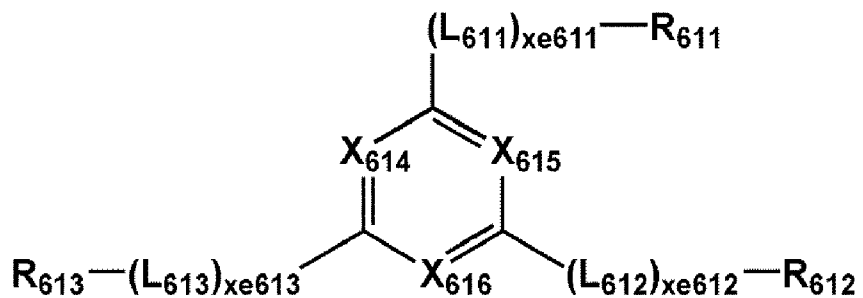
isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a thiadiazole group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), -S(=O)<sub>2</sub>(Q<sub>31</sub>), and -P(=O)(Q<sub>31</sub>)(Q<sub>32</sub>), 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.

[0141] When xe11 in Formula 601 is two or more, two or more Ar<sub>601</sub>(s) may be linked via a single bond.

[0142] In one or more embodiments, Ar<sub>601</sub> in Formula 601 may be an anthracene group.

[0143] In one or more embodiments, a compound represented by Formula 601 may be represented by Formula 601-1:

Formula 601-1



In Formula 601-1,

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

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

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

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

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.

[0144] 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.

[0145] In one embodiment, in Formulae 601 and 601-1, L<sub>601</sub> and L<sub>611</sub> to L<sub>613</sub> 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 anthracenylylene group, a fluoranthenylylene group, a triphenylylylene group, a pyrenylene group, a chrysenylene group, a perylynylene group, a pentaphenylylene group, a hexacenylylene group, a pentacenylylene group, a thiophenylylene group, a furanylylene group, a carbazolylylene group, an indolylylene group, an isoindolylylene group, a benzofuranylylene group, a benzothiophenylylene group, a dibenzofuranylylene group, a dibenzothiophenylylene group, a benzocarbazolylylene group, a dibenzocarbazolylylene group, a dibenzosilylylylene group, a pyridinylylene group, an imidazolylylene group, a pyrazolylylene group, a thiazolylylene group, an isothiazolylylene group, an oxazolylylene group, an isoxazolylylene group, a thiadiazolylylene group, an oxadiazolylylene group, a pyrazinylylene group, a pyrimidinylylene group, a pyridazinylylene group, a triazinylylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylylene group, a naphthyridinylylene group, a quinoxalinylylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylylene group, an acridinylylene group, a phenanthrolinylylene group, a phenazinylylene group, a benzimidazolylylene group, an isobenzothiazolylylene group, a benzoxazolylylene group, an isobenzoxazolylylene group, a triazolylylene group, a tetrazolylylene group, an imidazopyridinylylene group, an imidazopyrimidinylylene group, and an azacarbazolylylene group; and a phenylene group, a naphthylene group, a fluorenylylene group, a spiro-bifluorenylylene group, a benzofluorenylylene

group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylylene group, a hexacenylylene group, a pentacenylylene group, a thiophenylylene group, a furanylylene group, a carbazolylylene group, an indolylylene group, an isoindolylylene group, a benzofuranylylene group, a benzothiophenylylene group, a dibenzofuranylylene group, a dibenzothiophenylylene group, a benzocarbazolylylene group, a dibenzocarbazolylylene group, a dibenzosilolylylene group, a pyridinylylene group, an imidazolylylene group, a pyrazolylylene group, a thiazolylylene group, an isothiazolylylene group, an oxazolylylene group, an isoxazolylylene group, a thiadiazolylylene group, an oxadiazolylylene group, a pyrazinylylene group, a pyrimidinylylene group, a pyridazinylylene group, a triazinylylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylylene group, a naphthyridinylylene group, a quinoxalinylylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylylene group, an acridinylylene group, a phenanthrolinylylene group, a phenazinylylene group, a benzimidazolylylene group, an isobenzothiazolylylene group, a benzoxazolylylene group, an isobenzoxazolylylene group, a triazolylylene group, a tetrazolylylene group, an imidazopyridinylylene group, an imidazopyrimidinylylene group, and an azacarbazolylylene 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 pentacenylyl 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, but embodiments of the present disclosure are not limited thereto.

**[0146]** In one or more embodiment, in Formulae 601 and 601-1, xe1 and xe611 to xe613 may each independently be 0, 1, or 2.

**[0147]** 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>).

**[0148]** In one or more embodiments, in Formulae 601 and 601-1, R<sub>601</sub> and R<sub>611</sub> to R<sub>613</sub> may each independently be selected from:

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenylyl group, a pentacenylyl 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;

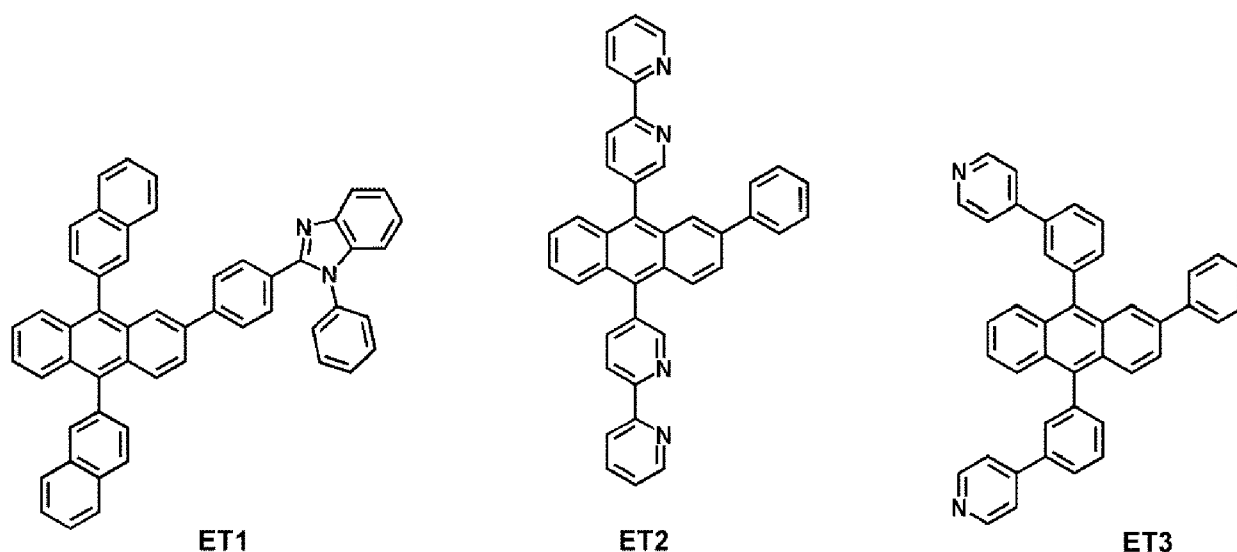
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenylyl group, a pentacenylyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl

group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>1</sub>-C<sub>20</sub> alkyl group, a C<sub>1</sub>-C<sub>20</sub> alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacaceny group, a pentacaceny 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

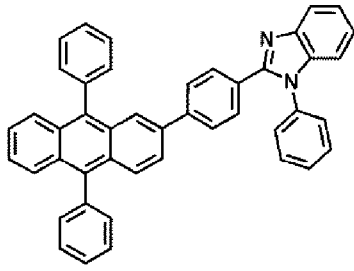
-S(=O)<sub>2</sub>(Q<sub>601</sub>) and -P(=O)(O<sub>601</sub>)(O<sub>602</sub>), and

Q<sub>601</sub> and O<sub>602</sub> may respectively be the same as described above.

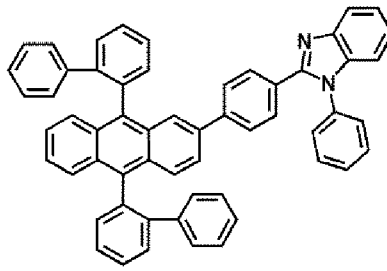
**[0149]** The electron transport region may include at least one compound selected from Compounds ET1 to ET36, but embodiments of the present disclosure are not limited thereto:



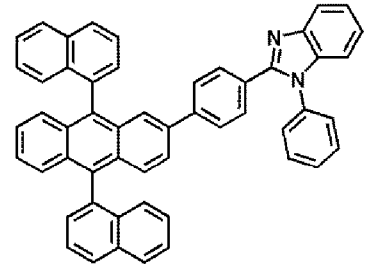
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ET4

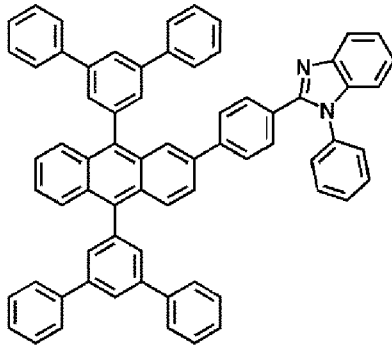


ET5

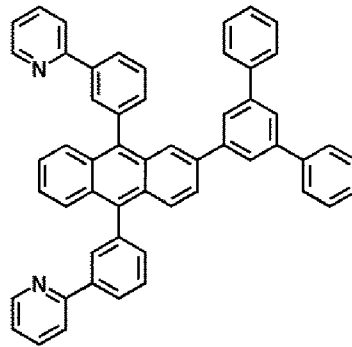


ET6

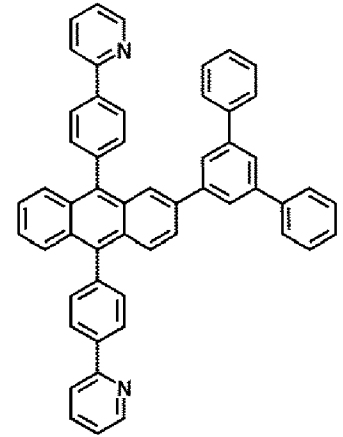
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ET7

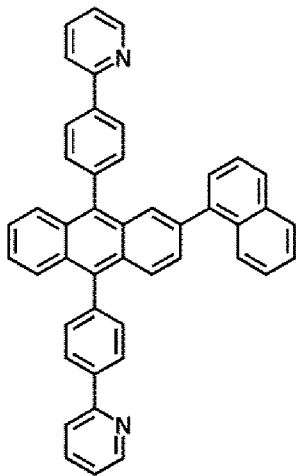


ET8

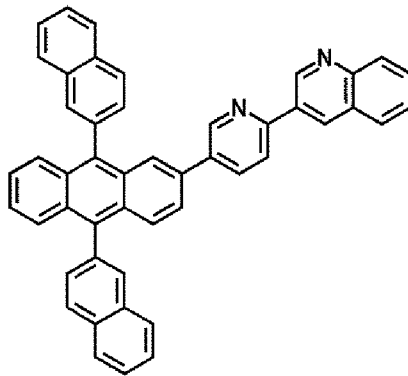


ET9

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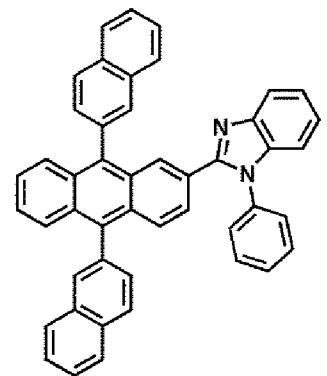


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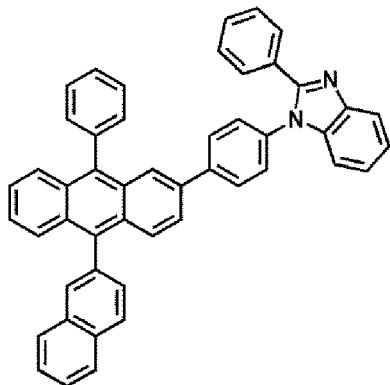
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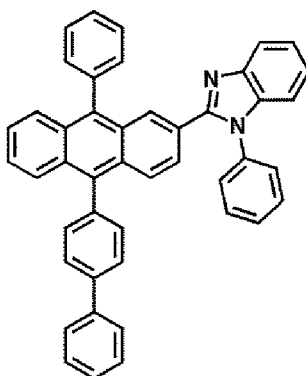
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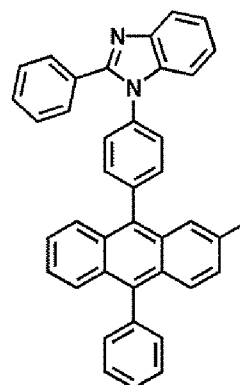
ET10



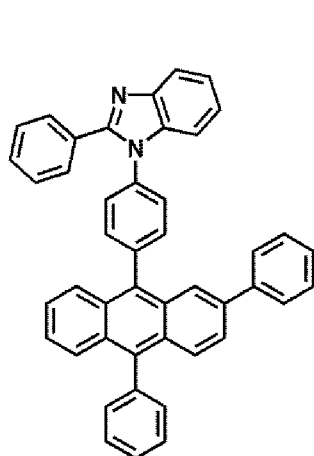
ET11



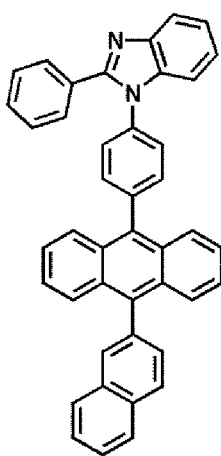
ET12



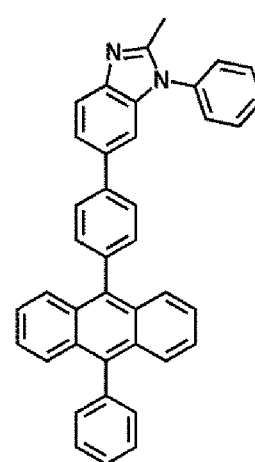
ET13



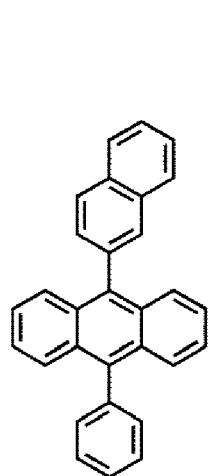
ET14



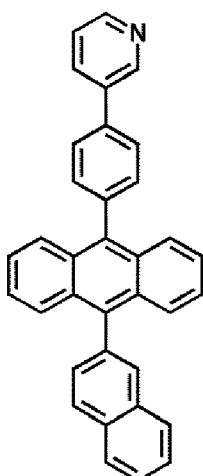
ET15



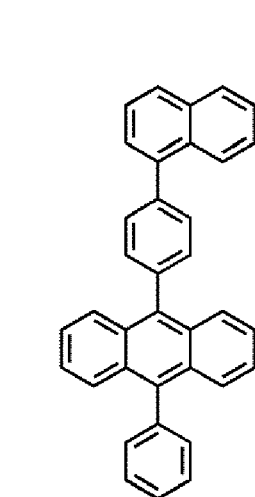
ET16



ET17



ET18



ET19



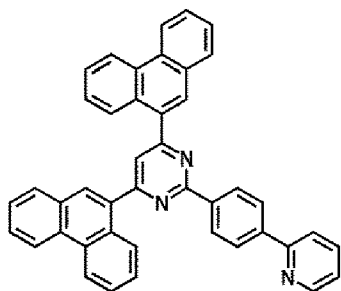
ET20



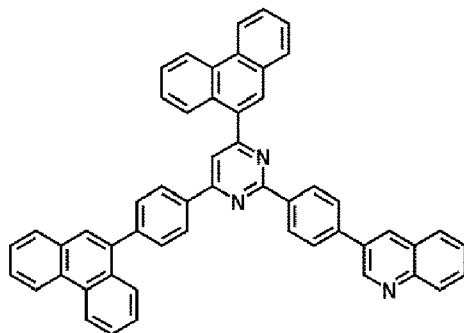
ET21



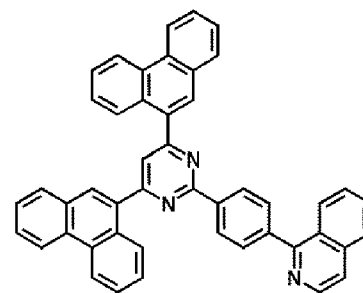
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ET22

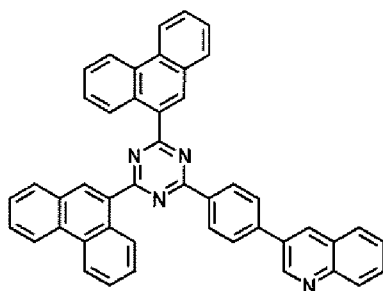


ET23

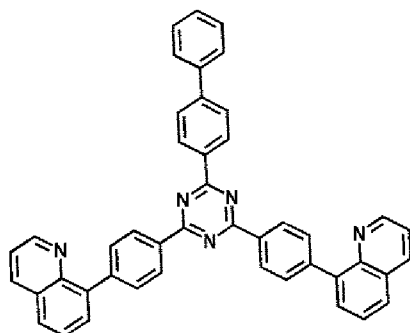


ET24

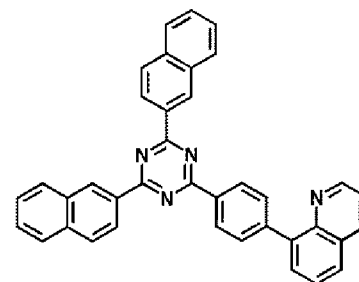
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ET25



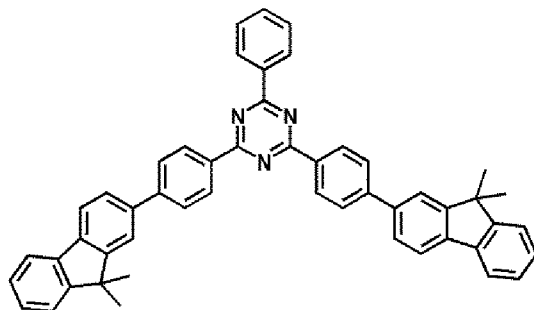
ET26



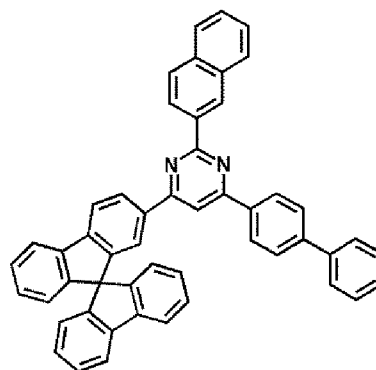
ET27

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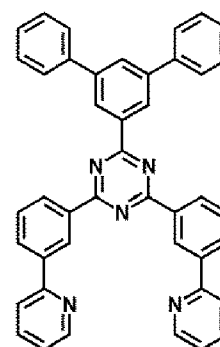
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ET28



ET29



ET30

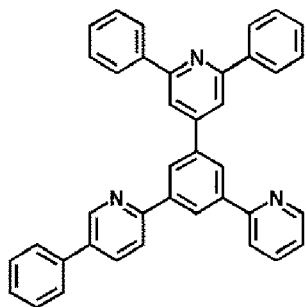
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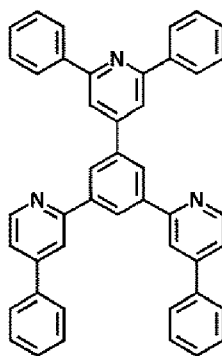
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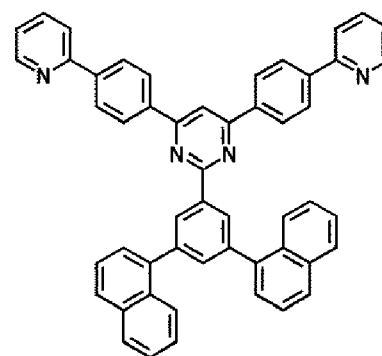
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ET31

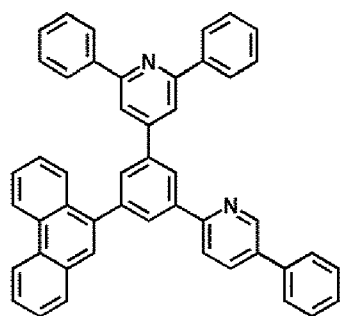


ET32

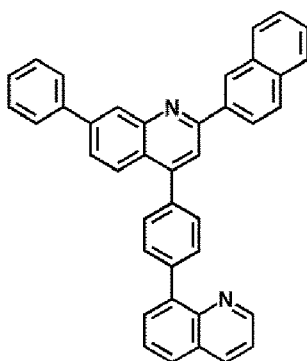


ET33

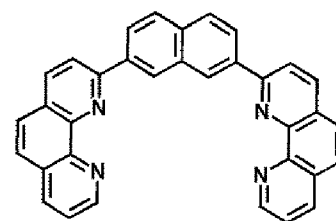
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ET34



ET35

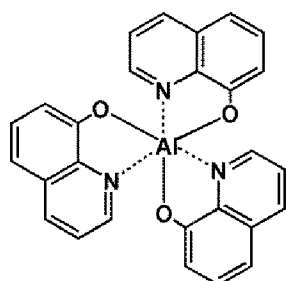
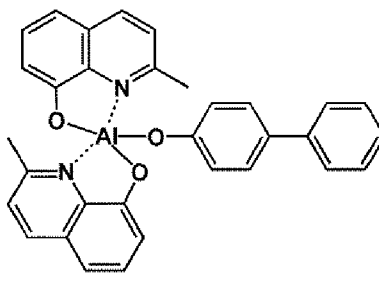


ET36

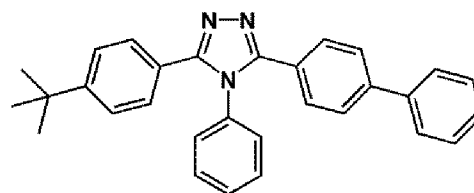
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**[0150]** In one or more embodiments, the electron transport region may include at least one selected from 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), Alq<sub>3</sub>, BAlq, 3-(biphenyl-4-yl)-5-(4-tert-butylphenyl)-4-phenyl-4H-1,2,4-triazole (TAZ), and NTAZ.

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Alq<sub>3</sub>

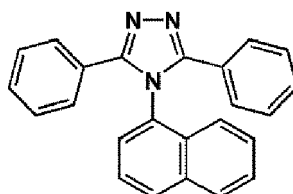
BAlq



TAZ

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NTAZ

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**[0151]** 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 the foregoing ranges, the electron blocking layer may have excellent electron blocking characteristics or electron control characteristics without a substantial increase in driving voltage.

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**[0152]** 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.

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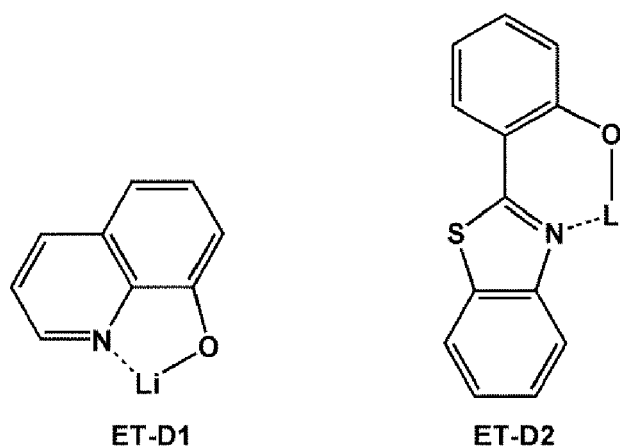
**[0153]** The electron transport region (for example, the electron transport layer in the electron transport region) may further include, in addition to the materials described above, a metal-containing material.

**[0154]** The metal-containing material may include at least one selected from alkali metal complex and 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

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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.

**[0155]** 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.



**[0156]** 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.

**[0157]** 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.

**[0158]** 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.

**[0159]** 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.

**[0160]** The alkaline earth metal may be selected from Mg, Ca, Sr, and Ba.

**[0161]** The rare earth metal may be selected from Sc, Y, Ce, Tb, Yb, and Gd.

**[0162]** 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.

**[0163]** 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 LiF, NaF, CsF, KF, LiI, NaI, CsI, KI, or RbI. In one embodiment, the alkali metal compound may be selected from LiF,  $\text{Li}_2\text{O}$ , NaF, LiI, NaI, CsI, and KI, but embodiments of the present disclosure are not limited thereto.

**[0164]** The alkaline earth-metal compound may be selected from alkaline earth-metal oxides, such as BaO, SrO, CaO,  $\text{Ba}_x\text{Sr}_{1-x}\text{O}$  ( $0 < x < 1$ ),  $\text{Ba}_x\text{Ca}_{1-x}\text{O}$  ( $0 < x < 1$ ). In one embodiment, the alkaline earth-metal compound may be selected from BaO, SrO, and CaO, but embodiments of the present disclosure are not limited thereto.

**[0165]** 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.

**[0166]** 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.

**[0167]** 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.

[0168] 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

[0169] The second electrode 190 may be disposed on the organic layer 150 having such a structure. The second electrode 190 may be a cathode which is an electron injection electrode, and in this regard, a material for forming the second electrode 190 may be selected from metal, an alloy, an electrically conductive compound, and a combination thereof, which have a relatively low work function.

[0170] 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), ITO, and IZO, but embodiments of the present disclosure are not limited thereto. The second electrode 190 may be a transmissive electrode, a semi-transmissive electrode, or a reflective electrode.

[0171] The second electrode 190 may have a single-layered structure, or a multi-layered structure including two or more layers.

#### Description of FIGS. 2-4

[0172] 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.

[0173] Regarding FIGS. 2-4, 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.

[0174] 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.

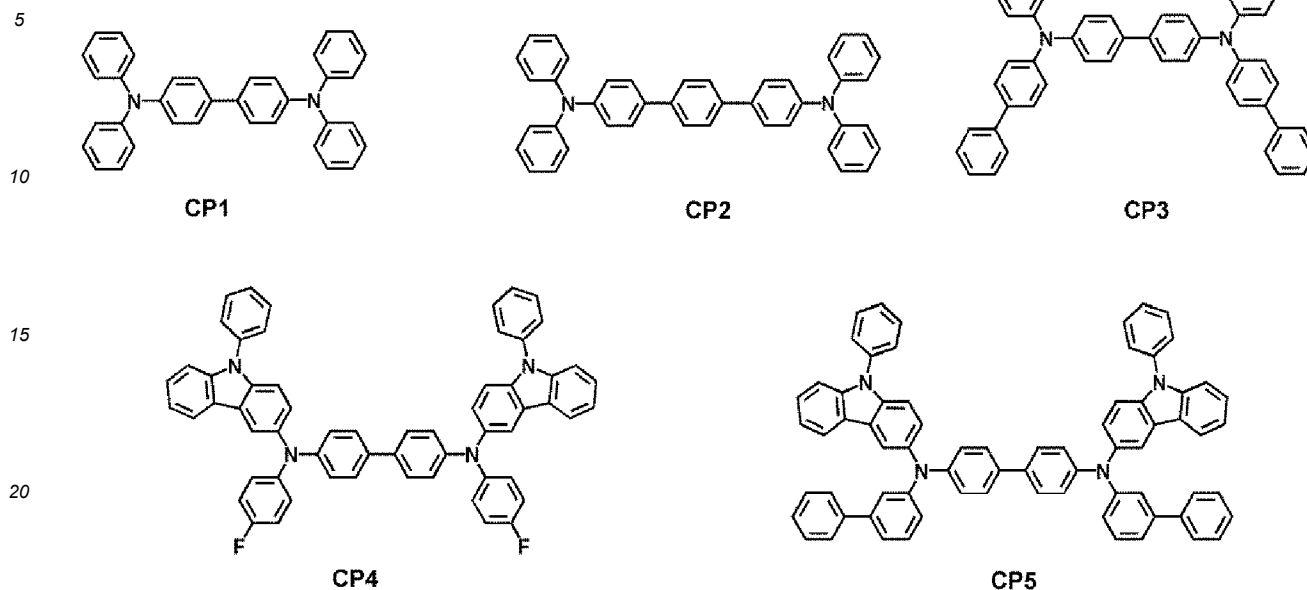
[0175] The first capping layer 210 and the second capping layer 220 may increase external luminescent efficiency according to the principle of constructive interference.

[0176] 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.

[0177] 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. 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.

[0178] 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.

[0179] 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.



25 **[0180]** Hereinbefore, the organic light-emitting device according to an embodiment has been described in connection with FIGS. 1-4. However, embodiments of the present disclosure are not limited thereto.

**[0181]** 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.

30 **[0182]** When layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region are formed by vacuum deposition, the deposition may be performed at a deposition temperature of about 100 °C to about 500 °C, a vacuum degree of about 10<sup>-8</sup> torr to about 10<sup>-3</sup> torr, and a deposition speed of about 0.01 Å/sec to about 100 Å/sec by taking into account a material to be included in a layer to be formed, and the structure of a layer to be formed.

35 **[0183]** When layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region are formed by spin coating, the spin coating may be performed at a coating speed of about 2,000 rpm to about 5,000 rpm and at a heat treatment temperature of about 80 °C to about 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.

40 **General definition of some of the substituents**

**[0184]** The term "C<sub>1</sub>-C<sub>60</sub> 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<sub>1</sub>-C<sub>60</sub> alkylene group," as used herein, refers to a divalent group having substantially the same structure as the C<sub>1</sub>-C<sub>60</sub> alkyl group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkyl/alkylene group.

50 **[0185]** The term "C<sub>2</sub>-C<sub>60</sub> 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 terminus of the C<sub>2</sub>-C<sub>60</sub> alkyl group, and examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term "C<sub>2</sub>-C<sub>60</sub> alkenylene group," as used herein, refers to a divalent group having substantially the same structure as the C<sub>2</sub>-C<sub>60</sub> alkenyl group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkenyl/alkenylene group.

**[0186]** The term "C<sub>2</sub>-C<sub>60</sub> 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 terminus of the C<sub>2</sub>-C<sub>60</sub> alkyl group, and examples thereof include an ethynyl group, and a propynyl group. The term "C<sub>2</sub>-C<sub>60</sub> alkynylene group," as used herein, refers to a divalent group having substantially the same structure as the C<sub>2</sub>-C<sub>60</sub> alkynyl group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkynyl/alkynylene group.

55 **[0187]** The term "C<sub>1</sub>-C<sub>60</sub> alkoxy group," as used herein, refers to a monovalent group represented by -OA<sub>101</sub> (wherein

A<sub>101</sub> is the C<sub>1</sub>-C<sub>60</sub> 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.

**[0188]** The term "C<sub>3</sub>-C<sub>10</sub> 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<sub>3</sub>-C<sub>10</sub> cycloalkylene group," as used herein, refers to a divalent group having substantially the same structure as the C<sub>3</sub>-C<sub>10</sub> cycloalkyl group.

**[0189]** The term "C<sub>1</sub>-C<sub>10</sub> 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 tetrahydrofuranlyl group, and a tetrahydrothiophenyl group. The term "C<sub>1</sub>-C<sub>10</sub> heterocycloalkylene group," as used herein, refers to a divalent group having substantially the same structure as the C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group.

**[0190]** The term "C<sub>3</sub>-C<sub>10</sub> 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 (e.g., the entire ring, group, and/molecule is not aromatic), and examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term "C<sub>3</sub>-C<sub>10</sub> cycloalkenylene group," as used herein, refers to a divalent group having substantially the same structure as the C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group.

**[0191]** The term "C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group," as used herein, refers to a monovalent monocyclic group that has at least one heteroatom 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<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group include a 4,5-dihydro-1,2,3,4-oxatriazolyl group, a 2,3-dihydrofuranlyl group, and a 2,3-dihydrothiophenyl group. The term "C<sub>1</sub>-C<sub>10</sub> heterocycloalkenylene group," as used herein, refers to a divalent group having substantially the same structure as the C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group.

**[0192]** 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 the term "C<sub>6</sub>-C<sub>60</sub> arylene group," as used herein, refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. 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.

**[0193]** 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 an heteroaryl/heteroarylene group.

**[0194]** 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.

**[0195]** 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>6</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). Corresponding definitions apply to other ranges given for the number of carbon atoms in a heteroaryloxy group and a heteroarylthio group.

**[0196]** 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 (e.g., the entire group and/or molecule is not aromatic). 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.

**[0197]** 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 (e.g., the entire group and/or molecule is not aromatic). An example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl 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.

**[0198]** 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.

**[0199]** 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.

**[0200]** 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> (e.g. C<sub>6</sub>-C<sub>30</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>) heteroarylthio group, a 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 biphenyl group, and a terphenyl group.

**[0201]** The term "Ph," as used herein, represents a phenyl group, the term "Me," as used herein, represents a methyl group, the term "Et," as used herein, represents an ethyl group, and the term "ter-Bu" or "Bu<sup>t</sup>," as used herein, represents a tert-butyl group.

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

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

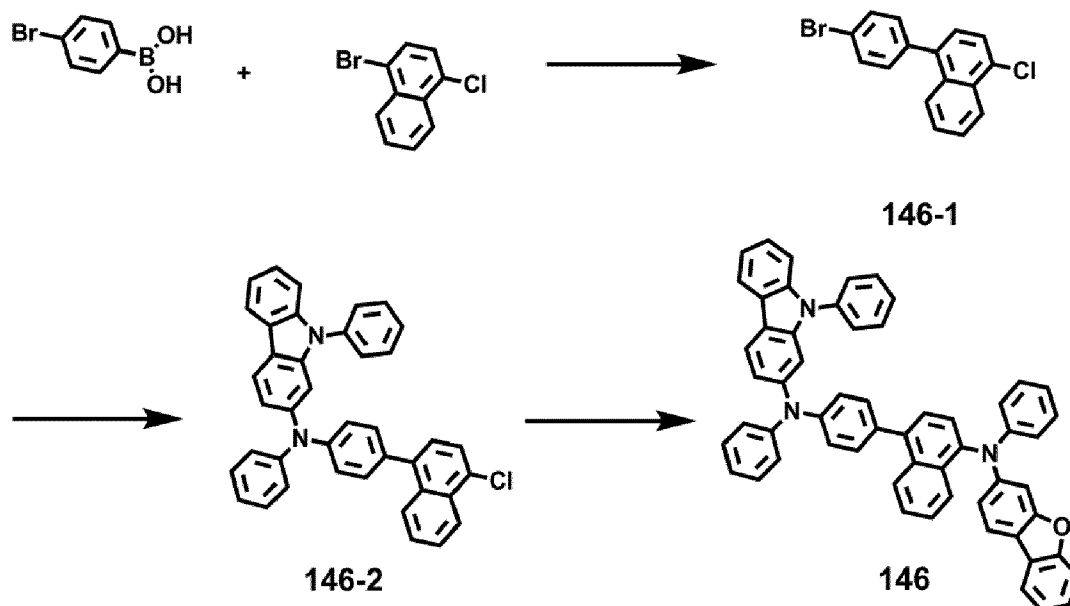
**[0204]** \* and \*' used herein, unless defined otherwise, each refer to a binding site to a neighboring atom in a corresponding formula.

**[0205]** 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 (e.g., substantially identical) molar equivalent of B was used in place of A.

## Examples

### Synthesis Example 1: Synthesis of Compound 146

**[0206]**



#### (1) Synthesis of Intermediate 146-1

**[0207]** 4 g of (4-bromophenyl)boronic acid and 4.8 g of 1-bromo-4-chloronaphthalene were added to 80 ml of tetrahydrofuran (THF), 560 mg of Pd(PPh<sub>3</sub>)<sub>4</sub> and 5.4 g of potassium carbonate diluted in 20 ml of water were added dropwise thereto, and the reaction mixture was stirred at a temperature of 60 °C for 4 hours. The reaction mixture was cooled to room temperature, and an organic layer was extracted three times by using ethyl acetate and separated therefrom. The organic layer was dried by anhydrous magnesium sulfate and filtered under reduced pressure. A residue obtained therefrom was separated and purified by column chromatography to obtain 5 g (yield of 81 %) of Intermediate 146-1.

**[0208]** C<sub>16</sub>H<sub>10</sub>BrCl: M<sup>+</sup> Calcd: 315.97 Found: 316.0.

## (2) Synthesis of Intermediate 146-2

[0209] 3.2 g of Intermediate 146-1, 3.4 g of N,9-diphenyl-9H-carbazole-2-amine, 0.34 g of Pd<sub>2</sub>(dba)<sub>3</sub>, 0.1 ml of PtBu<sub>3</sub>, and 3.4 g of KOt-Bu were dissolved in 60 ml of toluene and stirred at a temperature of 85 °C for 1 hour. The mixture was cooled to room temperature, and the reaction was terminated with water. Then, an organic layer was extracted therefrom three times by using ethyl acetate. The extracted organic layer was dried by using anhydrous magnesium sulfate and distilled under reduced pressure. A residue obtained therefrom was separated and purified by column chromatography to obtain 4.9 g (yield of 87 %) of Intermediate 146-2.

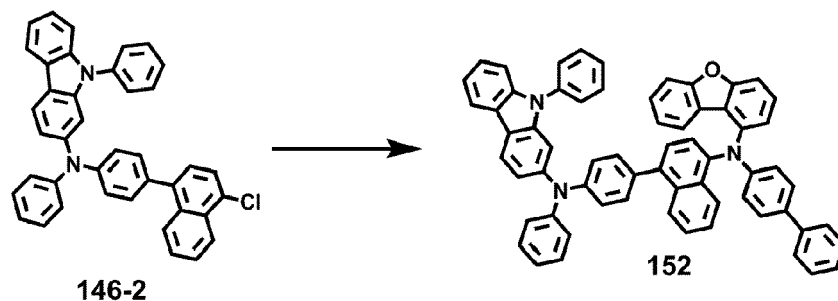
[0210] C<sub>40</sub>H<sub>27</sub>ClN<sub>2</sub>: M+ Calcd: 570.19 Found: 571.2.

## (3) Synthesis of Compound 146

[0211] 3.2 g (yield of 77 %) of Compound 146 was obtained in substantially the same manner as in Synthesis of Intermediate 146-2, except that 3 g of Intermediate 146-2 and 1.6 g of N-phenyldibenzo[b,d]furan-3-amine were used.

## Synthesis Example 2: Synthesis of Compound 152

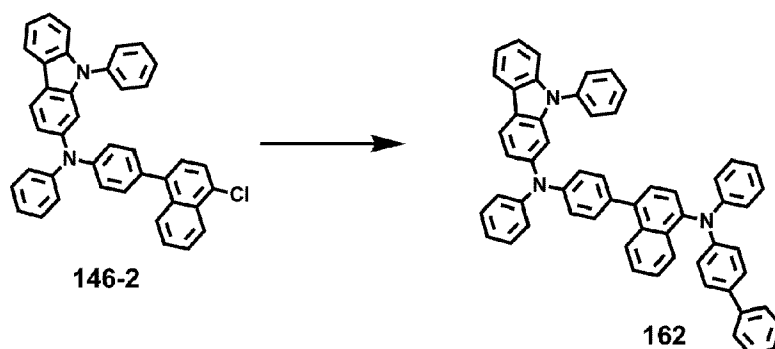
[0212]



[0213] 3.3 g (yield of 69 %) of Compound 152 was obtained in substantially the same manner as in Synthesis of Compound 146, except that 2.1 g of N-([1,1'-biphenyl]-4-yl)dibenzo[b,d]furan-1-amine was used instead of 1.6 g of N-phenyldibenzo[b,d]furan-3-amine.

## Synthesis Example 3: Synthesis of Compound 162

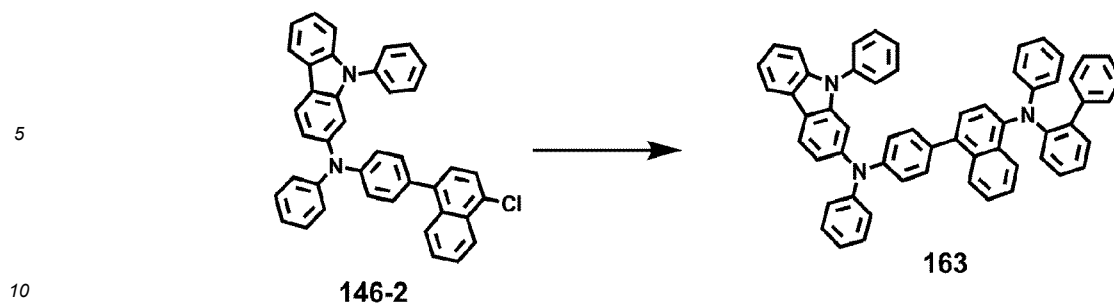
[0214]



[0215] 3 g (71 %) of Compound 162 was obtained in substantially the same manner as in Synthesis of Compound 146, except that 1.5 g of N-phenyl-[1,1'-biphenyl]-4-amine was used instead of 1.6 g of N-phenyldibenzo[b,d]furan-3-amine.

## Synthesis Example 4: Synthesis of Compound 163

[0216]

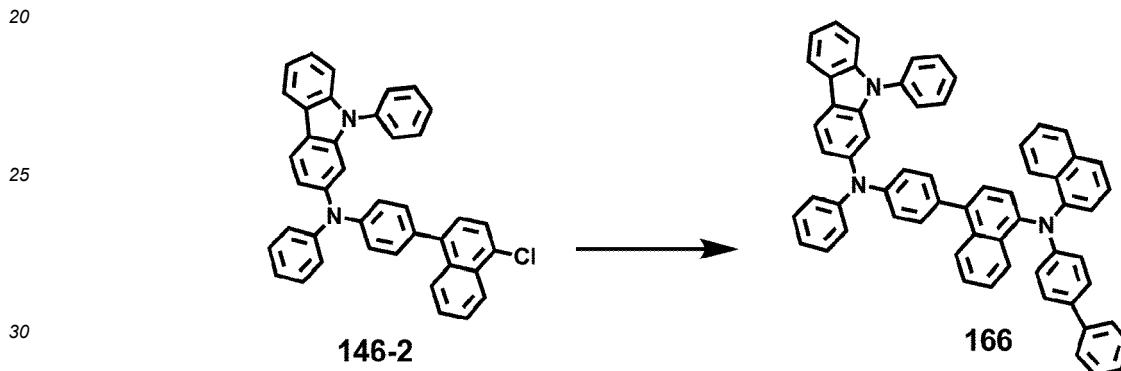


[0217] 3.1 g (yield of 72 %) of Compound 163 was obtained in substantially the same manner as in Synthesis of Compound 146, except that 1.5 g of N-phenyl-[1,1'-biphenyl]-2-amine was used instead of 1.6 g of N-phenyldibenzo[b,d]furan-3-amine.

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**Synthesis Example 5: Synthesis of Compound 166**

[0218]

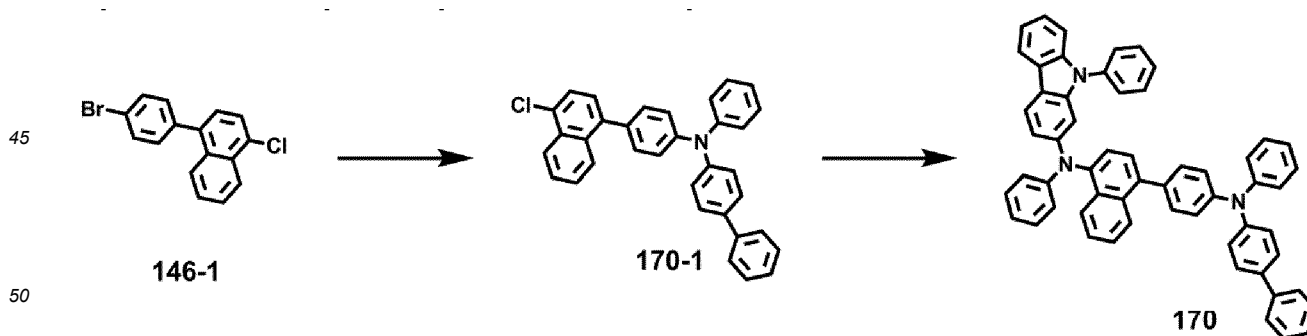


[0219] 2.8 g (yield of 66 %) of Compound 166 was obtained in substantially the same manner as in Synthesis of Compound 146, except that 1.8 g of N-([1,1'-biphenyl]-4-yl)naphthalene-1-amine was used instead of 1.6 g of N-phenyldibenzo[b,d]furan-3-amine.

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**Synthesis Example 6: Synthesis of Compound 170**

[0220]



(1) Synthesis of Intermediate 170-1

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[0221] 4 g (yield of 84%) of Intermediate 170-1 was obtained in substantially the same manner as in Synthesis of Intermediate 146-2, except that 2.5 g of N-phenyl-[1,1'-biphenyl]-4-amine was used instead of 3.4 g of N,9-diphenyl-9H-carbazole-2-amine.

## (2) Synthesis of Compound 170

**[0222]** 5.1 g (yield of 79 %) of Compound 170 was obtained in substantially the same manner as in Synthesis of Compound 146, except that 4 g of Intermediate 170-1 and 3.3 g of N,9-diphenyl-9H-carbazole-2-amine were respectively used instead of 3 g of Intermediate 146-2 and 1.6 g of N-phenyldibenzo[b,d]furan-3-amine.

**[0223]** <sup>1</sup>H NMR and MS/FAB of Compounds synthesized in Synthesis Examples 1 to 6 were shown in Table 1 below.

**[0224]** Methods of synthesizing compounds other than the compound shown in Table 1 (where the term "Calcd" indicates that the values were calculated) should be readily recognizable by those of ordinary skill in the art by referring to the synthesis paths and source materials described above.

Table 1

Compound	<sup>1</sup> H NMR (CDCl <sub>3</sub> , 400 MHz)	MS/FAB	
		Found	Calcd
146	8.17(m, 1H), 7.82(m, 1H), 7.75-7.65(m, 4H), 7.54-7.23(m, 15H), 7.08-7.02(m, 4H), 6.96-6.87(m, 5H), 6.80(dd, 1H), 6.66-6.60(m, 2H), 6.53-6.50(m, 2H), 6.41-6.39(m, 2H), 6.26-6.22(m, 2H)	793.32	793.31
152	8.17(m, 1H), 7.82-7.80(m, 2H), 7.72-7.70(m, 1H), 7.63-7.61(m, 2H), 7.54-7.23(m, 23H), 7.09-7.04(m, 2H), 6.95-6.87(4H), 6.82(dd, 1H), 6.66-6.59(m, 2H), 6.54-6.49(m, 4H), 6.42-6.39(m, 2H)	869.35	869.34
162	8.17(m, 1H), 7.82-7.80(m, 1H), 7.66-7.62(m, 3H), 7.55-7.23(m, 18H), 7.16(d, 1H), 7.09-7.04(m, 4H), 6.95-6.79(m, 5H), 6.66-6.59(m, 2H), 6.54-6.49(m, 2H), 6.42-6.39(m, 2H), 6.14-6.11(m, 2H)	779.35	779.33
163	8.17(m, 1H), 7.82-7.80(m, 1H), 7.60-7.44(m, 13H), 7.40-7.22(m, 6H), 7.18-7.12(m, 2H), 7.08-6.83(m, 9H), 6.81 (dd, 1H), 6.65-6.60(m, 2), 6.54-6.50(m, 2H), 6.41-6.38(m, 2H), 6.17-6.14(m, 2H)	779.35	779.33
166	8.17-8.15(m, 1H), 8.04-8.01(m, 1H), 7.87(m, 1H), 7.80(m, 1H), 7.63-7.61(m, 2H), 7.55-7.21(m, 22H), 7.17(t, 1H), 7.09-7.04(m, 2H), 6.92-6.88(m, 2H), 6.81 (dd, 1H), 6.70-6.62(m, 3H), 6.54-6.50(m, 3H), 6.43-6.39(m, 2H), 6.27-6.23(m, 2H)	829.38	829.35
170	8.18-8.15(m, 1H), 7.85-7.83(m, 1H), 7.71 (dd, 1), 7.64-7.61 (m, 2H), 7.55-7.23 (m, 18H), 7.08-6.82(m, 11H), 6.67-6.61 (m, 2H), 6.55(dd, 1H), 6.27-6.18(m, 4H)	779.35	779.33

## Example 1

**[0225]** As an anode, a 15 Ω/cm<sup>2</sup> (1200 Å) ITO glass substrate 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 glass substrate was provided to a vacuum deposition apparatus.

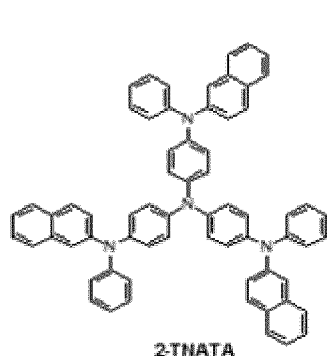
**[0226]** 2-TNATA was vacuum-deposited on the ITO glass substrate to form a hole injection layer having a thickness of 600 Å, Compound 146 was vacuum-deposited on the hole injection layer to form a hole transport layer having a thickness of 300 Å.

**[0227]** 9,10-di-naphthalene-2-yl-anthracene (ADN) (blue fluorescent host) and DPAVB<sub>i</sub> (blue fluorescent dopant) were co-deposited on the hole transport layer at a weight ratio of 98:2 to form an emission layer having a thickness of 300 Å.

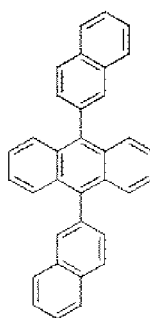
**[0228]** Alq<sub>3</sub> was deposited on the emission layer to form an electron transport layer having a thickness of 300 Å, LiF was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and Al was deposited on the electron injection layer to form a cathode having a thickness of 3000 Å, thereby completing the manufacture of an organic light-emitting device.

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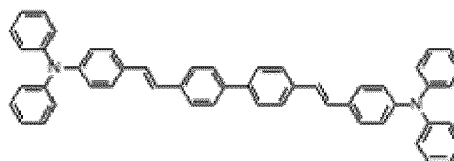
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2-TNATA



ADN



DPAVBI

### Examples 2 to 6 and Comparative Examples 1 to 3

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[0229] Organic light-emitting devices were manufactured in substantially the same manner as in Example 1, except that Compounds shown in Table 2 were each used instead of Compound 146 in forming a hole transport layer.

### Evaluation Example

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[0230] The driving voltage, luminance, efficiency, and lifespan of the organic light-emitting devices manufactured according to Examples 1 to 6 and Comparative Examples 1 to 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. The lifespan indicates an amount of time that lapses when luminance was 50 % of initial luminance (100 %) (at a current density of 100 mA/cm<sup>2</sup>) after driving an organic light-emitting device.

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Table 2

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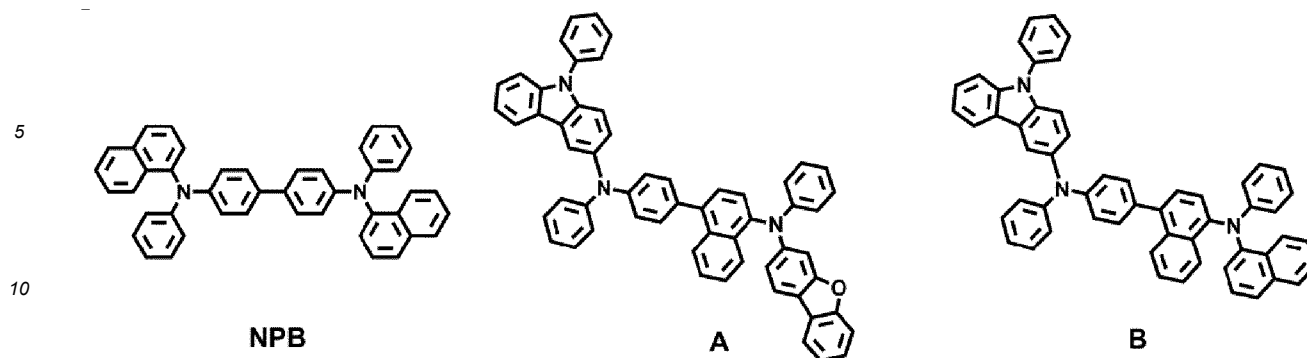
	Material for hole transport layer	Driving voltage (V)	Current density (mA/cm <sup>2</sup> )	Luminance (cd/m <sup>2</sup> )	Efficiency (cd/A)	Emission color	Lifespan (time)
Comparative Example 1	NPB	7.01	50	2645	5.29	Blue	258
Comparative Example 2	Compound A	4.53	50	3300	6.6	Blue	291
Comparative Example 3	Compound B	4.48	50	3215	6.43	Blue	293
Example 1	Compound 146	4.20	50	3750	7.50	Blue	320
Example 2	Compound 152	4.20	50	3750	7.50	Blue	324
Example 3	Compound 162	4.26	50	3730	7.46	Blue	371
Example 4	Compound 163	4.26	50	3670	7.34	Blue	332
Example 5	Compound 166	4.25	50	3675	7.35	Blue	392
Example 6	Compound 170	4.32	50	3585	7.17	Blue	414

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15 **[0231]** Referring to Table 2, it is confirmed that the driving voltage and the efficiency of the organic light-emitting devices of Examples 1 to 6 are improved as compared with the organic light-emitting devices of Comparative Examples 1 to 3. For example, it has been confirmed that the lifespan of the organic light-emitting devices of Examples 1 to 6 is remarkably improved as compared with the organic light-emitting devices of Comparative Examples 1 to 3.

**[0232]** The organic light-emitting device including the diamine compound may have a low driving voltage, high efficiency, high luminance, high color purity, and a long lifespan.

20 **[0233]** 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.

25 **[0234]** 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 scope of the present disclosure.

30 **[0235]** 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.

35 **[0236]** As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

40 **[0237]** 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.

45 **[0238]** 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.

50 **[0239]** 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 appended claims, and equivalents thereof.

## Claims

1. An organic light-emitting device comprising:

5 a first electrode;  
 a second electrode; and  
 an organic layer between the first electrode and the second electrode and comprising an emission layer,  
 wherein the organic layer comprises a diamine compound comprising a naphthyl-phenyl linker and a 2-carbazolyl  
 10 group.

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

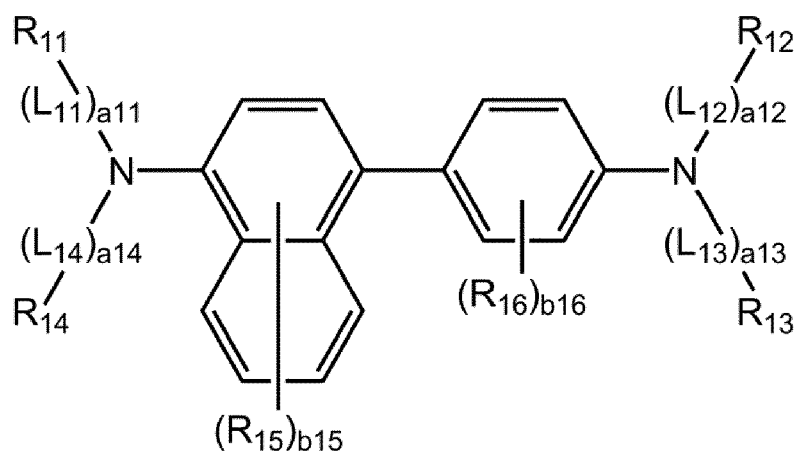
15 the first electrode is an anode,  
 the second electrode is a cathode,  
 the organic layer further comprises a hole transport region between the first electrode and the emission layer, and  
 the hole transport region comprises the diamine compound; preferably wherein: the hole transport region com-  
 prises at least one of a hole injection layer and a hole transport layer, and  
 at least one of the hole injection layer and the hole transport layer comprises the diamine compound.

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

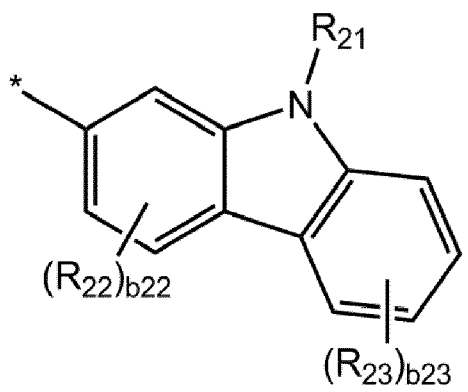
20 the hole transport region comprises a p-dopant, and  
 the p-dopant has a lowest unoccupied molecular orbital (LUMO) energy level of about -3.5 eV or less.

4. An organic light-emitting device according to any one of claims 1 to 3, wherein:  
 25 the diamine compound is a diamine compound represented by Formula 1:

Formula 1



Formula 2



wherein, in Formula 1,

L<sub>11</sub> to L<sub>14</sub> are each independently selected from a single bond, 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>11</sub> to a<sub>14</sub> are each independently selected from 0, 1, 2, and 3,

R<sub>11</sub> to R<sub>14</sub> are each independently selected from a group represented by Formula 2, 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>1</sub>-C<sub>60</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 of R<sub>11</sub> to R<sub>14</sub> is a group represented by Formula 2,

R<sub>15</sub>, R<sub>16</sub>, and R<sub>21</sub> to R<sub>23</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 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 C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heteroarylthio 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>),

b<sub>15</sub> is selected from 1, 2, 3, 4, 5, and 6,

b<sub>16</sub> and b<sub>23</sub> are each independently selected from 1, 2, 3, and 4,

b<sub>22</sub> is selected from 1, 2, and 3,

Q<sub>1</sub> to Q<sub>3</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>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 C<sub>1</sub>-C<sub>60</sub> alkyl group substituted with at least one selected from deuterium, -F, and a cyano group, a C<sub>6</sub>-C<sub>60</sub> aryl group substituted with at least one selected from deuterium, -F, and a cyano group, a biphenyl group, and a terphenyl group, \* indicates a binding site to a neighboring atom,

at least one substituent of the substituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group, the substituted C<sub>1</sub>-C<sub>60</sub> heterocyclic 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> aryl group, the substituted C<sub>1</sub>-C<sub>60</sub> heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, the substituted monovalent non-aromatic condensed heteropolycyclic group, the substituted C<sub>1</sub>-C<sub>60</sub> alkyl group, the substituted C<sub>2</sub>-C<sub>60</sub> alkenyl group, the substituted C<sub>2</sub>-C<sub>60</sub> alkynyl group, the substituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, the substituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, the substituted C<sub>6</sub>-C<sub>60</sub> arylthio group, the substituted C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, and the substituted C<sub>1</sub>-C<sub>60</sub> heteroarylthio group is selected from

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

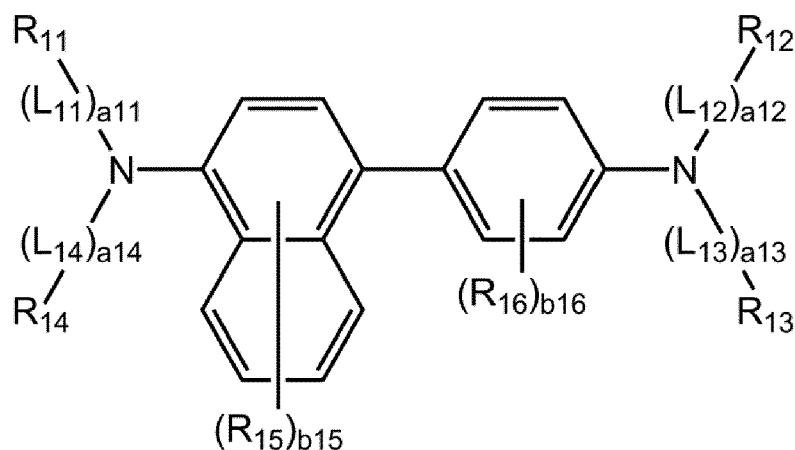
a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> 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, -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> 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

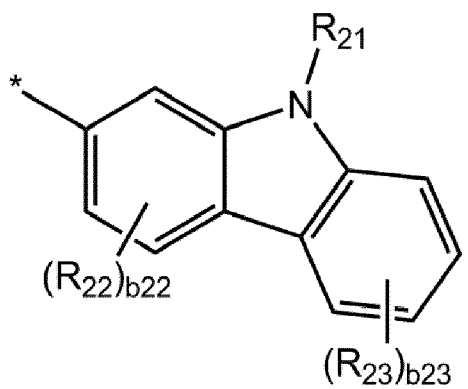
polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;  
 a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> 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, 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> 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, -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> 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>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.

5. A diamine compound represented by Formula 1:

Formula 1



Formula 2



wherein, in Formula 1,

L<sub>11</sub> to L<sub>14</sub> are each independently selected from a single bond, 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>11</sub> to a<sub>14</sub> are each independently selected from 0, 1, 2, and 3,

R<sub>11</sub> to R<sub>14</sub> are each independently selected from a group represented by Formula 2, 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>1</sub>-C<sub>60</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 of R<sub>11</sub> to R<sub>14</sub> is a group represented by Formula 2,

R<sub>15</sub>, R<sub>16</sub>, and R<sub>21</sub> to R<sub>23</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 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 C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heteroarylthio 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>),

b<sub>15</sub> is selected from 1, 2, 3, 4, 5, and 6,

b<sub>16</sub> and b<sub>23</sub> are each independently selected from 1, 2, 3, and 4,

b<sub>22</sub> is selected from 1, 2, and 3,

Q<sub>1</sub> to Q<sub>3</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>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 C<sub>1</sub>-C<sub>60</sub> alkyl group substituted with at least one selected from deuterium, -F, and a cyano group, a C<sub>6</sub>-C<sub>60</sub> aryl group substituted with at least one selected from deuterium, -F, and a cyano group, a biphenyl group, and a terphenyl group, \* indicates a binding site to a neighboring atom,

at least one substituent of the substituted C<sub>5</sub>-C<sub>60</sub> carbocyclic group, the substituted C<sub>1</sub>-C<sub>60</sub> heterocyclic 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> aryl group, the substituted C<sub>1</sub>-C<sub>60</sub> heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, the substituted monovalent non-aromatic condensed heteropolycyclic group, the substituted C<sub>1</sub>-C<sub>60</sub> alkyl group, the substituted C<sub>2</sub>-C<sub>60</sub> alkenyl group, the substituted C<sub>2</sub>-C<sub>60</sub> alkynyl group, the substituted C<sub>1</sub>-C<sub>60</sub> alkoxy group, the substituted C<sub>6</sub>-C<sub>60</sub> aryloxy group, the substituted C<sub>6</sub>-C<sub>60</sub> arylthio group, the substituted C<sub>1</sub>-C<sub>60</sub> heteroaryloxy group, and the substituted C<sub>1</sub>-C<sub>60</sub> heteroarylthio group is selected from

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

a C<sub>1</sub>-C<sub>60</sub> alkyl group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, and a C<sub>1</sub>-C<sub>60</sub> alkoxy group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>6</sub>-C<sub>60</sub> aryloxy group, a C<sub>6</sub>-C<sub>60</sub> arylthio group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a C<sub>1</sub>-C<sub>60</sub> 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, -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> 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, 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> 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, 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> 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, -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> 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>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.

6. A diamine compound according to claim 5, wherein:

R<sub>11</sub> is a group represented by Formula 2;  
 R<sub>12</sub> is a group represented by Formula 2;  
 R<sub>11</sub> and R<sub>12</sub> are each a group represented by Formula 2;  
 R<sub>11</sub> and R<sub>14</sub> are each a group represented by Formula 2;  
 R<sub>11</sub>, R<sub>12</sub>, and R<sub>14</sub> are each a group represented by Formula 2;  
 R<sub>11</sub>, R<sub>12</sub>, and R<sub>13</sub> are each a group represented by Formula 2; or  
 R<sub>11</sub>, R<sub>12</sub>, R<sub>13</sub>, and R<sub>14</sub> are each a group represented by Formula 2.

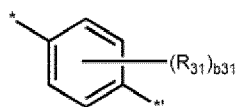
7. A diamine compound according to claim 5 or claim 6, wherein:

R<sub>11</sub> is a group represented by Formula 2; or  
 R<sub>12</sub> is a group represented by Formula 2.

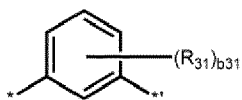
8. A diamine compound according to any one of claims 5 to 7, wherein:

L<sub>11</sub> to L<sub>14</sub> are each independently selected from a single bond, 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; and 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, 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 thiophenyl group, a furanyl group, a silolyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, -Si(Q<sub>31</sub>)(Q<sub>32</sub>)(Q<sub>33</sub>), -N(Q<sub>31</sub>)(Q<sub>32</sub>), and -B(Q<sub>31</sub>)(Q<sub>32</sub>), and Q<sub>31</sub> to Q<sub>33</sub> are each independently selected from a C<sub>1</sub>-C<sub>60</sub> alkyl group, a phenyl group, a biphenyl group, and a terphenyl group; preferably wherein:  
 L<sub>11</sub> to L<sub>14</sub> are each independently selected from a single bond and groups represented by Formulae 3-1 to 3-41:

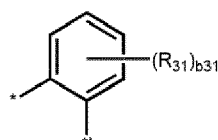
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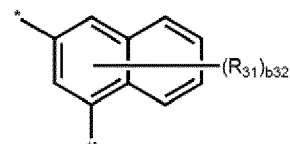
3-1



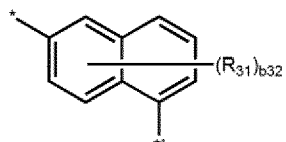
3-2



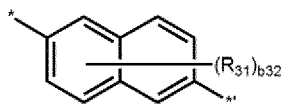
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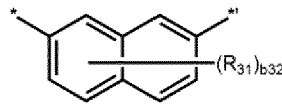
3-4



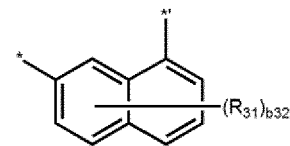
3-5



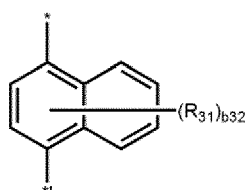
3-6



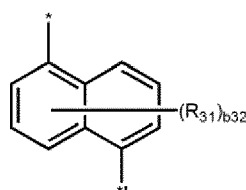
3-7



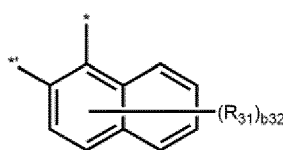
3-8



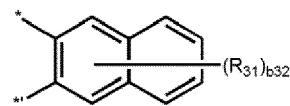
3-9



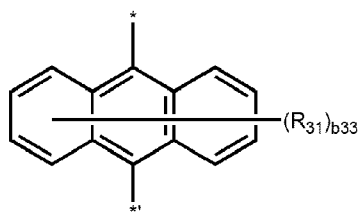
3-10



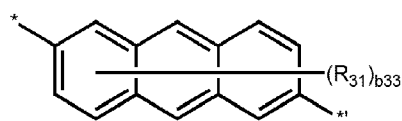
3-11



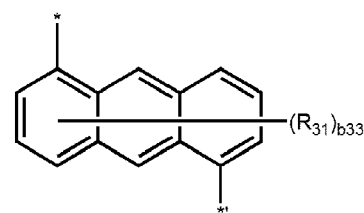
3-12



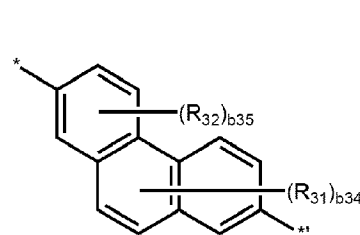
3-13



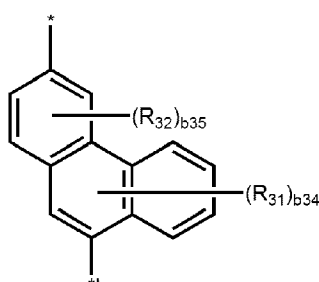
3-14



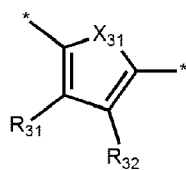
3-15



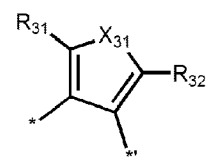
3-16



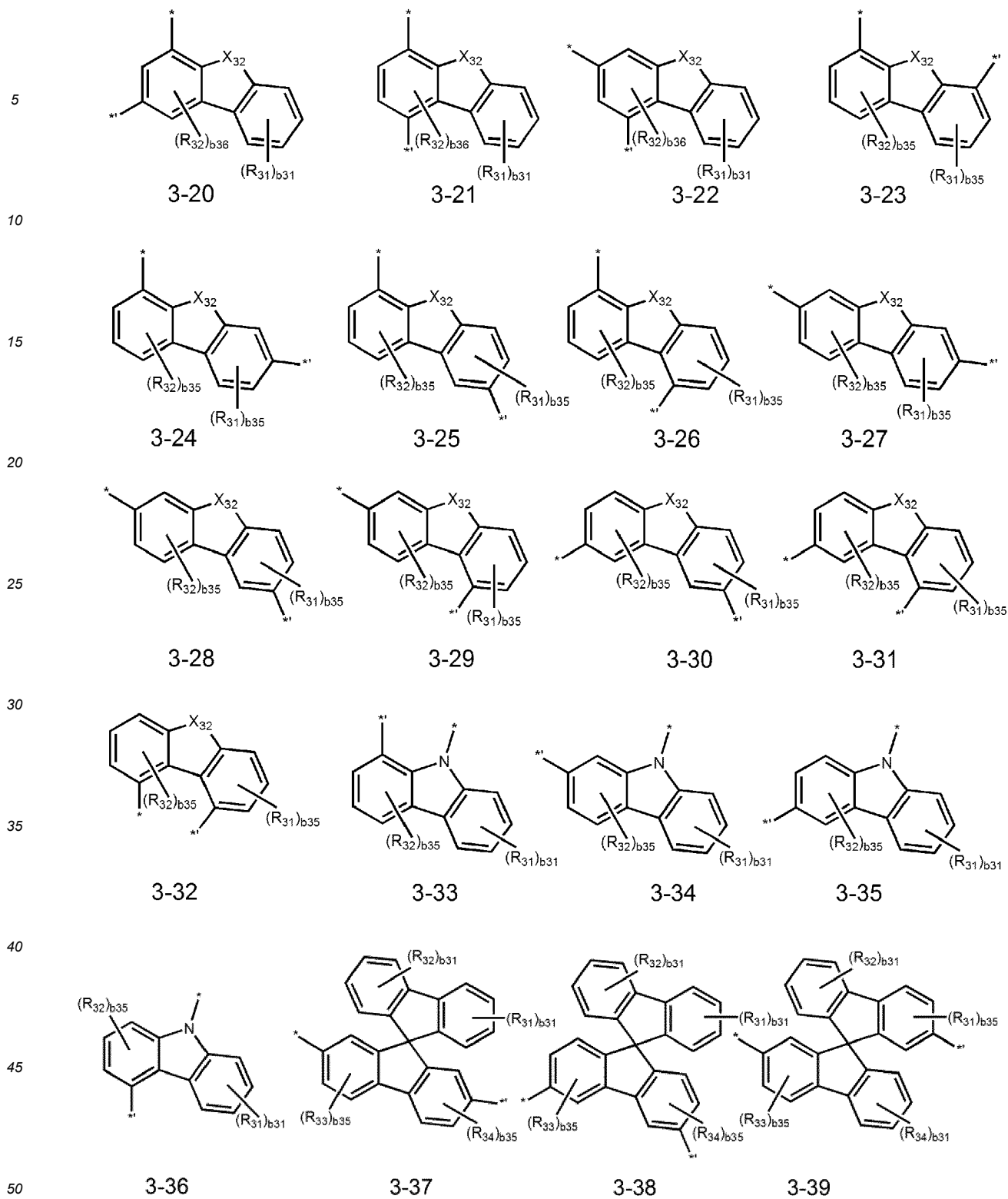
3-17

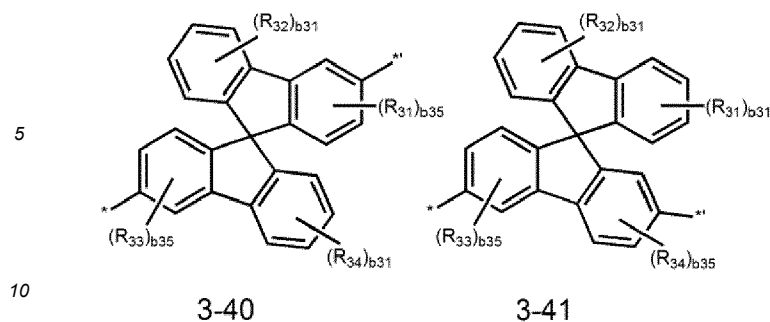


3-18



3-19





wherein, in Formulae 3-1 to 3-41,

$X_{31}$  is selected from O and S,

$X_{32}$  is selected from O, S, N(R33), and C(R33)(R34),

$R_{31}$  to  $R_{34}$  are each independently selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  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 thiophenyl group, a furanyl group, a silolyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, -Si( $Q_{31}$ )( $Q_{32}$ )( $Q_{33}$ ), -N( $Q_{31}$ )( $Q_{32}$ ), and -B( $Q_{31}$ )( $Q_{32}$ ),

$Q_{31}$  to  $Q_{33}$  are each independently selected from a  $C_1$ - $C_{60}$  alkyl group, a phenyl group, a biphenyl group, and a terphenyl group,

$b_{31}$  is selected from 1, 2, 3, and 4,

$b_{32}$  is selected from 1, 2, 3, 4, 5, and 6,

$b_{33}$  is selected from 1, 2, 3, 4, 5, 6, 7, and 8,

$b_{34}$  is selected from 1, 2, 3, 4, and 5,

$b_{35}$  is selected from 1, 2, and 3,

$b_{36}$  is selected from 1 and 2, and

\* and \*\* each indicate a binding site to a neighboring atom.

9. A diamine compound according to any one of claims 5 to 8, wherein:  
a11 to a14 are each independently selected from 0 and 1.

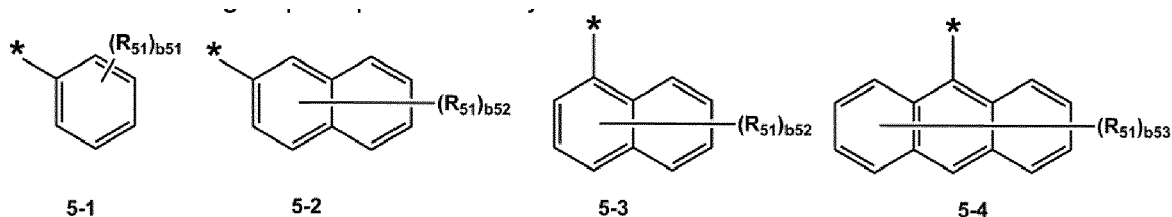
10. A diamine compound according to any one of claims 5 to 9, wherein:

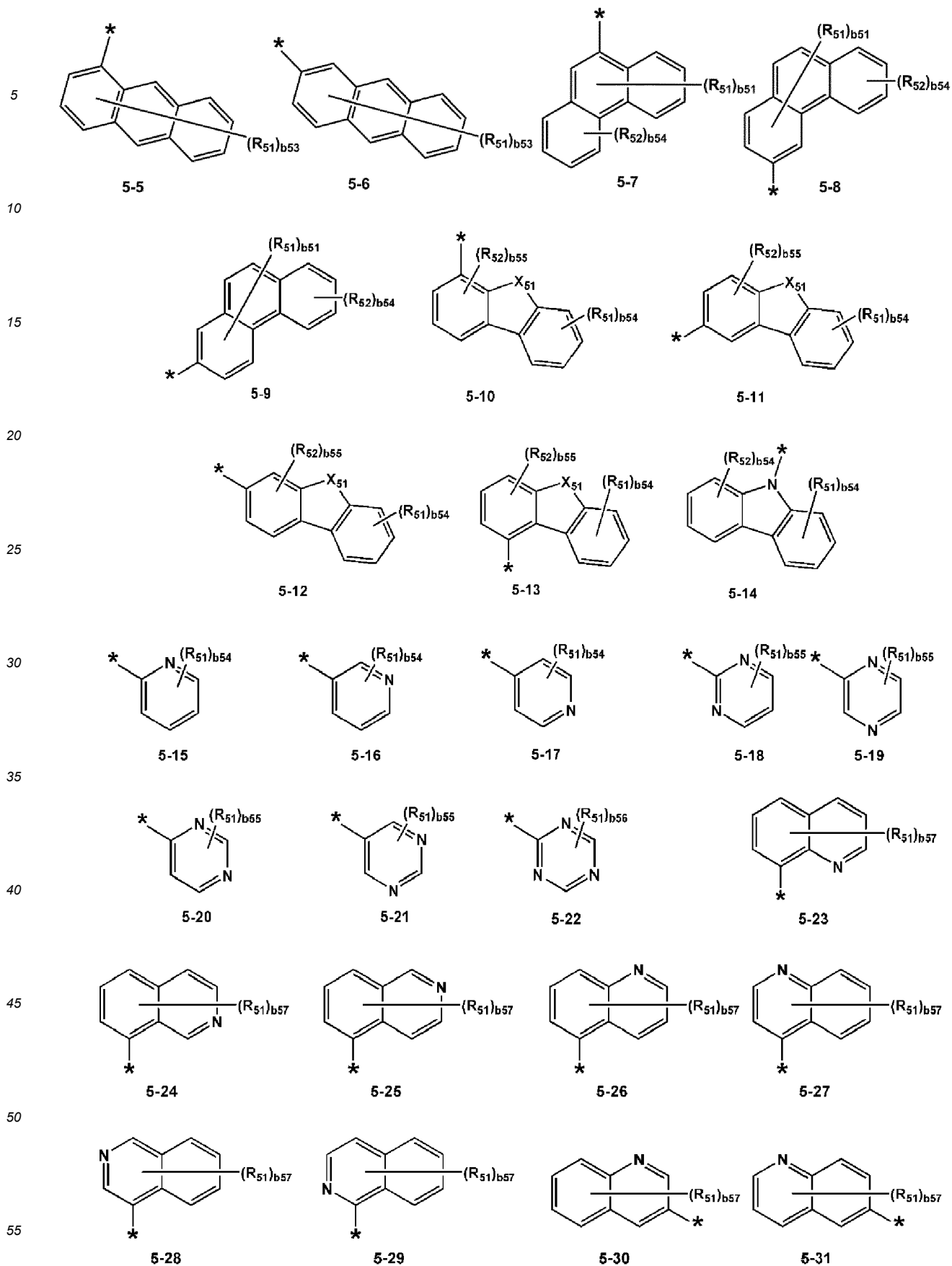
$R_{11}$  to  $R_{14}$  are each independently a group represented by Formula 2, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quinazolinyl group, a benzoquinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthyridinyl group, an azafluorenyl group,

an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl group; and

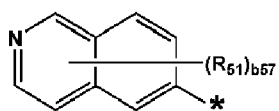
a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quina-  
 zolinyl group, a benzoquinazoliny group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyr-  
 rolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl 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 cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quina-  
 zolinyl group, a benzoquinazoliny group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzo-  
 thiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyr-  
 rolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl group, wherein at least one of R<sub>11</sub> to R<sub>14</sub> is a group represented by Formula 2; preferably wherein:

R<sub>11</sub> to R<sub>14</sub> are each independently selected from a group represented by Formula 2 and groups represented by Formulae 5-1 to 5-138:

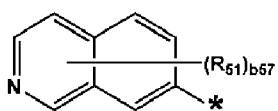




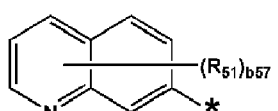
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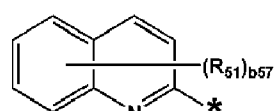
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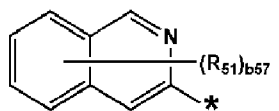
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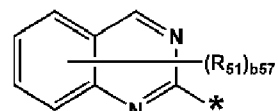
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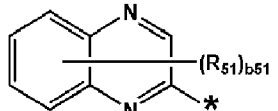
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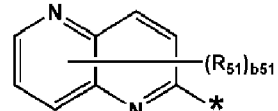
5-36



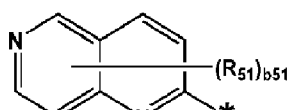
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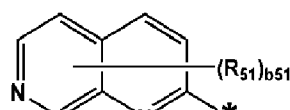
5-38



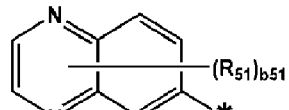
5-39



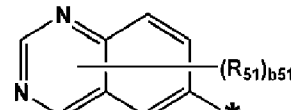
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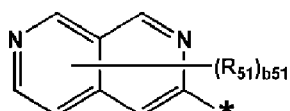
5-41



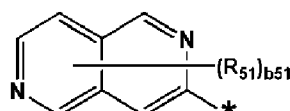
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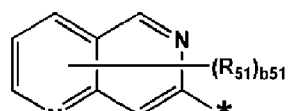
5-43



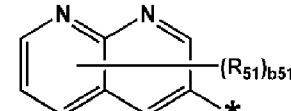
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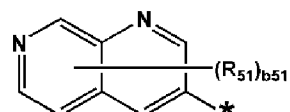
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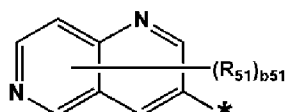
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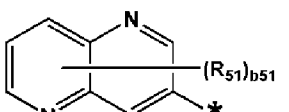
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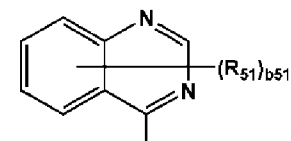
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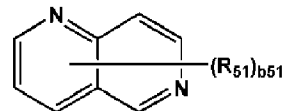
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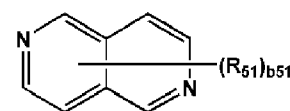
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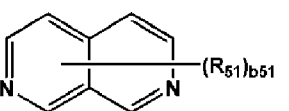
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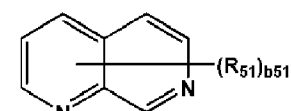
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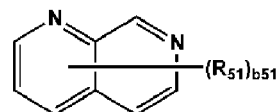
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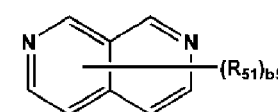
5-54



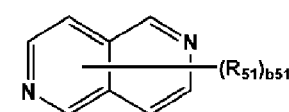
5-55



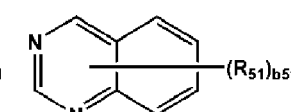
5-56



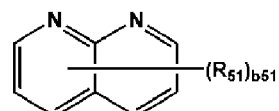
5-57



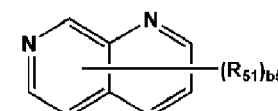
5-58



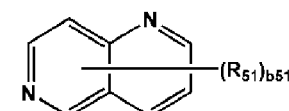
5-59



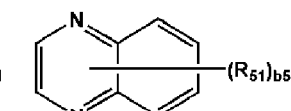
5-60



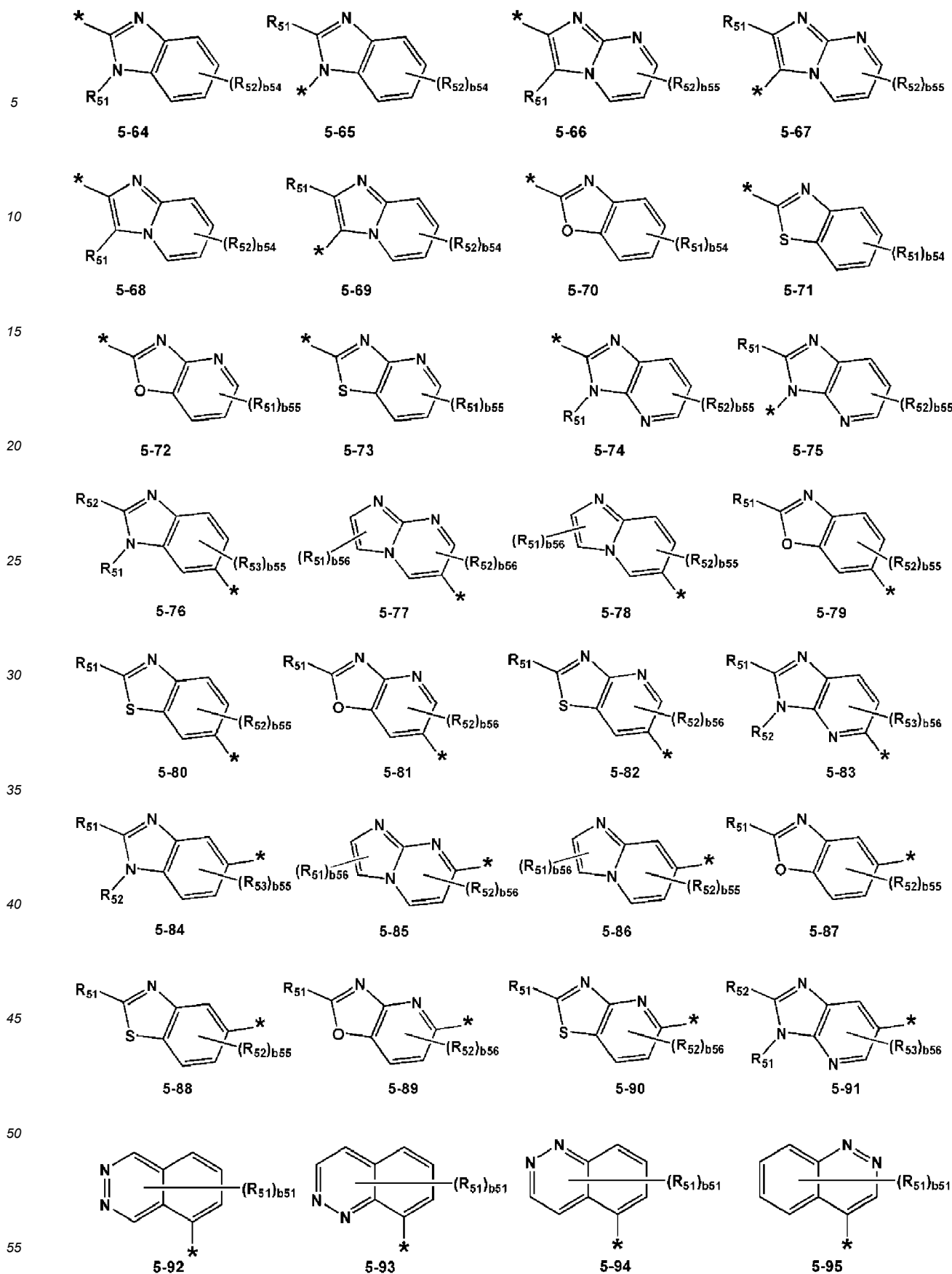
5-61

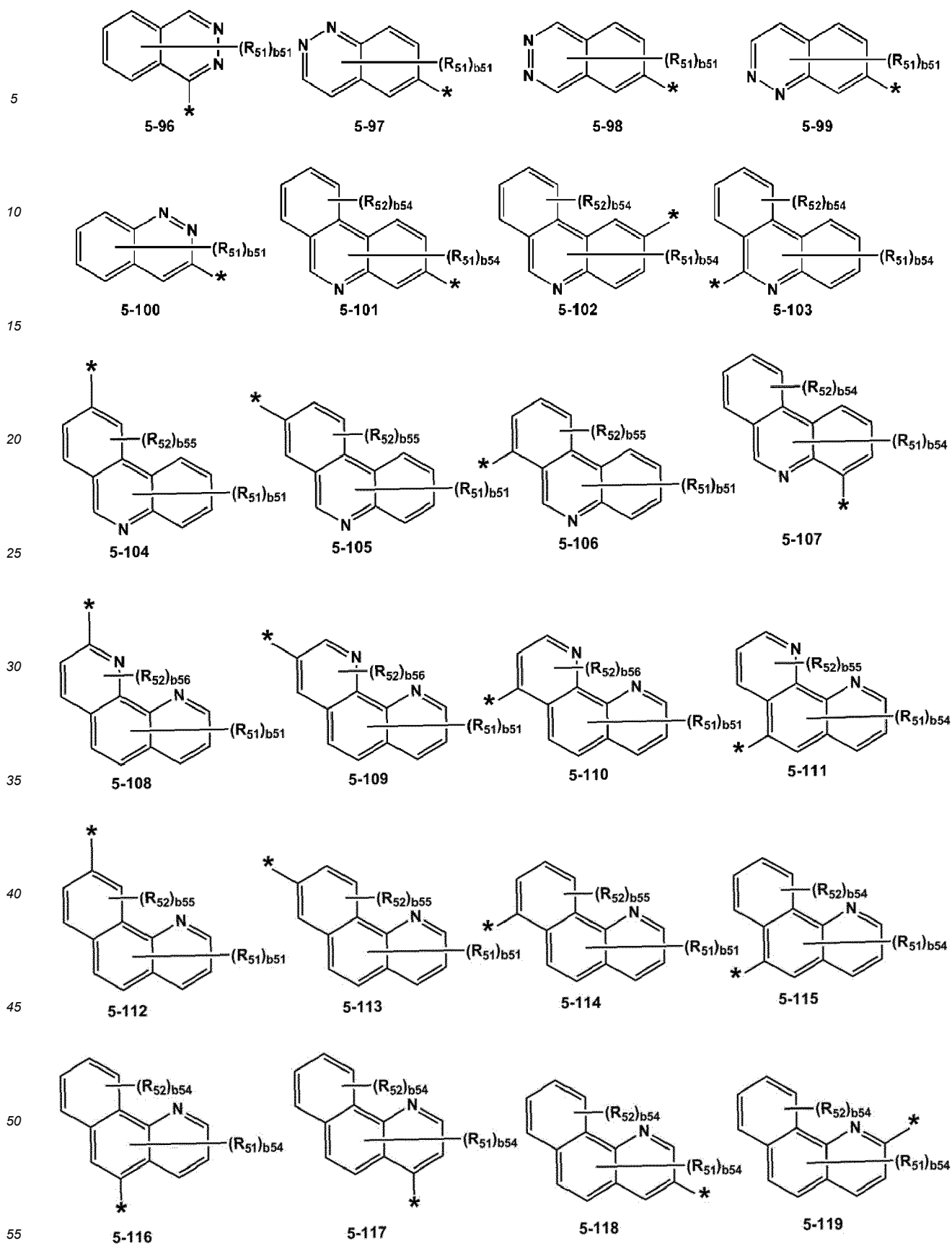


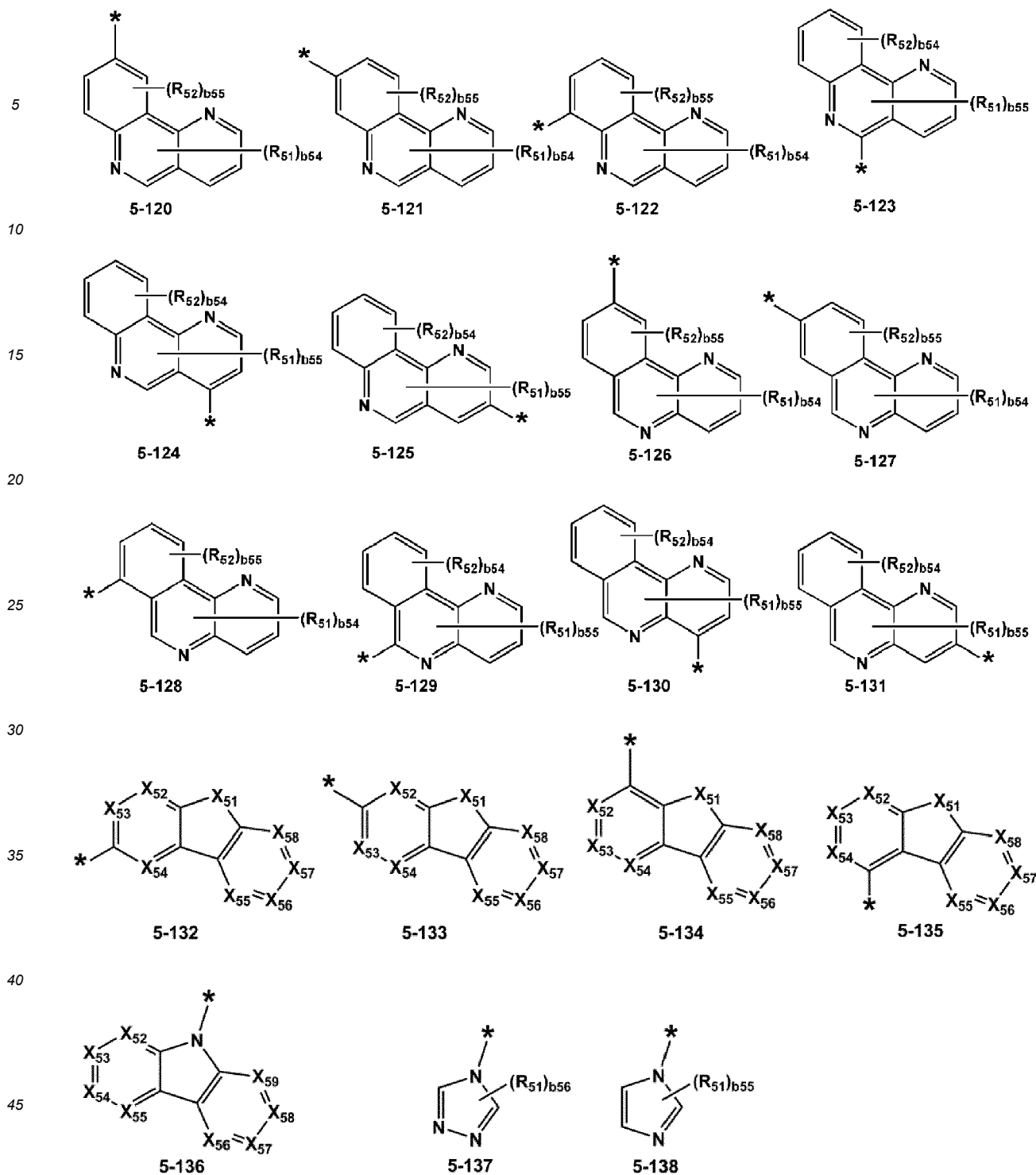
5-62



5-63







wherein, in Formulae 5-1 to 5-138,

$X_{51}$  is selected from O, S, N( $R_{51}$ ), and C( $R_{51}$ )( $R_{60}$ ),

$X_{52}$  is N or C( $R_{52}$ ),  $X_{53}$  is N or C( $R_{53}$ ),  $X_{54}$  is N or C( $R_{54}$ ),  $X_{55}$  is N or C( $R_{55}$ ),  $X_{56}$  is N or C( $R_{56}$ ),  $X_{57}$  is N or C( $R_{57}$ ),  $X_{58}$  is N or C( $R_{58}$ ), and  $X_{59}$  is N or C( $R_{59}$ ),

$R_{51}$  to  $R_{60}$  are each independently selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a  $C_1$ - $C_{20}$  alkyl group, a  $C_1$ - $C_{20}$  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 thiophenyl group, a furanyl group, a silolyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, -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)(Q<sub>31</sub>), -S(=O)<sub>2</sub>(Q<sub>31</sub>), -P(=O)(Q<sub>31</sub>)(Q<sub>32</sub>), and -P(=S)(Q<sub>31</sub>)(Q<sub>32</sub>), Q<sub>31</sub> to Q<sub>33</sub> are each independently selected from a C<sub>1</sub>-C<sub>60</sub> alkyl group, a phenyl group, a biphenyl group, and a terphenyl group,

b51 is selected from 1, 2, 3, 4, and 5,

b52 is selected from 1, 2, 3, 4, 5, 6, and 7,

b53 is selected from 1, 2, 3, 4, 5, 6, 7, 8, and 9,

b54 is selected from 1, 2, 3, and 4,

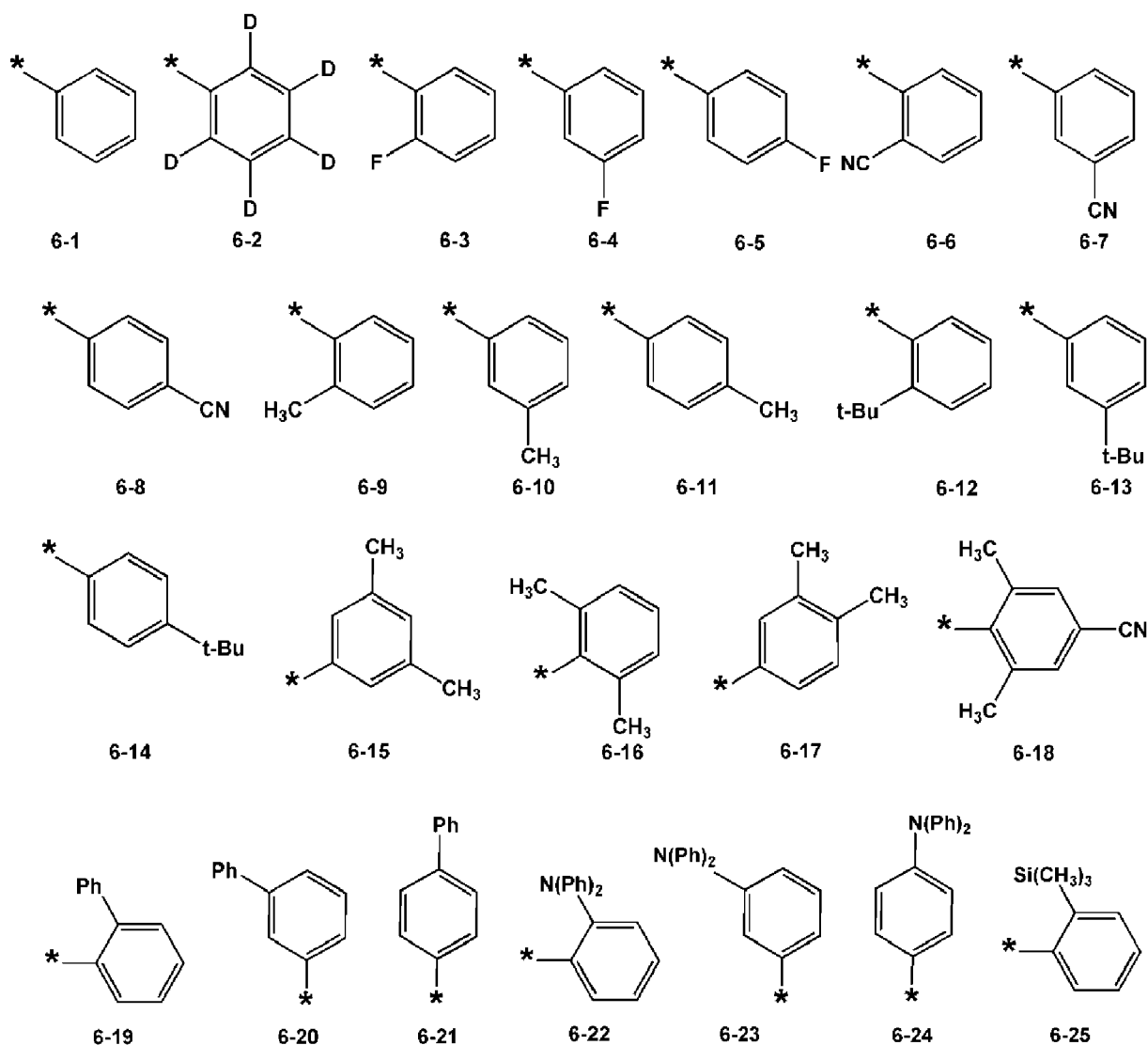
b55 is selected from 1, 2, and 3,

b56 is selected from 1 and 2,

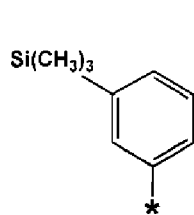
b57 is selected from 1, 2, 3, 4, 5, and 6, and

\* indicates a binding site to a neighboring atom; preferably wherein:

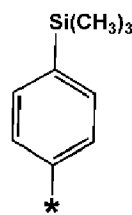
R<sub>11</sub> to R<sub>14</sub> are each independently selected from a group represented by Formula 2 and groups represented by Formulae 6-1 to 6-257:



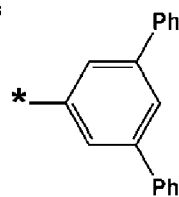
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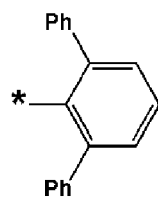
6-26



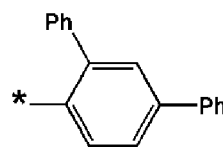
6-27



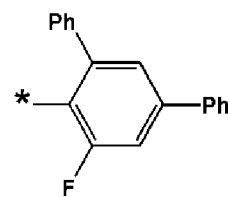
6-28



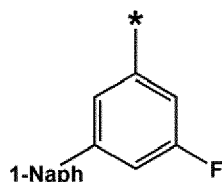
6-29



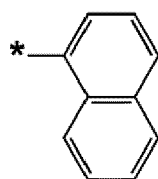
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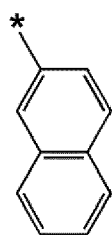
6-31



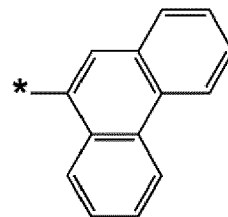
6-32



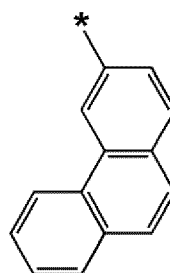
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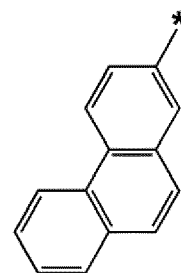
6-34



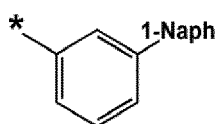
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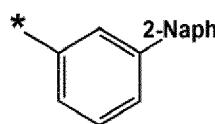
6-36



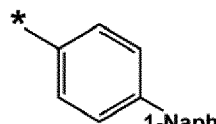
6-37



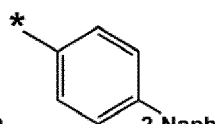
6-38



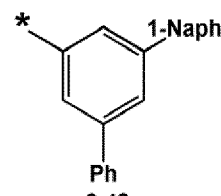
6-39



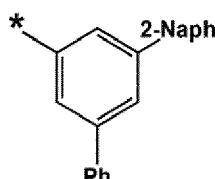
6-40



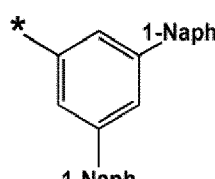
6-41



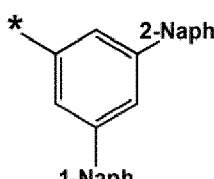
6-42



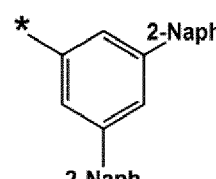
6-43



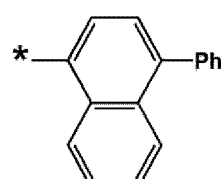
6-44



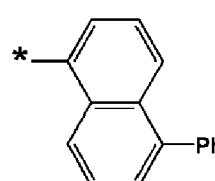
6-45



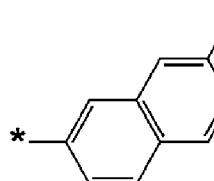
6-46



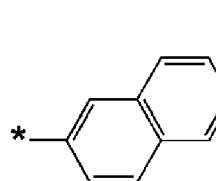
6-47



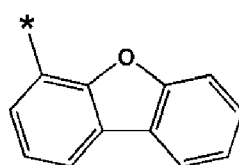
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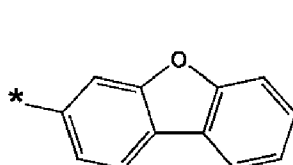
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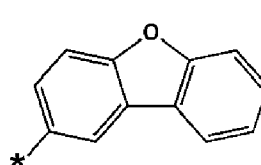
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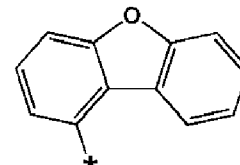
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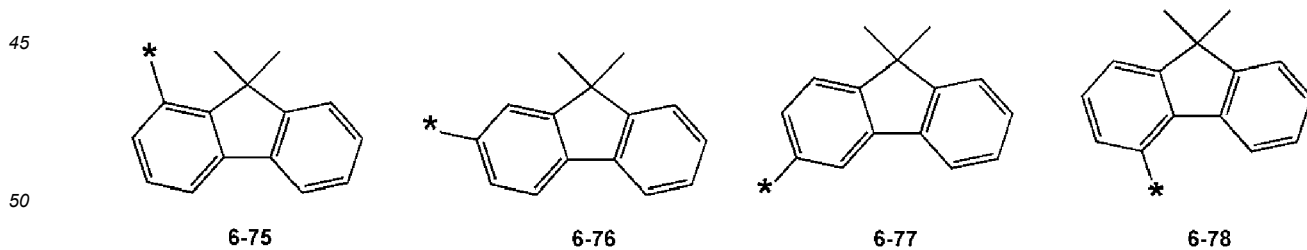
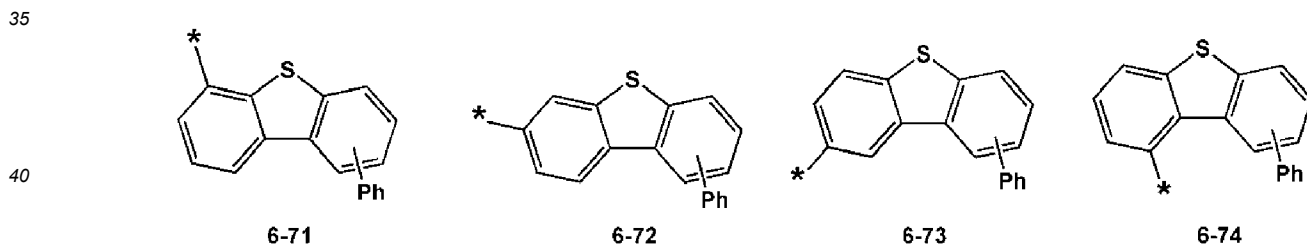
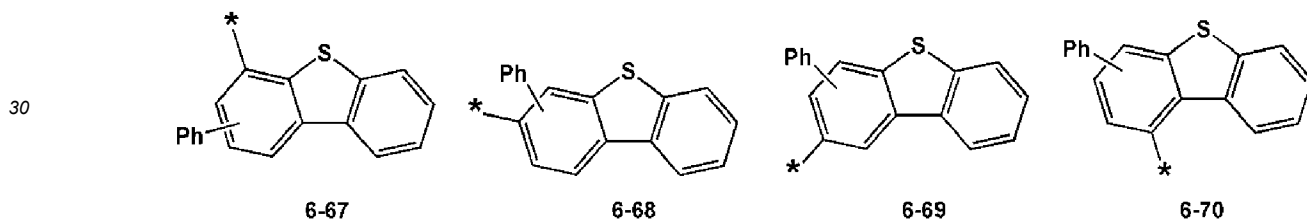
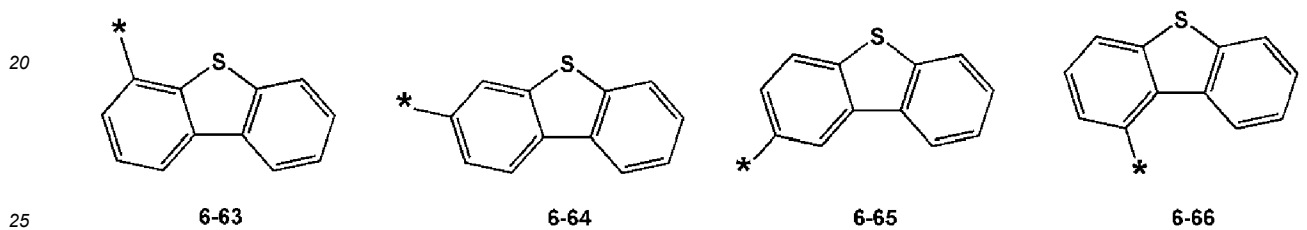
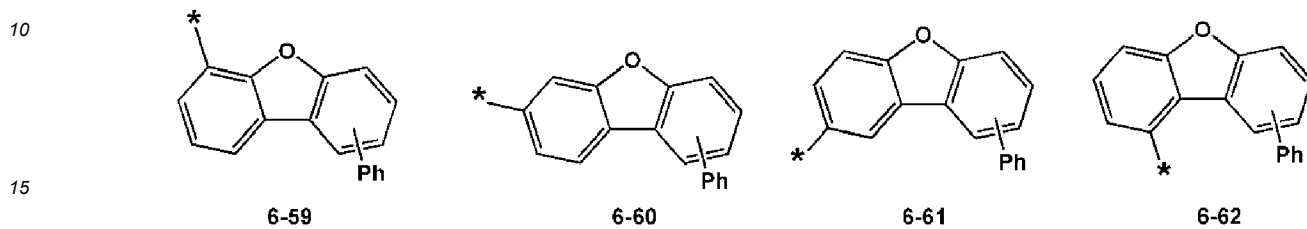
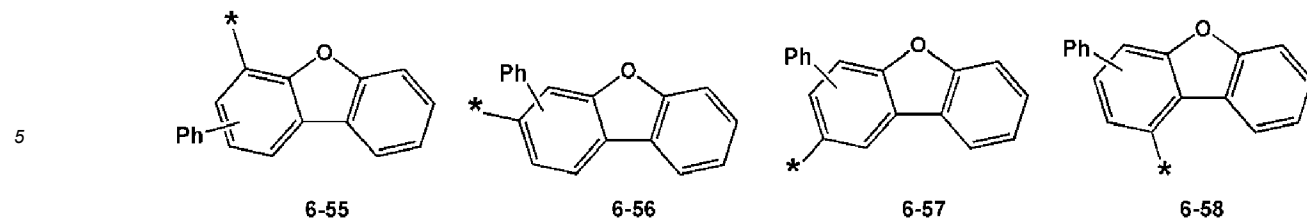
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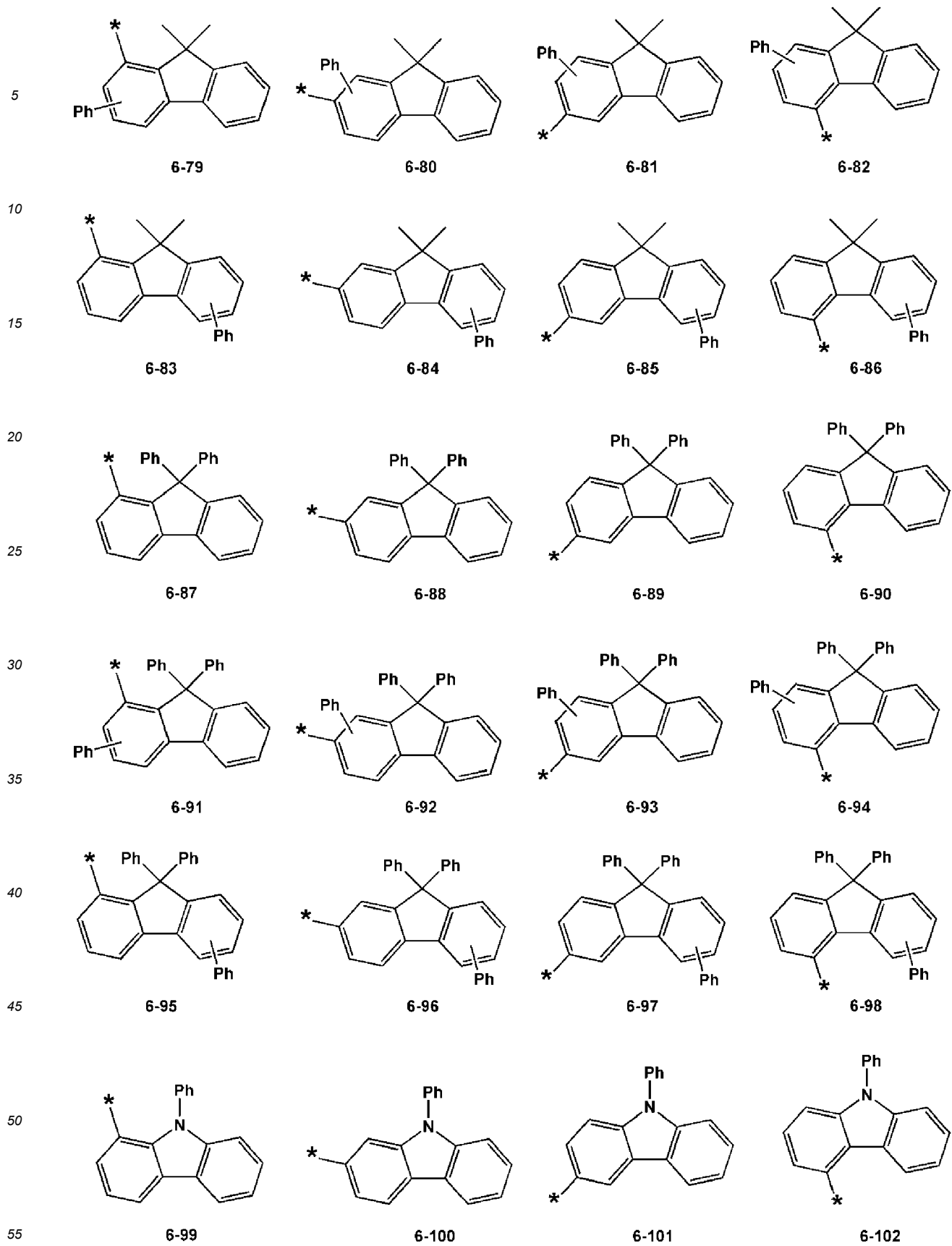
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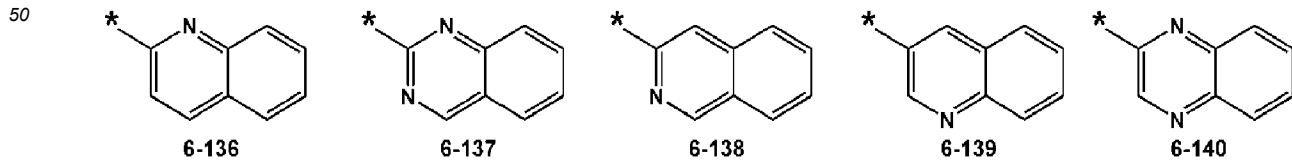
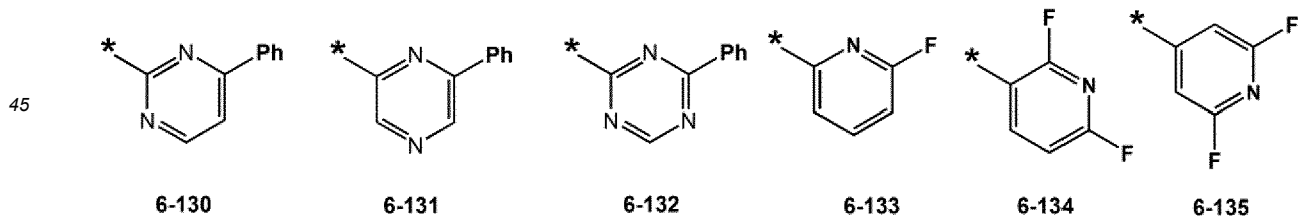
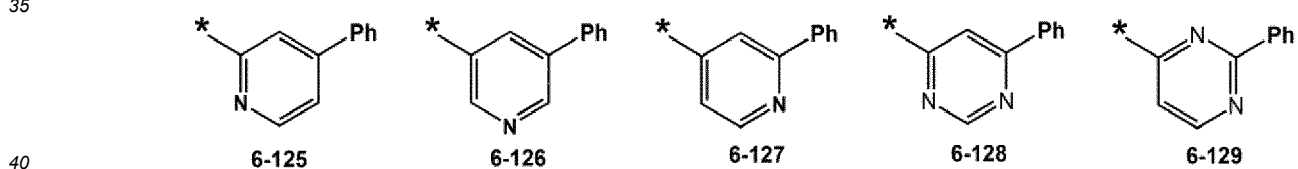
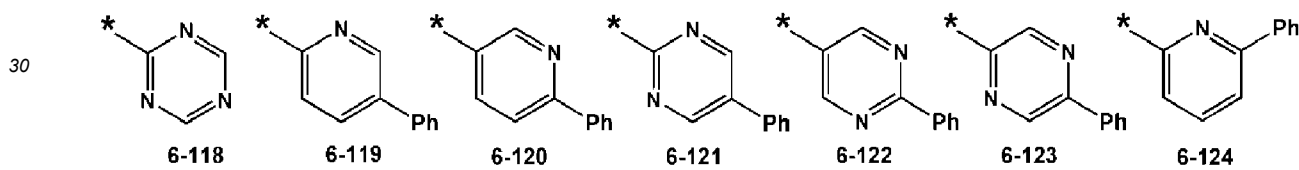
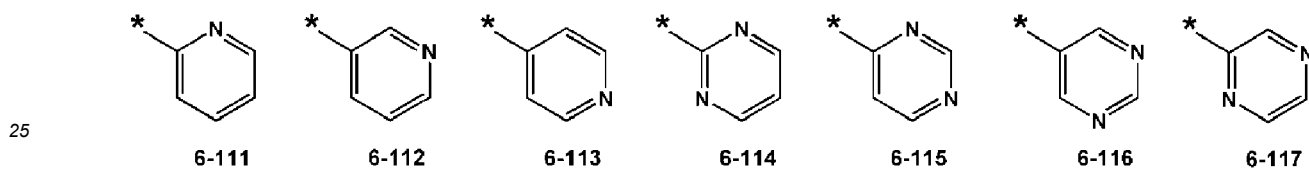
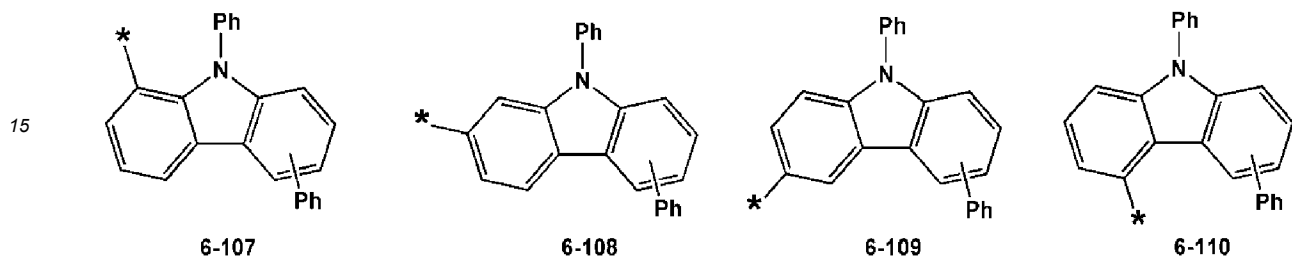
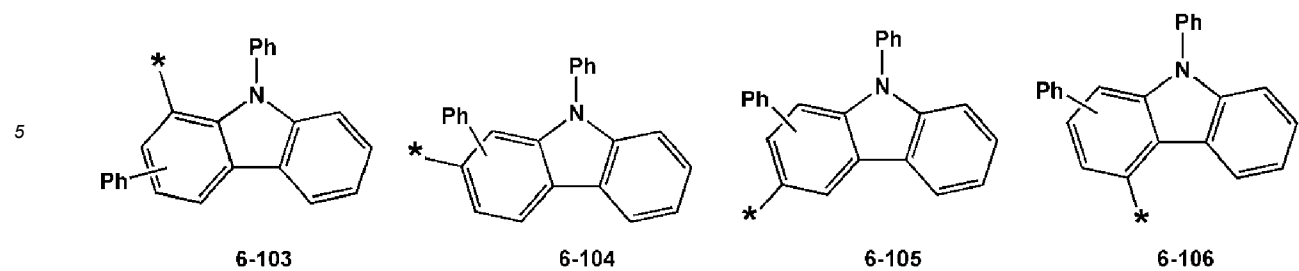


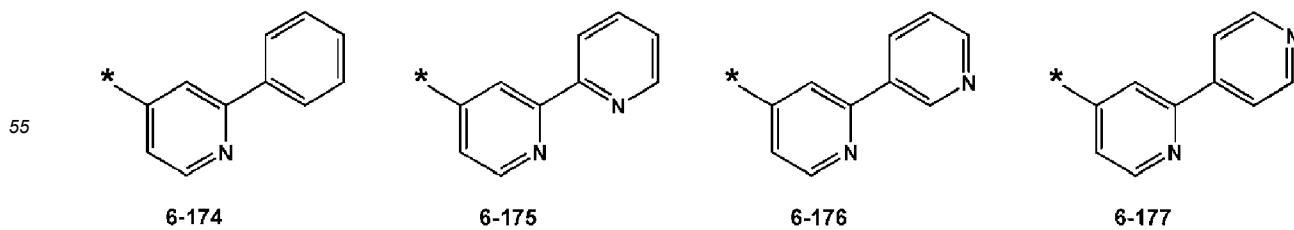
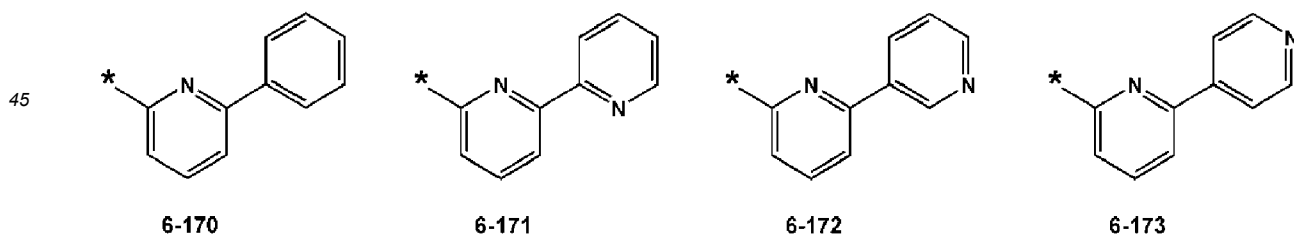
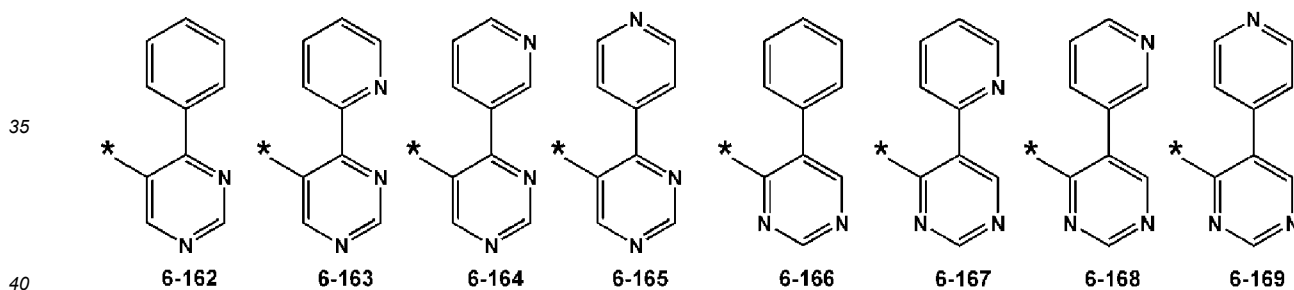
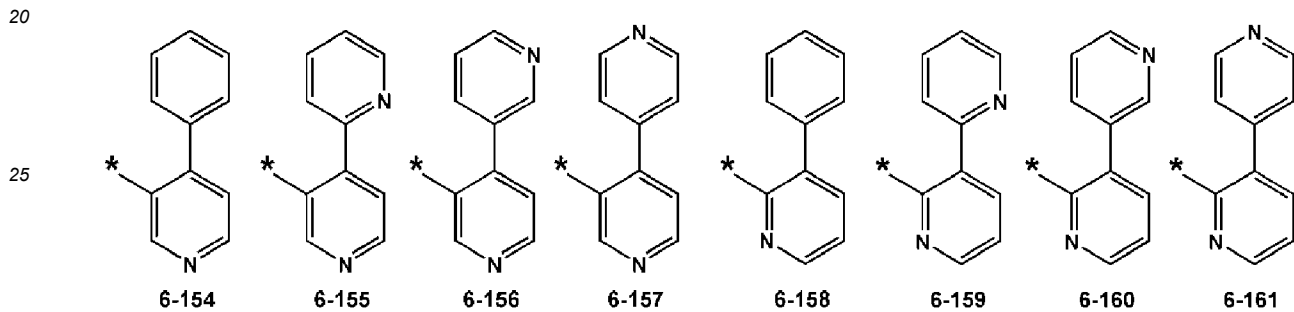
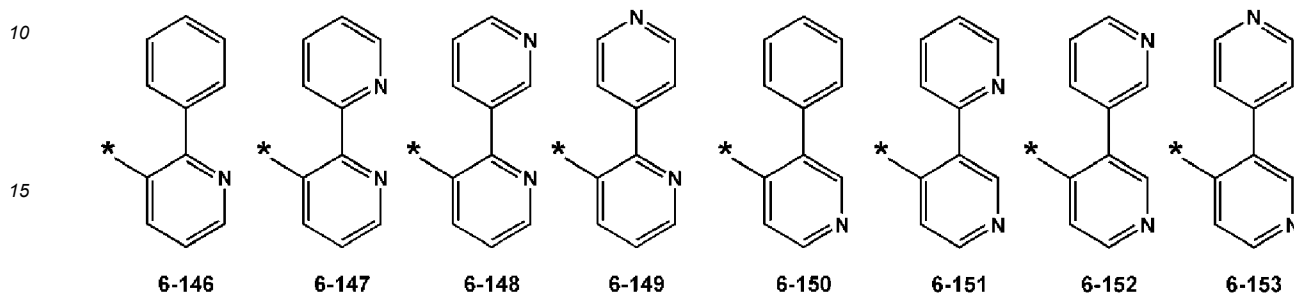
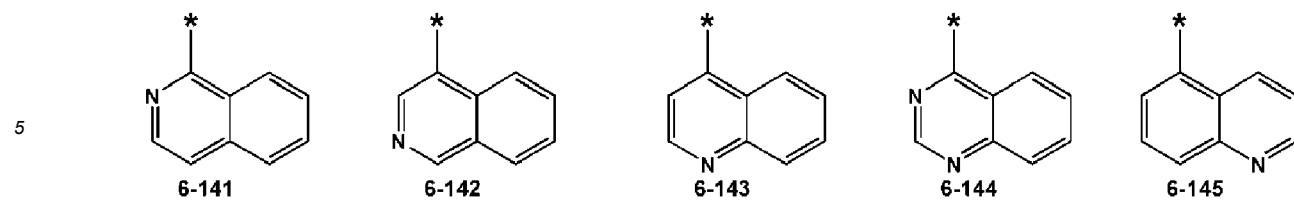
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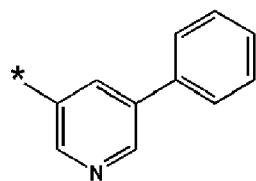
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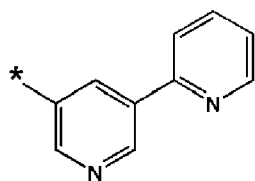




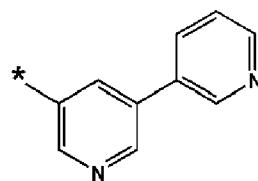
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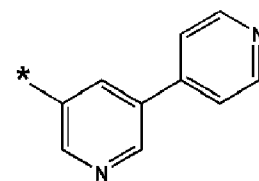
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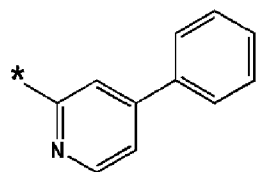


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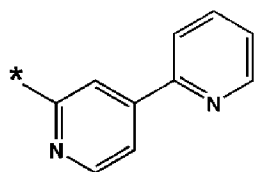


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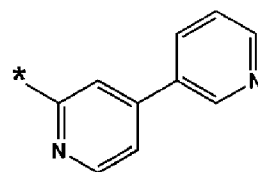
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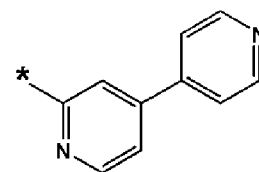
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6-183

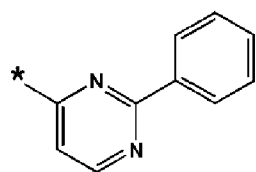


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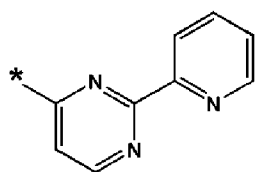


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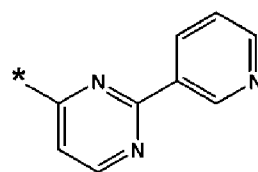
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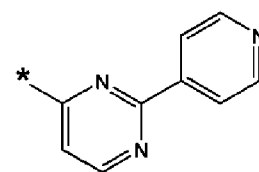
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6-187

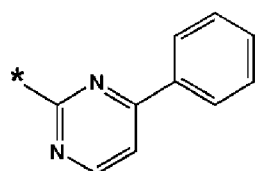


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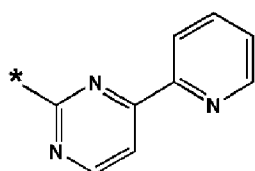


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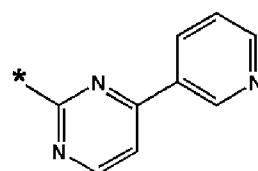
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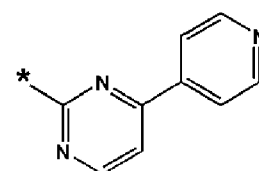
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6-191

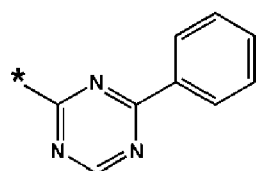


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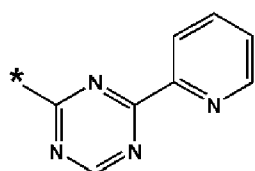


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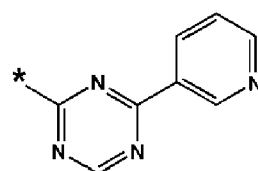
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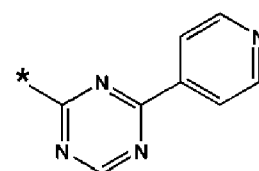
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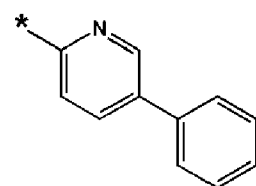


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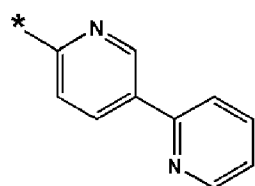


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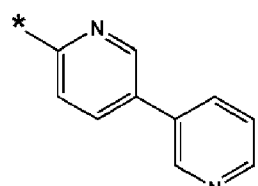
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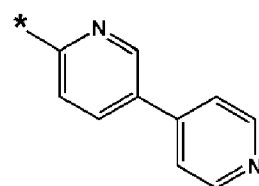
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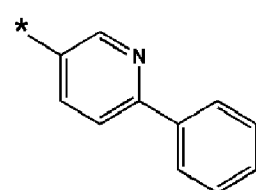


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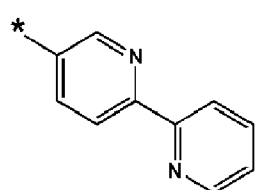


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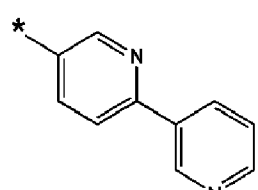
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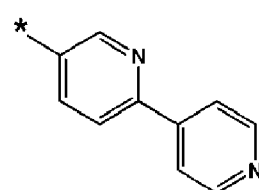
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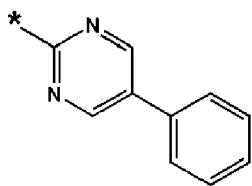
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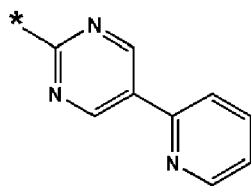
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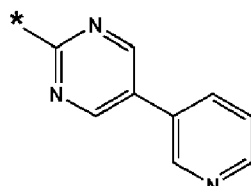
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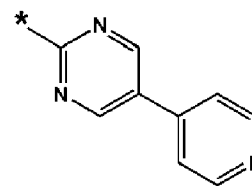
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6-207

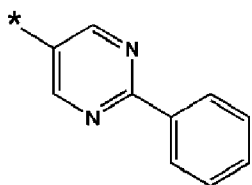


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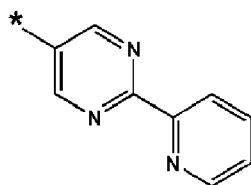


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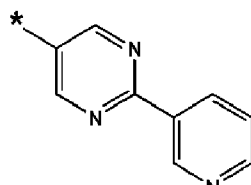
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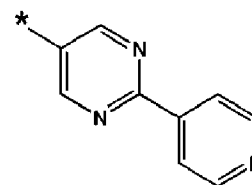
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6-211



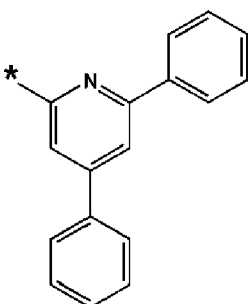
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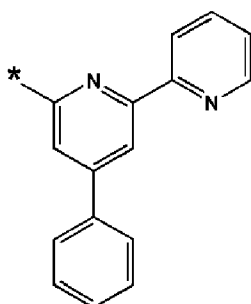
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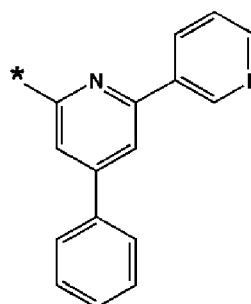
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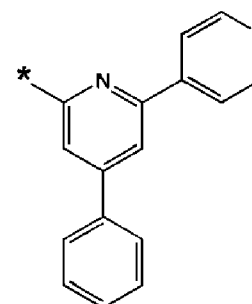
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6-215



6-216

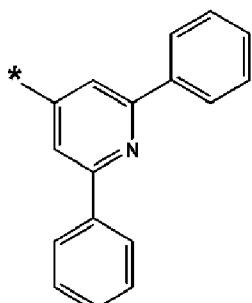


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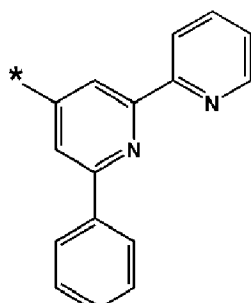
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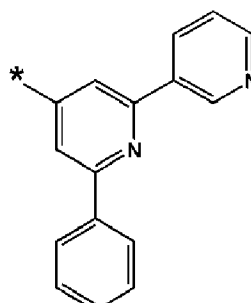
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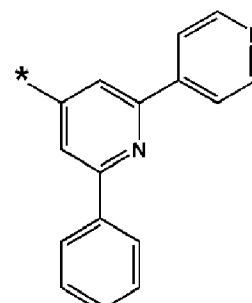
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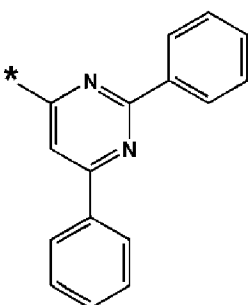
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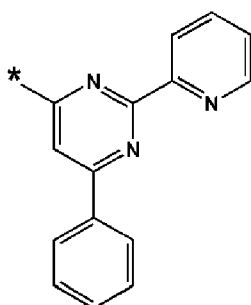
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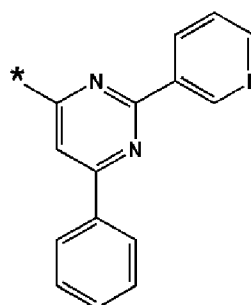
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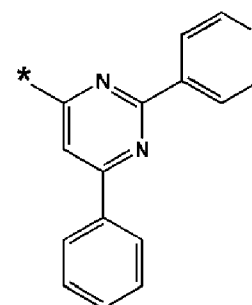
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6-223



6-224

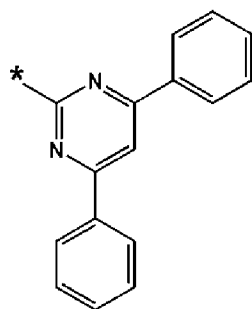


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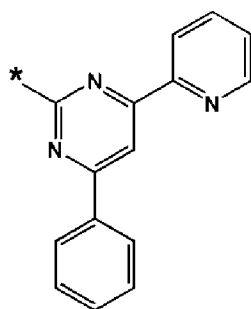
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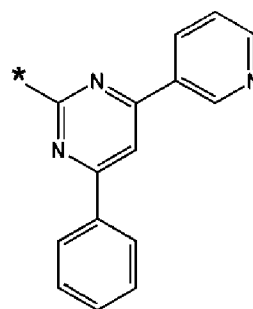
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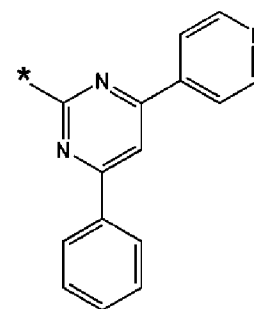
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6-227

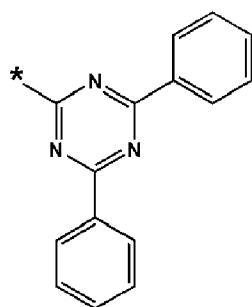


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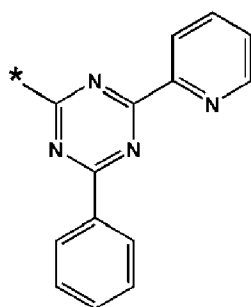


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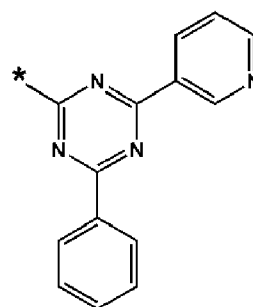
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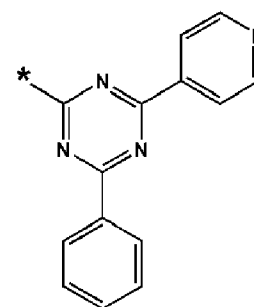
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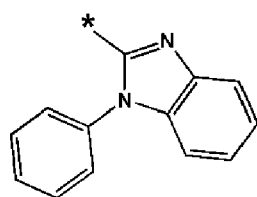
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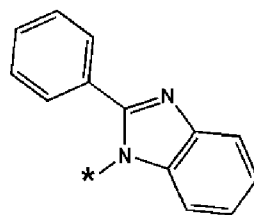
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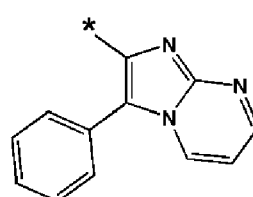
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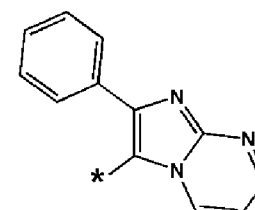
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6-235



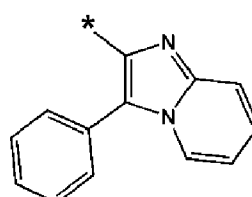
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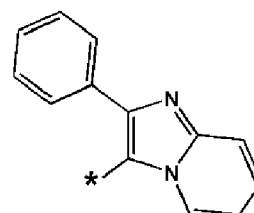
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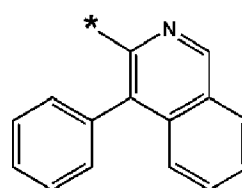
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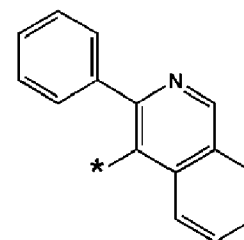
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6-239



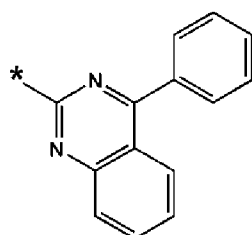
6-240



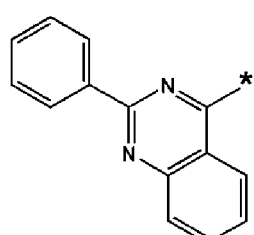
6-241

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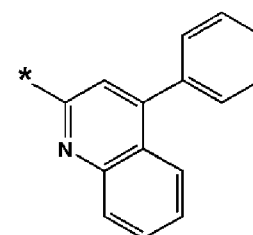
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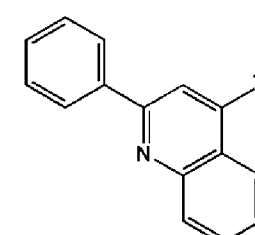
6-242



6-243



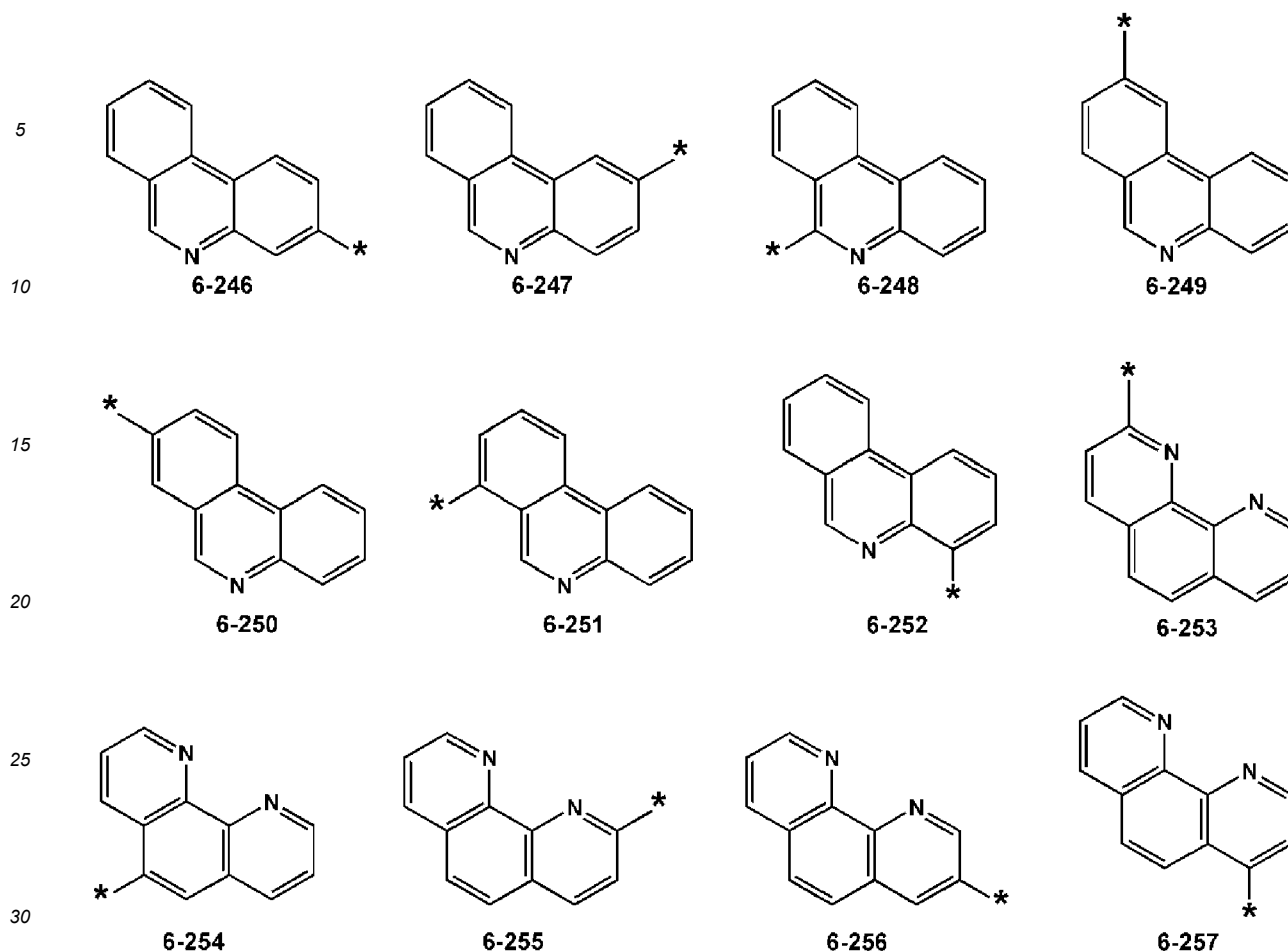
6-244



6-245

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wherein, in Formulae 6-1 to 6-257,

35 t-Bu indicates a tert-butyl group,  
 Ph indicates a phenyl group,  
 1-Naph indicates a 1-naphthyl group,  
 2-Naph indicates a 2-naphthyl group, and  
 \* indicates a binding site to a neighboring atom.

40 11. A diamine compound according to any one of claims 5 to 10, wherein:

45  $R_{15}$ ,  $R_{16}$ , and  $R_{21}$  to  $R_{23}$  are each independently selected from:  
 hydrogen, deuterium, -F, -Cl, -Br, -I, a cyano group, a  $C_1$ - $C_{20}$  alkyl group, and a  $C_1$ - $C_{20}$  alkoxy group;  
 a  $C_1$ - $C_{20}$  alkyl group and a  $C_1$ - $C_{20}$  alkoxy group, each substituted with at least one selected from deuterium,  
 -F, -Cl, -Br, -I, a cyano group, a phenyl group, and a biphenyl 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 pentalenyl group, an indenyl group, a naphthyl group, an  
 azulenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a ben-  
 50 zofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group,  
 a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaceny-  
 l group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl  
 group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a  
 pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl  
 55 group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl  
 group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quina-  
 zolinyl group, a benzoquinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a  
 phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl

group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl 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 pentalenyl group, an indenyl group, a naphthyl group, an azulenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quinazolinyl group, a benzoquinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, and an indolocarbazolyl 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 cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl 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 perylenyl group, a pentacenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a benzoisoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a benzoquinoxalinyl group, a quinazolinyl group, a benzoquinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a benzothiazolyl group, a benzoisothiazolyl group, a benzoxazolyl group, a benzoisoxazolyl group, a triazolyl group, a tetrazolyl group, a thiadiazolyl group, an oxadiazolyl group, a triazinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a benzocarbazolyl group, a naphthobenzofuranyl group, a naphthobenzothiophenyl group, a naphthobenzosilolyl group, a dibenzocarbazolyl group, a dinaphthofuranyl group, a dinaphthothiophenyl group, a dinaphthosilolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an oxazolopyridinyl group, a thiazolopyridinyl group, a benzonaphthridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, an indenopyrrolyl group, an indolopyrrolyl group, an indenocarbazolyl group, an indolocarbazolyl group, -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)(Q<sub>31</sub>), -S(=O)<sub>2</sub>(Q<sub>31</sub>), -P(=O)(Q<sub>31</sub>)(Q<sub>32</sub>), and -P(=S)(Q<sub>31</sub>)(Q<sub>32</sub>); and

-Si(Q<sub>1</sub>)(Q<sub>2</sub>)(Q<sub>3</sub>), -N(Q<sub>1</sub>)(Q<sub>2</sub>), -B(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

Q<sub>1</sub> to Q<sub>3</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

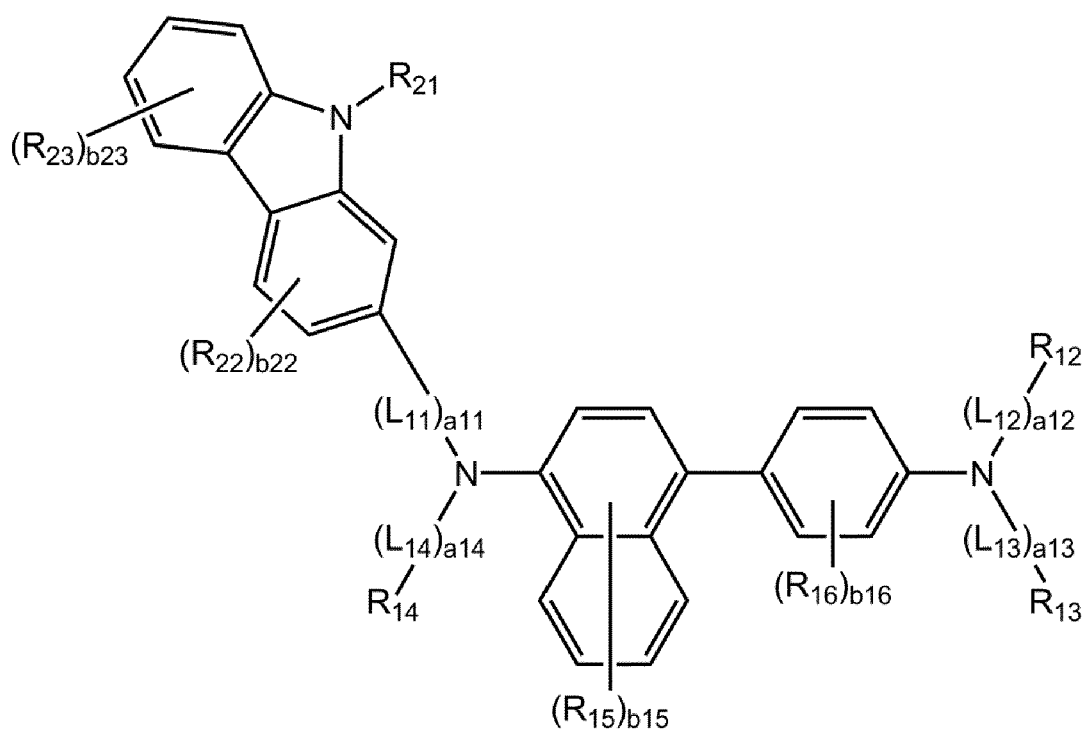
group, a C<sub>2</sub>-C<sub>60</sub> alkenyl group, a C<sub>2</sub>-C<sub>60</sub> alkynyl group, a C<sub>1</sub>-C<sub>60</sub> alkoxy group, a C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a C<sub>3</sub>-C<sub>10</sub> cycloalkenyl group, a C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a C<sub>6</sub>-C<sub>60</sub> aryl group, a C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group; preferably wherein:

R<sub>15</sub>, R<sub>16</sub>, R<sub>22</sub>, and R<sub>23</sub> are each independently 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, and a tert-butyl group; and 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, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, and a cyano group.

12. A diamine compound according to any one of claims 5 to 11, wherein:

the diamine compound represented by Formula 1 is represented by one selected from Formulae 1-1 and 1-2:



1-1

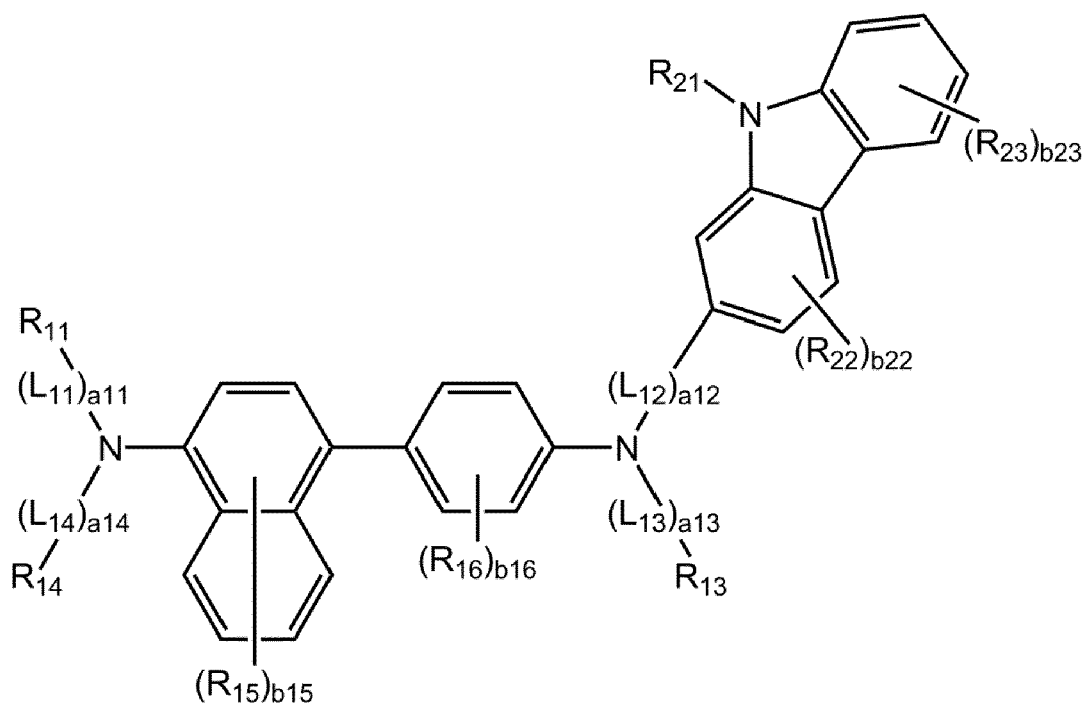
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1-2

wherein, in Formulae 1-1 and 1-2,

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$L_{11}$  to  $L_{14}$ ,  $a_{11}$  to  $a_{14}$ ,  $R_{15}$ ,  $R_{16}$ ,  $b_{15}$ , and  $b_{16}$  are respectively the same as described in Formula 1,  $R_{21}$  to  $R_{23}$ ,  $b_{22}$ , and  $b_{23}$  are respectively the same as described in Formula 2, and  $R_{11}$  to  $R_{14}$  are each independently 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  $C_1$ - $C_{60}$  heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

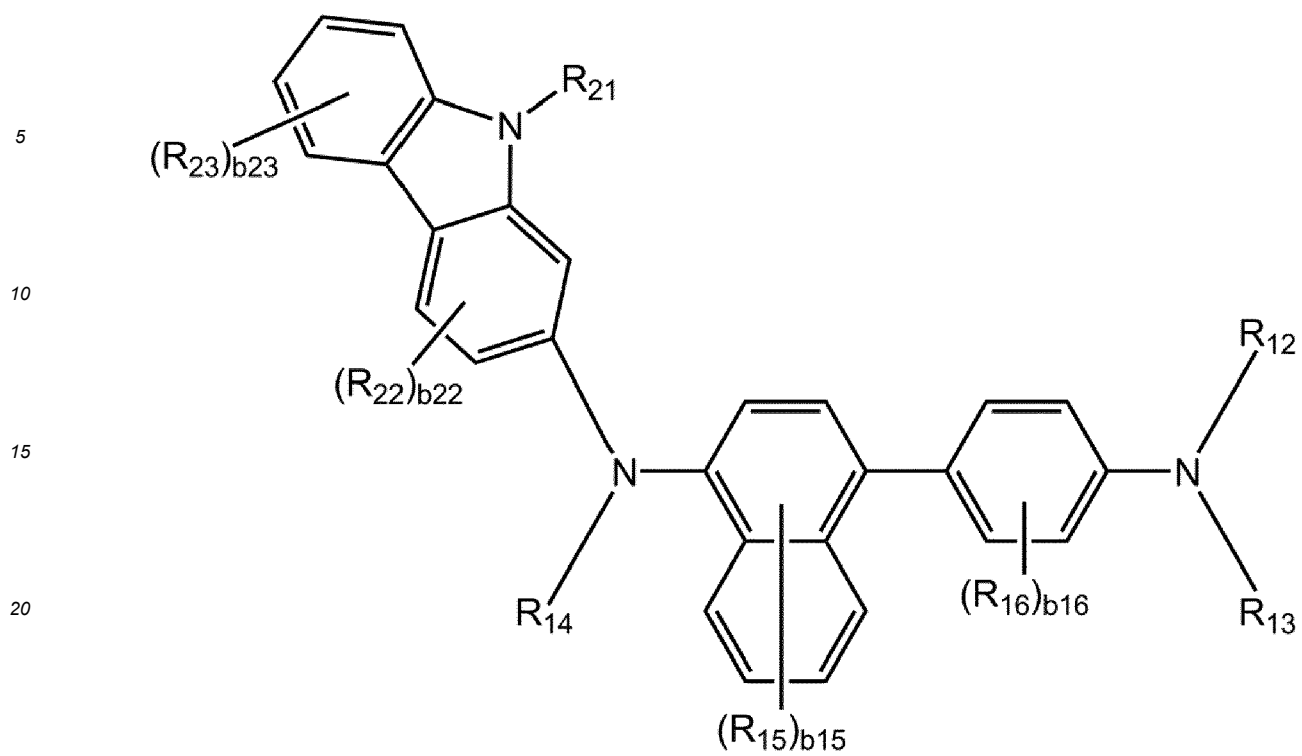
13. A diamine compound according to any one of claims 5 to 12, wherein:  
the diamine compound represented by Formula 1 is represented by one selected from Formulae 1-11 and 1-12:

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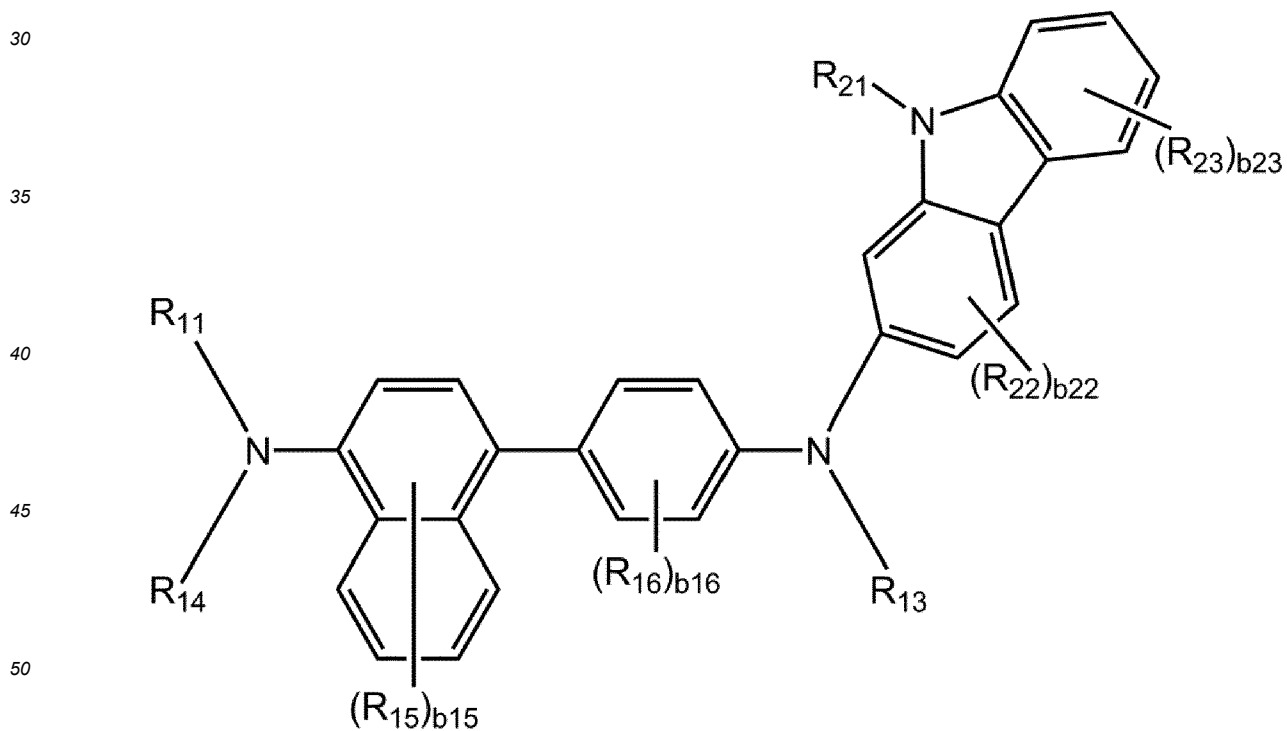
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1-11



1-12

wherein, in Formulae 1-11 and 1-12,

R<sub>15</sub>, R<sub>16</sub>, b15, and b16 are respectively the same as described in Formula 1,  
 R<sub>21</sub> to R<sub>23</sub>, b22, and b23 are respectively the same as described in Formula 2,  
 R<sub>11</sub> to R<sub>14</sub> are each independently selected from a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkyl group, a  
 substituted or unsubstituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkyl group, a substituted or unsubstituted C<sub>3</sub>-C<sub>10</sub> cycloalkenyl  
 group, a substituted or unsubstituted C<sub>1</sub>-C<sub>10</sub> heterocycloalkenyl group, a substituted or unsubstituted C<sub>6</sub>-C<sub>60</sub>  
 aryl group, a substituted or unsubstituted C<sub>1</sub>-C<sub>60</sub> heteroaryl group, a substituted or unsubstituted monovalent  
 non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed  
 heteropolycyclic group.

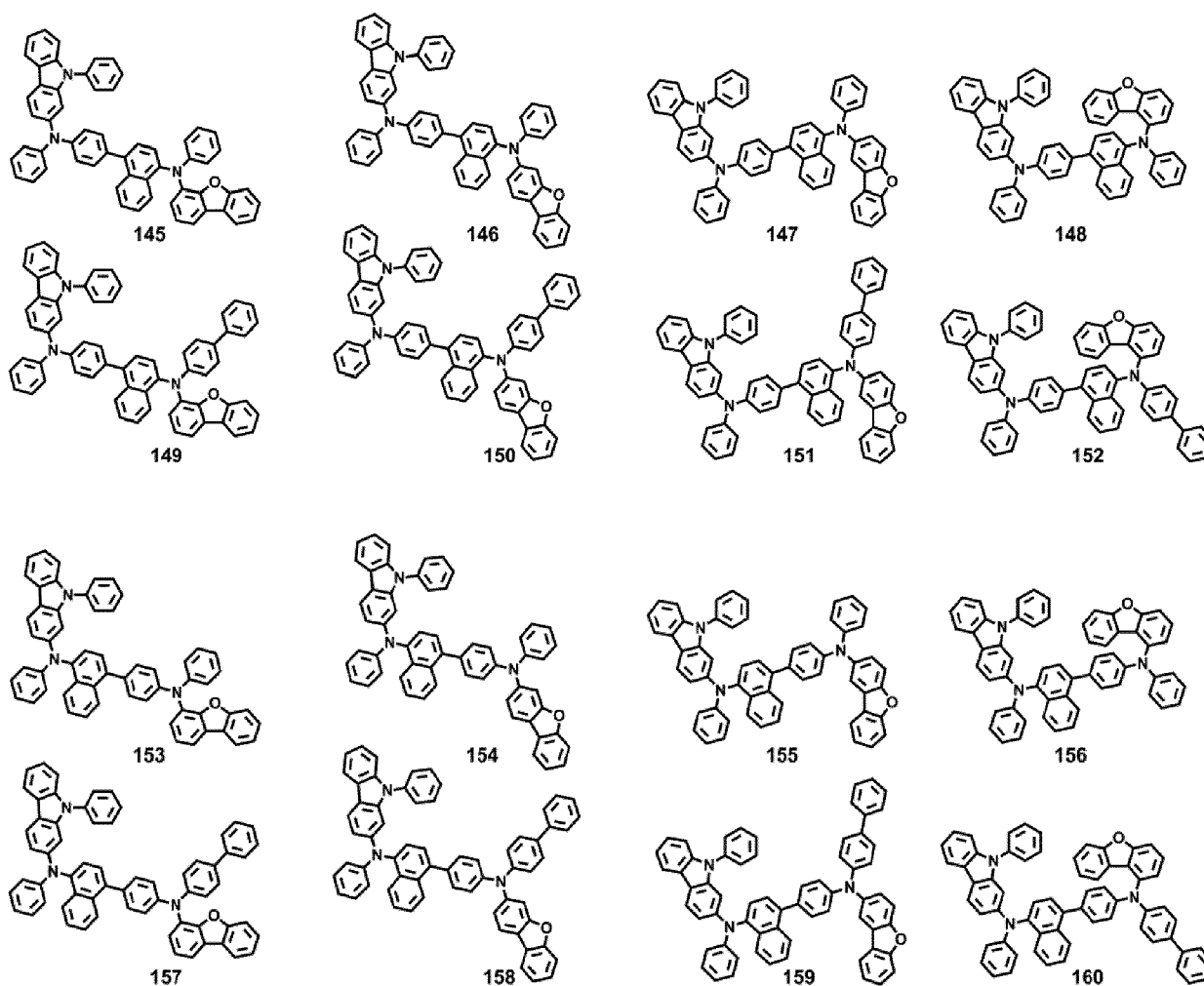
14. A diamine compound according to claim 13, wherein:

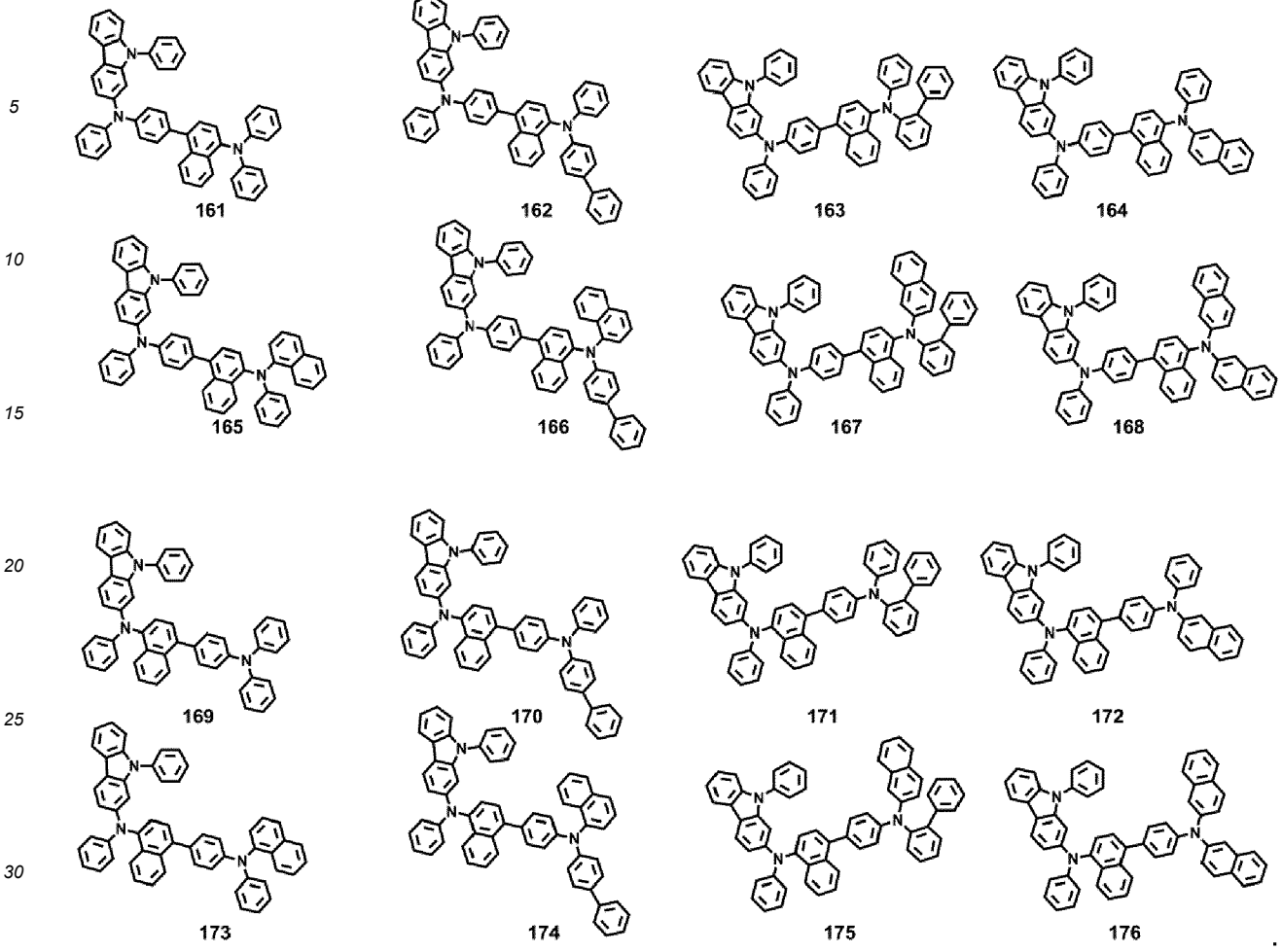
R<sub>15</sub>, R<sub>16</sub>, R<sub>22</sub>, and R<sub>23</sub> in Formulae 1-11 and 1-12 are each independently selected from:

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, and a tert-butyl group; and  
 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, each substituted with at least one selected from deuterium, -F, -Cl, -Br,  
 -I, and a cyano group.

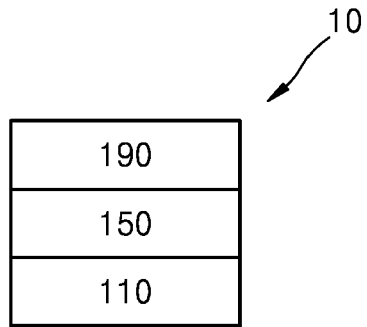
15. A diamine compound according to claim 5, wherein:

the diamine compound represented by Formula 1 is selected from Compounds 145 to 176:

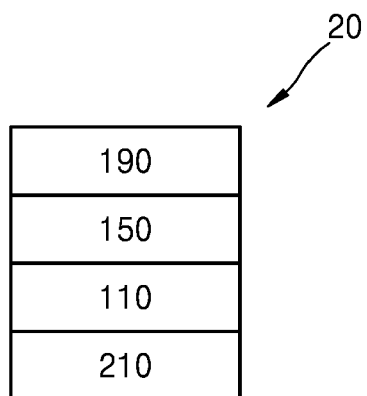




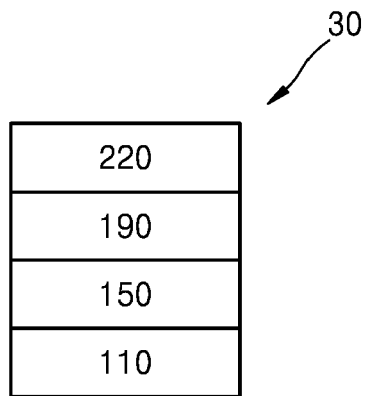
**FIG. 1**



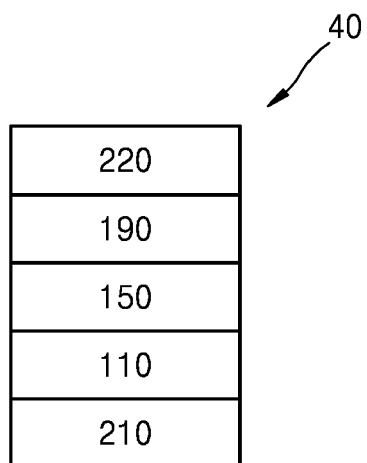
**FIG. 2**



**FIG. 3**



**FIG. 4**





EUROPEAN SEARCH REPORT

Application Number  
EP 19 17 0211

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X A	EP 2 093 271 A1 (SAMSUNG MOBILE DISPLAY CO LTD [KR]) 26 August 2009 (2009-08-26) * paragraphs [0110] - [0113]; example 1; compounds 1-54 *	1,2 3-15	
X A	KR 2010 0008947 A (DUKSAN HIGH METAL CO LTD [KR]) 27 January 2010 (2010-01-27) * paragraphs [0077] - [0080]; compounds 37-48 *	1,2 3-15	
X A	KR 2010 0006072 A (HANA FINE CHEMICALS CO LTD [KR]) 18 January 2010 (2010-01-18) * abstract; compounds 84,108,130 *	1,2 3-15	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			H01L
Place of search		Date of completion of the search	Examiner
The Hague		20 September 2019	Welter, Steve
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 03/02 (P04/C01)

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

EP 19 17 0211

5 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.

20-09-2019

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EP 2093271 A1	26-08-2009	CN 101508670 A EP 2093271 A1 JP 5015182 B2 JP 2009185030 A KR 20090086756 A TW 200940482 A US 2009200928 A1	19-08-2009 26-08-2009 29-08-2012 20-08-2009 14-08-2009 01-10-2009 13-08-2009
KR 20100008947 A	27-01-2010	NONE	
KR 20100006072 A	18-01-2010	NONE	

EPO FORM P0459

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

专利名称(译)	二胺化合物和包括该化合物的有机发光器件		
公开(公告)号	<a href="#">EP3561894A1</a>	公开(公告)日	2019-10-30
申请号	EP2019170211	申请日	2019-04-18
[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 JONGWOO KIM DONGJUN BAEK JANGYEOL JEONG EUNJAE HAN SANGHYUN KIM YOUNGKOOK HWANG SEOKHWAN		
发明人	KIM, JONGWOO KIM, DONGJUN BAEK, JANGYEOL JEONG, EUNJAE HAN, SANGHYUN KIM, YOUNGKOOK HWANG, SEOKHWAN		
IPC分类号	H01L51/54		
CPC分类号	C07D209/88 C07D405/12 H01L51/0035 H01L51/5056 H01L51/5088 H01L51/006 H01L51/0061 H01L51/0072 H01L51/0073 H01L51/0081 H01L51/506		
审查员(译)	韦尔特, 史蒂夫		
优先权	1020180049403 2018-04-27 KR		
外部链接	<a href="#">Espacenet</a>		

摘要(译)

提供一种包括萘基-苯基连接基和2-咪唑基的二胺化合物以及包括该二胺化合物的有机发光装置。该有机发光装置包括：第一电极；以及第二电极。第二电极；在第一电极和第二电极之间并包括发射层的有机层，其中有机层包括具有萘基-苯基连接基和2-咪唑基的二胺化合物。

**FIG. 1**

