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ORGANIC LIGHT-EMITTING DEVICE
INCLUDING THE SAME**(52) **U.S. Cl.**
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Publication Classification(51) **Int. Cl.**
H01L 51/00 (2006.01)
C07D 491/048 (2006.01)(57) **ABSTRACT**

Provided are a condensed cyclic compound represented by the following formulas and an organic light-emitting device including the same. The organic lightemitting device includes a first electrode; a second electrode facing the first electrode, and an organic layer between the first electrode and the second electrode, where the organic layer includes an emission layer and at least one of the condensed cyclic compound described above.

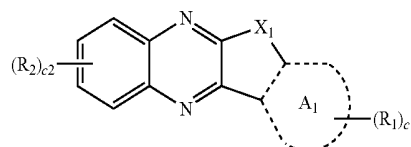
**10****190****150****110**

FIG. 1

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FIG. 2

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FIG. 3

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FIG. 4

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

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Patent Application No. 10-2017-0142566, filed on Oct. 30, 2017, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

1. Field

[0002] One or more embodiments relate to a condensed cyclic compound and an organic light-emitting device including the same.

2. Description of the Related Art

[0003] Organic light-emitting devices are self-emission devices that produce full-color images, and also have wide viewing angles, high contrast ratios, short response times, and excellent characteristics in terms of brightness, driving voltage, and response speed, compared to devices in the art.

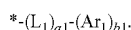
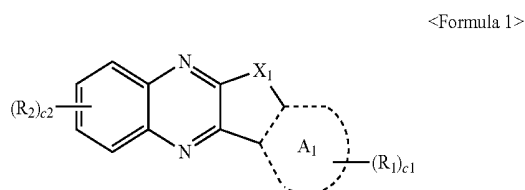
[0004] An example of such organic light-emitting devices may include a first electrode disposed on a substrate, and a hole transport region, an emission layer, an electron transport region, and a second electrode, which are sequentially disposed on the first electrode. Holes provided from the first electrode 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. These excitons transit from an excited state to a ground state, thereby generating light.

SUMMARY

[0005] Aspects of the present disclosure provide a condensed cyclic compound and an organic light-emitting device including the same.

[0006] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

[0007] An aspect provides a condensed cyclic compound represented by Formula 1 below:



<Formula 2>

[0008] In Formulae 1 and 2,

[0009] A₁ may be selected from a benzene group, a naphthalene group, a pyridine group, a pyrimidine group, a

pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a naphthyridine group, a quinoxaline group, a quinazoline group, and a cinnoline group,

[0010] X₁ may be O or S,

[0011] L₁ may be selected from a substituted or unsubstituted C₅-C₆₀ carbocyclic group, a substituted or unsubstituted C₁-C₆₀ heterocyclic group, *—P(=O)(Q₁)—*, *—P(=O)₂—*, *—P(=S)(Q₁)—*, *—P(=S)₂—*, *—S(=O)(Q₁)—*, and *—S(=O)₂—*,

[0012] a₁ may be an integer from 0 to 5, wherein, when a₁ is zero, -(L₁)_{a1}- may be a single bond, and when a₁ is two or more, two or more L₁(s) may be identical to or different from each other,

[0013] Ar₁ may be selected from a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), —C(=O)(Q₁), —N(Q₁)(Q₂), —P(=O)(Q₁)(Q₂), —P(=O)₂(Q₁), —P(=S)(Q₁)(Q₂), —P(=S)₂(Q₁), —S(=O)(Q₁)(Q₂), and —S(=O)₂(Q₁)(Q₂),

[0014] b₁ may be an integer from 1 to 10, wherein, when b₁ is two or more, two or more Ar₁(s) may be identical to or different from each other,

[0015] R₁ and R₂ may each independently be selected from a group represented by Formula 2, 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 C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₆₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), —C(=O)(Q₁), —N(Q₁)(Q₂), —P(=O)(Q₁)(Q₂), —P(=O)₂(Q₁), —P(=S)(Q₁)(Q₂), —P(=S)₂(Q₁), —S(=O)(Q₁)(Q₂), and —S(=O)₂(Q₁)(Q₂),

[0016] at least one of R₁(s) in the number of c₁ and R₂(s) in the number of c₂ may be a group represented by Formula 2,

[0017] c₁ may be an integer from 1 to 6, wherein, when c₁ is two or more, two or more R₁(s) may be identical to or different from each other,

[0018] c₂ may be an integer from 1 to 4, wherein, when c₂ is two or more, two or more R₂(s) may be identical to or different from each other,

[0019] at least one substituent of the substituted C_5 - C_{60} carbocyclic group, the substituted C_1 - C_{60} heterocyclic group, the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_1 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_1 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, the substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_1 - C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

[0020] 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, and a C_1 - C_{60} alkoxy group;

[0021] a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group, 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_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_{11})(Q_{12})(Q_{13}), —N(Q_{11})(Q_{12}), —B(Q_{11})(Q_{12}), —C(=O)(Q_{11}), —S(=O)₂(Q_{11}), and —P(=O)(Q_{11})(Q_{12});

[0022] a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0023] a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a 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_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_{21})(Q_{22})(Q_{23}), —N(Q_{21})(Q_{22}), —B(Q_{21})(Q_{22}), —C(=O)(Q_{21}), —S(=O)₂(Q_{21}), and —P(=O)(Q_{21})(Q_{22}); and

[0024] —Si(Q_{31})(Q_{32})(Q_{33}), —N(Q_{31})(Q_{32}), —B(Q_{31})(Q_{32}), —C(=O)(Q_{31}), —S(=O)₂(Q_{31}), and —P(=O)(Q_{31})(Q_{32});

[0025] Q_1 to Q_3 , Q_{11} to Q_{13} , Q_{21} to Q_{23} , and Q_{31} to Q_{33} 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_{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 monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, and

[0026] * and *' each indicate a binding site to a neighboring atom.

[0027] Another aspect provides an organic light-emitting device including: a first electrode; a second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode, wherein the organic layer includes an emission layer and at least one of the condensed cyclic compound.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

[0029] FIG. 1 is a schematic views of an organic light-emitting device according to an embodiment;

[0030] FIG. 2 is a schematic views of an organic light-emitting device according to an embodiment;

[0031] FIG. 3 is a schematic views of an organic light-emitting device according to an embodiment; and

[0032] FIG. 4 is a schematic views of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

[0033] The present disclosure will now be described more fully with reference to exemplary embodiments. The disclosure may, however, be embodied in many different forms and should not be construed as being limited to the embodiments set forth herein; rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the disclosure to those skilled in the art. Advantages, features, and how to achieve them of the present invention will become apparent by reference to the embodiment that will be described later in detail, together with the accompanying drawings. This invention may, however, be embodied in many different forms and should not be limited to the exemplary embodiments.

[0034] Hereinafter, embodiments are described in 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.

[0035] 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.

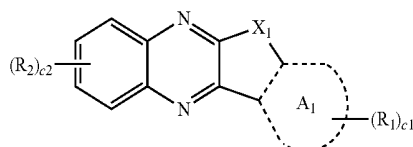
[0036] It will be further understood that the terms “comprises” and/or “comprising” may be used herein to specify the presence of stated features or components, but do not preclude the presence or addition of one or more other features or components.

[0037] It will be understood that when a layer, region, or component is referred to as being “on” or “onto” another layer, region, or component, it may be directly or indirectly formed on the other layer, region, or component. That is, for example, intervening layers, regions, or components may be present.

[0038] 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 are arbitrarily illustrated for convenience of explanation, the following embodiments of the present disclosure are not limited thereto.

[0039] A condensed cyclic compound according to an embodiment may be represented by Formula 1 below:

<Formula 1>



*-(L₁)_{a1}-(Ar₁)_{b1}

<Formula 2>

[0040] In Formula 1, A₁ may be selected from a benzene group, a naphthalene group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a naphthyridine group, a quinoxaline group, a quinazoline group, and a cinnoline group.

[0041] For example, in Formula 1, A₁ may be a benzene group or a naphthalene group, but embodiments of the present disclosure are not limited thereto.

[0042] In Formula 1, X₁ may be O or S.

[0043] For example, in Formula 1, X₁ may be O, but embodiments of the present disclosure are not limited thereto.

[0044] In Formula 2, L₁ may be selected from a substituted or unsubstituted C₅-C₆₀ carbocyclic group, a substituted or unsubstituted C₁-C₆₀ heterocyclic group, *—P(=O)(Q₁)—*, *—P(=O)₂—*, *—P(=S)(Q₁)—*, *—P(=S)₂—*, *—S(=O)(Q₁)—*, and *—S(=O)₂—*, and

[0045] Q₁ may 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 C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group.

[0046] In one embodiment, in Formula 2, L₁ may be selected from:

[0047] a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene 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 naph-

thacene group, a picene group, a perylene group, a penta-phenylene group, a hexacene group, a pyrrole group, an imidazole group, a pyrazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an iso-indole group, an indole 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 carbazole group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzoxazole group, a benzimidazole group, a furan group, a benzofuran group, a thiophene group, a benzothiophene group, a thiazole group, an isothiazole group, a benzothiazole group, an isoxazole group, an oxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a benzoxazole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, and a dibenzocarbazole group;

[0048] a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-fluorene 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 penta-phenylene group, a hexacene group, a pyrrole group, an imidazole group, a pyrazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an iso-indole group, an indole 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 carbazole group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzoxazole group, a benzimidazole group, a furan group, a benzofuran group, a thiophene group, a benzothiophene group, a thiazole group, an isothiazole group, a benzothiazole group, an isoxazole group, an oxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a benzoxazole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, and a dibenzocarbazole group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a C₆-C₂₀ aryl group, a C₁-C₂₀ heteroaryl group, and —Si(Q₃₁)(Q₃₂)(Q₃₃); and

[0049] *—P(=O)(Q₁)—*, *—P(=O)₂—*, *—P(=S)(Q₁)—*, *—P(=S)₂—*, *—S(=O)(Q₁)—*, and *—S(=O)₂—*, and

[0050] Q₁ and Q₃₁ to Q₃₃ may each independently be selected from a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a C₆-C₂₀ aryl group, a C₁-C₂₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, but embodiments of the present disclosure are not limited thereto.

[0051] For example, in Formula 2, L₁ may be selected from:

[0052] a benzene group, a naphthalene group, an anthracene group, a fluorene group, a dibenzofuran group, a carbazole group, a benzimidazole group, an imidazopyridine group, and a triazine group;

[0053] a benzene group, a naphthalene group, an anthracene group, a fluorene group, a dibenzofuran group, a carbazole group, a benzimidazole group, an imidazopyridine group, and a triazine group, each substituted with at least one selected from —F, a cyano group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, and a pyridinyl group; and

[0054] *—P(=O)(Q₁)—*¹, *—P(=O)₂—*¹, *—P(=S)(Q₁)—*¹, *—P(=S)₂—*¹, *—S(=O)(Q₁)—*¹, and *—S(=O)₂—*¹, and

[0055] Q₁ may be selected from a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a C₆-C₂₀ aryl group, a C₁-C₂₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, but embodiments of the present disclosure are not limited thereto.

[0056] In one embodiment, in Formula 2, L₁ may be selected from:

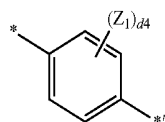
[0057] a benzene group, a naphthalene group, an anthracene group, a carbazole group, and a triazine group;

[0058] a benzene group, a naphthalene group, an anthracene group, a carbazole group, and a triazine group, each substituted with at least one selected from —F, a cyano group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, and a pyridinyl group; and

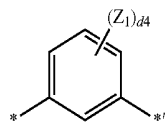
[0059] *—P(=O)(Q₁)—*¹, *—P(=O)₂—*¹, *—P(=S)(Q₁)—*¹, *—P(=S)₂—*¹, *—S(=O)(Q₁)—*¹, and *—S(=O)₂—*¹, and

[0060] Q₁ may be selected from a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a C₆-C₂₀ aryl group, a C₁-C₂₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, but embodiments of the present disclosure are not limited thereto.

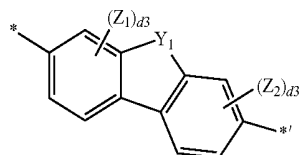
[0061] In one or more embodiments, in Formula 2, L₁ may be selected from groups represented by Formulae 3-1 to 3-48, *—P(=O)(Q₁)—*¹, *—P(=O)₂—*¹, *—P(=S)(Q₁)—*¹, *—P(=S)₂—*¹, *—S(=O)(Q₁)—*¹, and *—S(=O)₂—*¹, but embodiments of the present disclosure are not limited thereto:



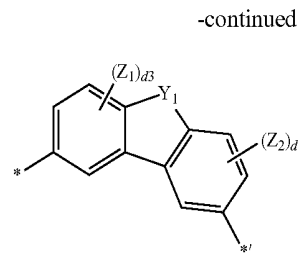
3-1



3-2

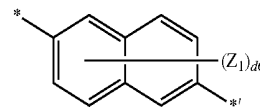


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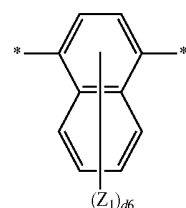


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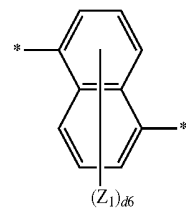
3-4



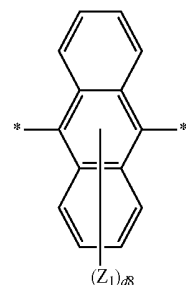
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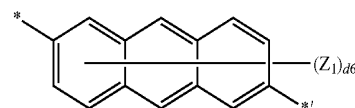
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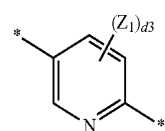
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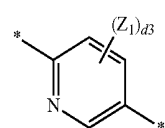
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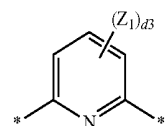
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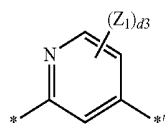


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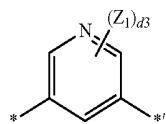


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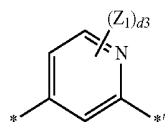
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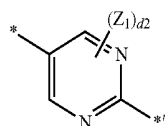
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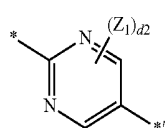
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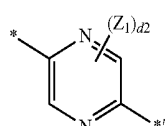
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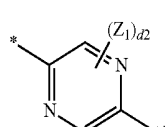
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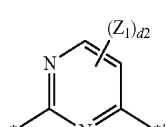
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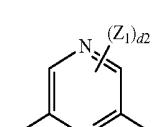
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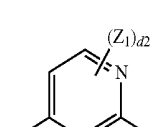
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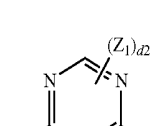
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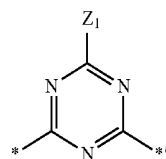


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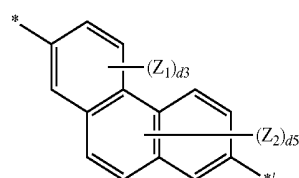


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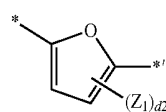
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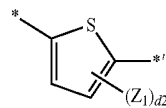
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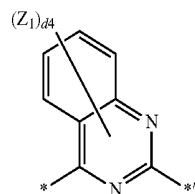
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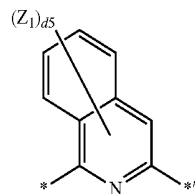
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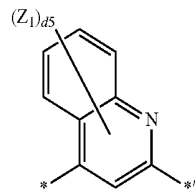
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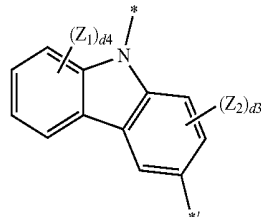
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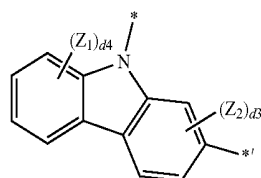
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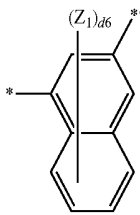


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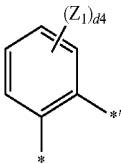


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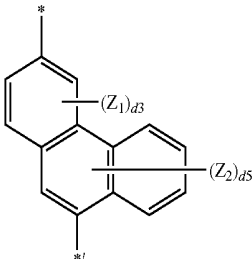
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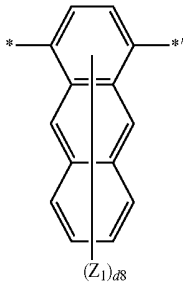
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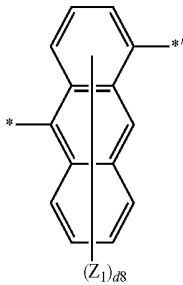
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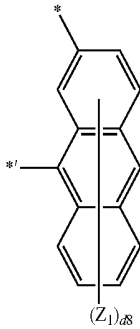
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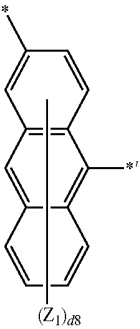


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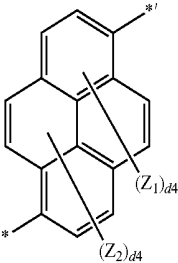


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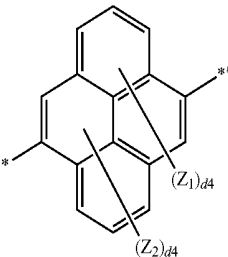
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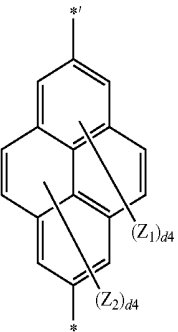
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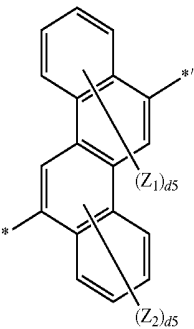
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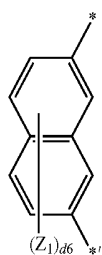


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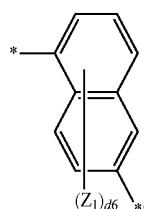


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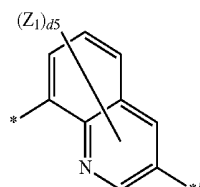
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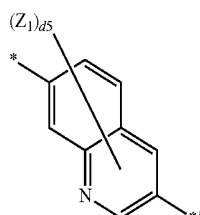
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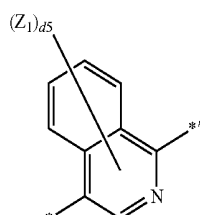
3-45



3-46



3-47



3-48

[0062] In Formulae 3-1 to 3-48,

[0063] Y_1 may be O, S, $C(Z_3)(Z_4)$, $N(Z_5)$, or $Si(Z_6)(Z_7)$,

[0064] Z_1 to Z_7 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 naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, and $-Si(Q_{31})(Q_{32})(Q_{33})$,

[0065] d_2 may be an integer from 0 to 2, wherein, when d_2 is two or more, two or more $Z_1(s)$ may be identical to or different from each other,

[0066] d_3 may be an integer from 0 to 3, wherein, when d_3 is two or more, two or more $Z_1(s)$ may be identical to or different from each other, and two or more $Z_2(s)$ may be identical to or different from each other,

[0067] d_4 may be an integer from 0 to 4, wherein, when d_4 is two or more, two or more $Z_1(s)$ may be identical to or different from each other, and two or more $Z_2(s)$ may be identical to or different from each other,

[0068] d_5 may be an integer from 0 to 5, wherein, when d_5 is two or more, two or more $Z_1(s)$ may be identical to or different from each other, and two or more $Z_2(s)$ may be identical to or different from each other,

[0069] d_6 may be an integer from 0 to 6, wherein, when d_6 is two or more, two or more $Z_1(s)$ may be identical to or different from each other,

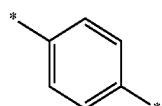
[0070] d_8 may be an integer from 0 to 8, wherein, when d_8 is two or more, two or more $Z_1(s)$ may be identical to or different from each other,

[0071] Q_1 and Q_{31} to Q_{33} may each independently be selected from a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, and

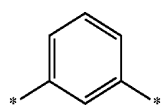
[0072] * and *1 each indicate a binding site to a neighboring atom.

[0073] For example, L_1 in Formula 2 may be selected from groups represented by Formulae 3-1 to 3-6, 3-8, 3-24, 3-31, 3-38, and 3-39, but embodiments of the present disclosure are not limited thereto.

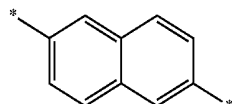
[0074] In one or more embodiments, L_1 in Formula 2 may be selected from groups represented by Formulae 4-1 to 4-20, but embodiments of the present disclosure are not limited thereto:



4-1

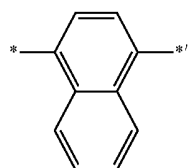


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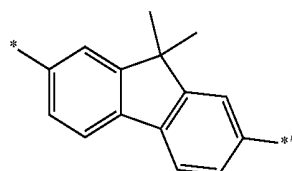


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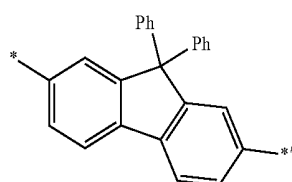
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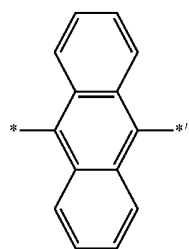
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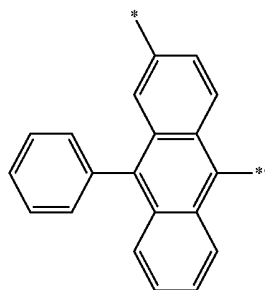
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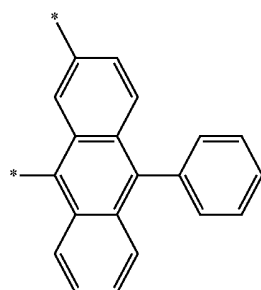
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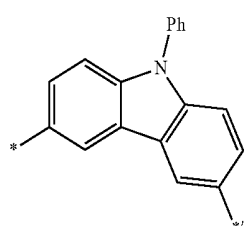
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4-8

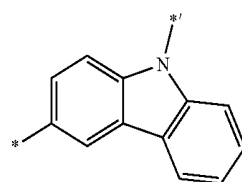


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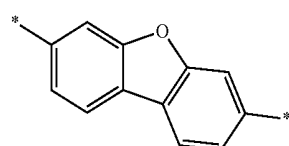


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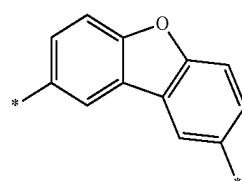
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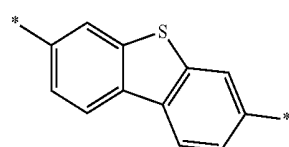
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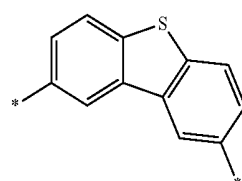
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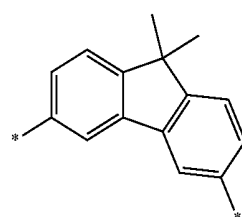
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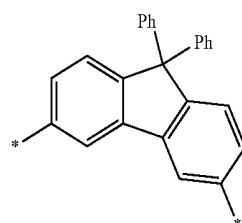
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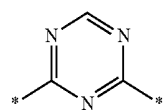
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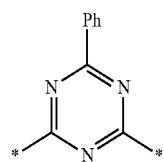
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4-17



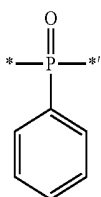
4-18



4-19

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4-20



[0075] In Formulae 4-1 to 4-20,

[0076] Ph indicates a phenyl group, and

[0077] * and *' each indicate a binding site to a neighboring atom.

[0078] a1 in Formula 2 may be an integer from 0 to 5. a1 indicates the number of L₁(s), wherein, when a1 is two or more, two or more L₁(s) may be identical to or different from each other. When a1 is zero, -(L₁)_{a1}- may be a single bond.

[0079] In one embodiment, a1 in Formula 2 may be 0, 1, 2, or 3, but embodiments of the present disclosure are not limited thereto.

[0080] In Formula 2, Ar₁ may be selected from a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), —C(=O)(Q₁), —N(Q₁)(Q₂), —P(=O)(Q₁)(Q₂), —P(=O)₂(Q₁), —P(=S)(Q₁)(Q₂), —P(=S)₂(Q₁), —S(=O)(Q₁)(Q₂), and —S(=O)₂(Q₁)(Q₂), and

[0081] Q₁ to Q₃ 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 C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group.

[0082] In one embodiment, in Formula 2, Ar₁ may be selected from:

[0083] a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene 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 pentaphenylene group, a hexacene group, a pyrrole group, an imidazole group, a pyrazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an iso-indole group, an indole group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine

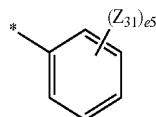
group, a quinoxaline group, a quinazoline group, a cinnoline group, a carbazole group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzoxazole group, a benzimidazole group, a furan group, a benzofuran group, a thiophene group, a benzothiophene group, a thiazole group, an isothiazole group, a benzothiazole group, an isoxazole group, an oxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a benzoxazole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, and a dibenzocarbazole group;

[0084] a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-fluorene 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 pentaphenylene group, a hexacene group, a pyrrole group, an imidazole group, a pyrazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an iso-indole group, an indole 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 carbazole group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzoxazole group, a benzimidazole group, a furan group, a benzofuran group, a thiophene group, a benzothiophene group, a thiazole group, an isothiazole group, a benzothiazole group, an isoxazole group, an oxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a benzoxazole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, and a dibenzocarbazole group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a C₆-C₂₀ aryl group, a C₁-C₂₀ heteroaryl group, —Si(Q₃₁)(Q₃₂)(Q₃₃), and P(=O)(Q₃₁)(Q₃₂); and

[0085] —Si(Q₁)(Q₂)(Q₃), —P(=O)(Q₁)(Q₂), —P(=O)₂(Q₁), —P(=S)(Q₁)(Q₂), —P(=S)₂(Q₁), —S(=O)(Q₁)(Q₂), and —S(=O)₂(Q₁), and

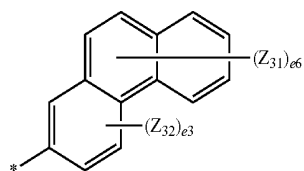
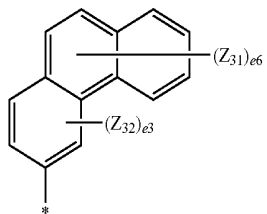
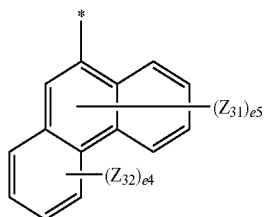
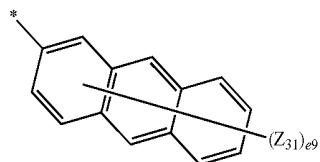
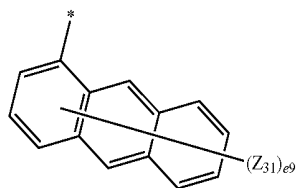
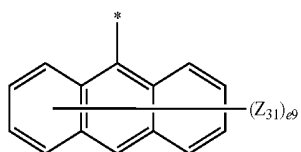
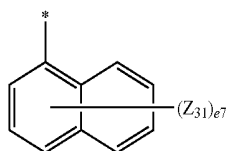
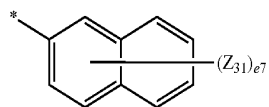
[0086] Q₁ to Q₃ and Q₃₁ to Q₃₃ may each independently be selected from a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a C₆-C₂₀ aryl group, a C₁-C₂₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, but embodiments of the present disclosure are not limited thereto.

[0087] In one or more embodiments, in Formula 2, Ar₁ may be selected from groups represented by Formulae 5-1 to 5-36, —Si(Q₁)(Q₂)(Q₃), —P(=O)(Q₁)(Q₂), —P(=O)₂(Q₁), —P(=S)(Q₁)(Q₂), —P(=S)₂(Q₁), —S(=O)(Q₁)(Q₂), and —S(=O)₂(Q₁), but embodiments of the present disclosure are not limited thereto:



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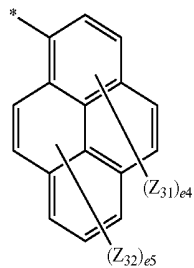
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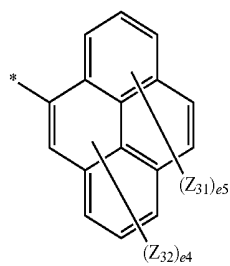
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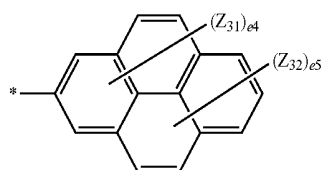
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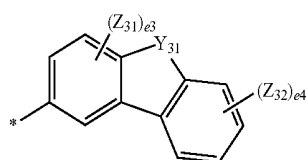
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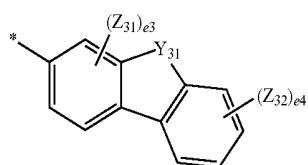
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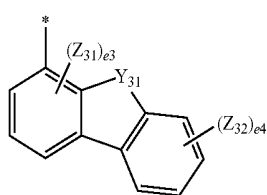
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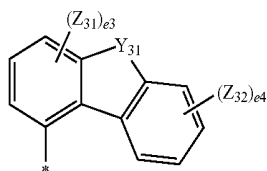
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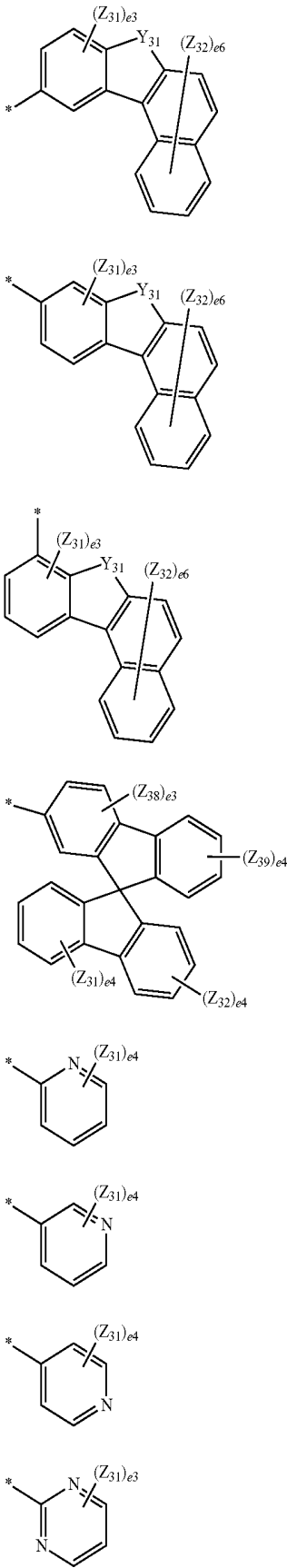


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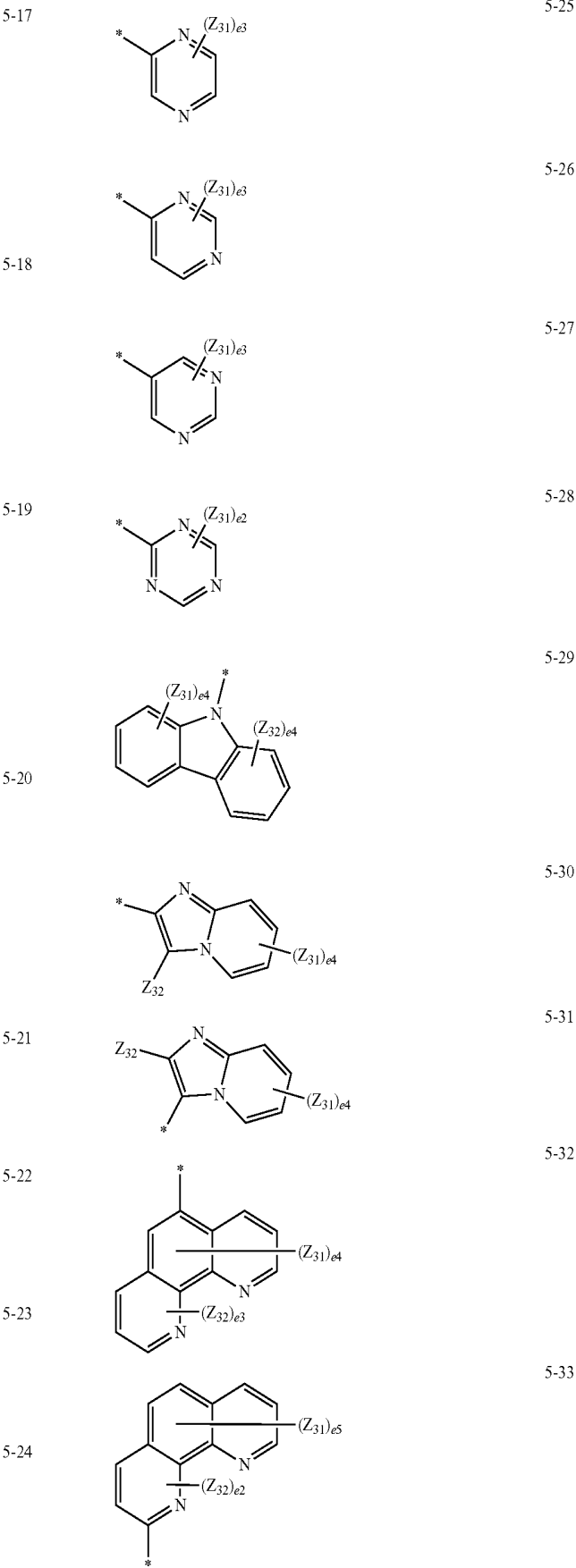


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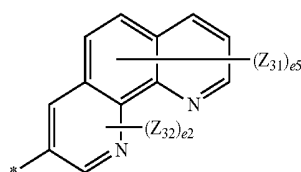
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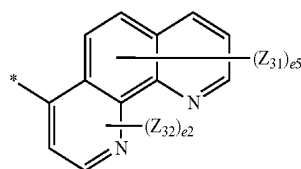
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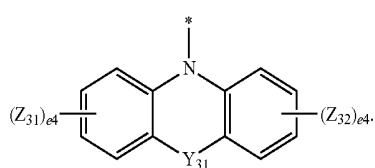
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5-34



5-35



5-36

[0088] In Formulae 5-1 to 5-36,**[0089]** Y_{31} may be O, S, $C(Z_{33})(Z_{34})$, $N(Z_{35})$, or $Si(Z_{36})(Z_{37})$,

[0090] Z_{31} to Z_{39} 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 naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a spiro-fluorene-benzofluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazoyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, — $Si(Q_{31})(Q_{32})(Q_{33})$, and $P(=O)(Q_{31})(Q_{32})$,

[0091] Q_1 to Q_3 and Q_{31} to Q_{33} may each independently be selected from a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazoyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group,

[0092] e_2 may be an integer from 0 to 2, wherein, when e_2 is two or more, two or more $Z_{31}(s)$ may be identical to or different from each other, and two or more $Z_{32}(s)$ may be identical to or different from each other,

[0093] e_3 may be an integer from 0 to 3, wherein, when e_3 is two or more, two or more $Z_{31}(s)$ may be identical to or

different from each other, two or more $Z_{32}(s)$ may be identical to or different from each other, and two or more $Z_{38}(s)$ may be identical to or different from each other,

[0094] e_4 may be an integer from 0 to 4, wherein, when e_4 is two or more, two or more $Z_{31}(s)$ may be identical to or different from each other, two or more $Z_{32}(s)$ may be identical to or different from each other, and two or more $Z_{39}(s)$ may be identical to or different from each other,

[0095] e_5 may be an integer from 0 to 5, wherein, when e_5 is two or more, two or more $Z_{31}(s)$ may be identical to or different from each other, and two or more $Z_{32}(s)$ may be identical to or different from each other,

[0096] e_6 may be an integer from 0 to 6, wherein, when e_6 is two or more, two or more $Z_{31}(s)$ may be identical to or different from each other, and two or more $Z_{32}(s)$ may be identical to or different from each other,

[0097] e_7 may be an integer from 0 to 7, wherein, when e_7 is two or more, two or more $Z_{31}(s)$ may be identical to or different from each other,

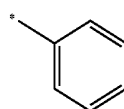
[0098] e_9 may be an integer from 0 to 9, wherein, when e_9 is two or more, two or more $Z_{31}(s)$ may be identical to or different from each other, and

[0099] * indicates a binding site to a neighboring atom.

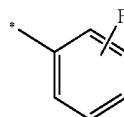
[0100] For example, $Y_{31}(s)$ in Formulae 5-13 to 5-16 may be O, $C(Z_{33})(Z_{34})$, or $N(Z_{35})$, but embodiments of the present disclosure are not limited thereto.

[0101] In one embodiment, Y_{31} in Formula 5-36 may be O, $C(Z_{33})(Z_{34})$, or $Si(Z_{36})(Z_{37})$, but embodiments of the present disclosure are not limited thereto.

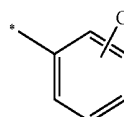
[0102] In one or more embodiments, Ar_1 in Formula 2 may be selected from groups represented by Formulae 6-1 to 6-93, — $Si(Q_1)(Q_2)(Q_3)$, and — $P(=O)(Q_1)(Q_2)$, but embodiments of the present disclosure are not limited thereto:



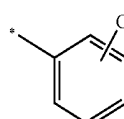
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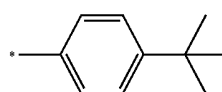
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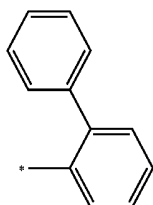
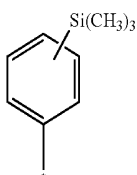
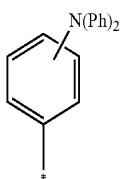
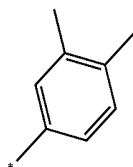
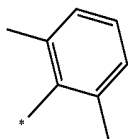
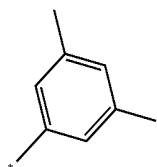
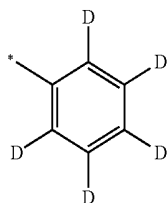
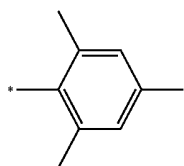


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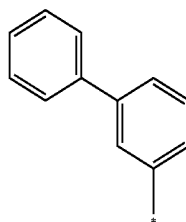
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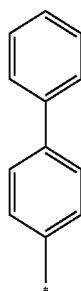
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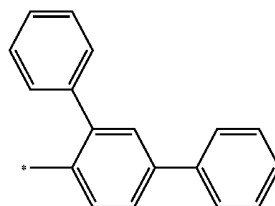
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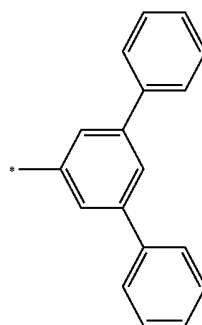
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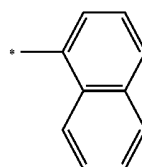
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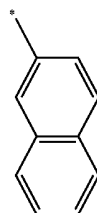
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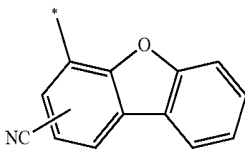
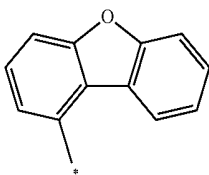
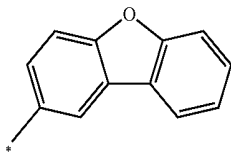
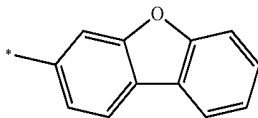
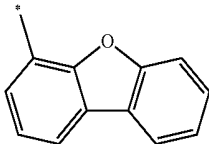
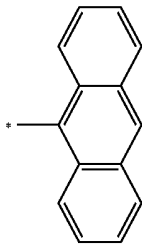
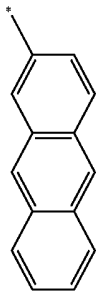
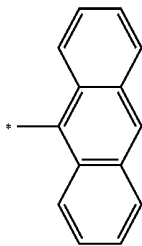
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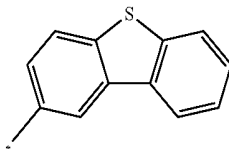
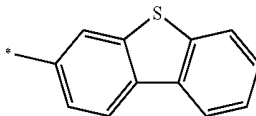
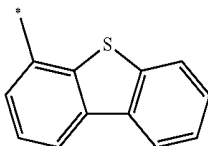
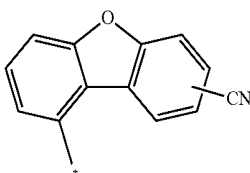
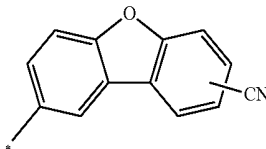
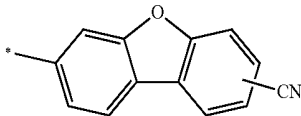
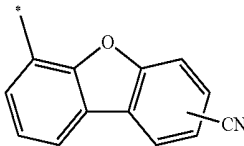
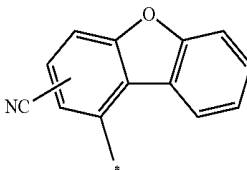
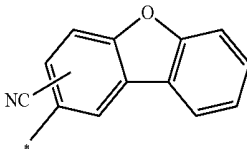
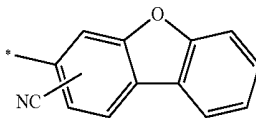
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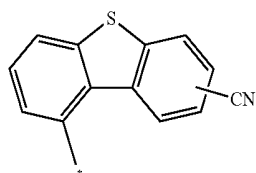
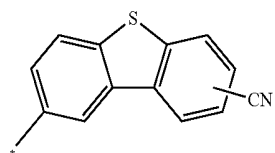
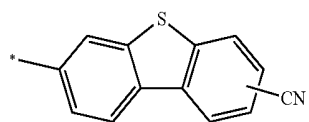
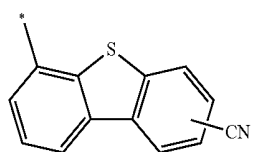
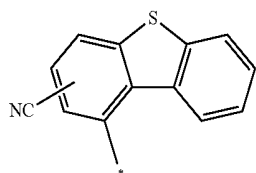
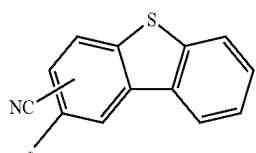
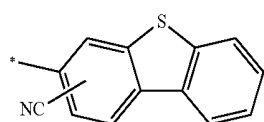
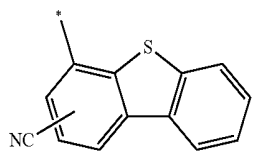
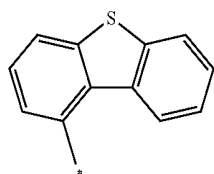
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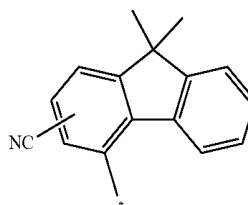
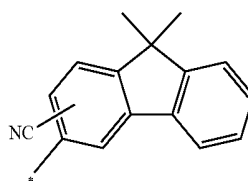
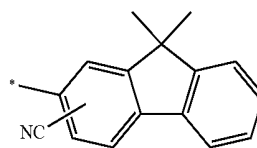
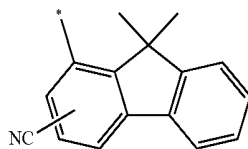
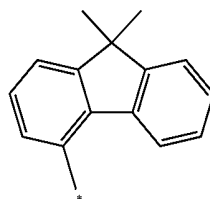
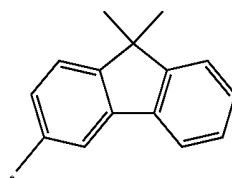
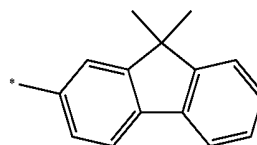
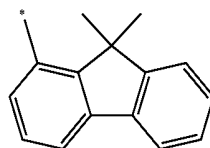
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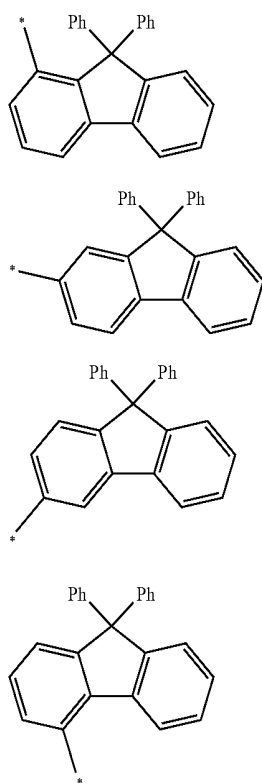
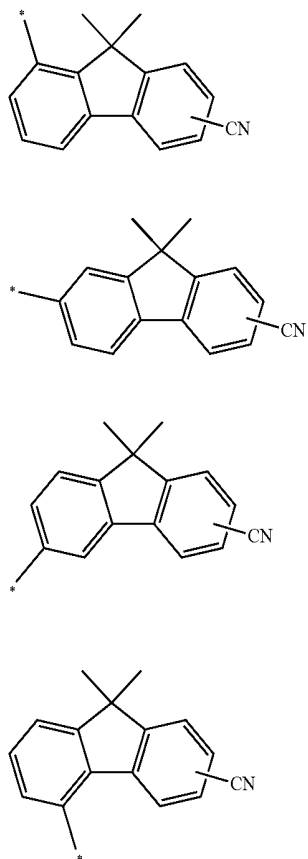
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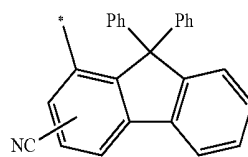


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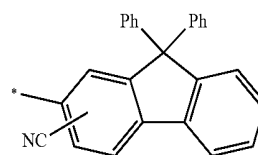
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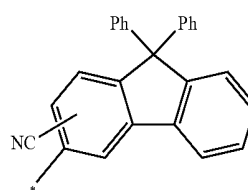
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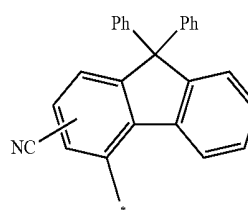
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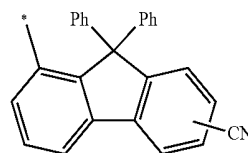
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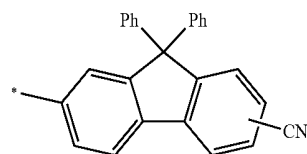
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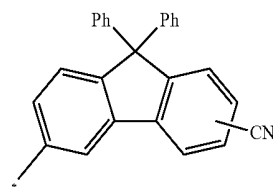
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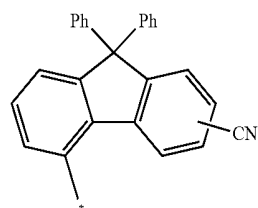
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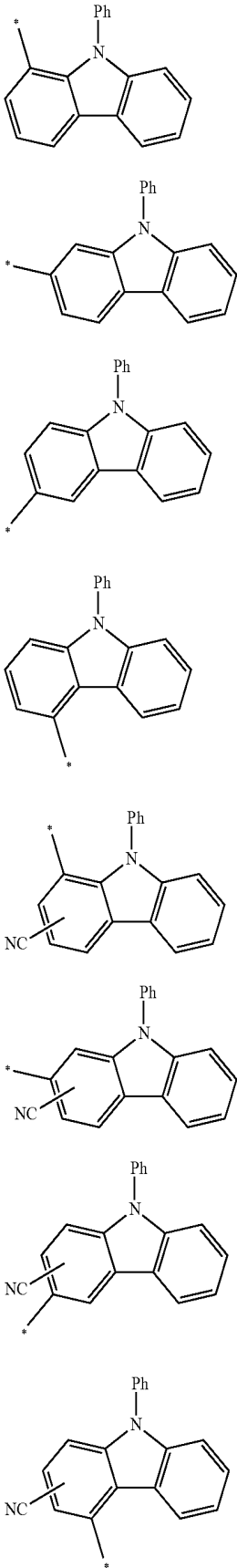
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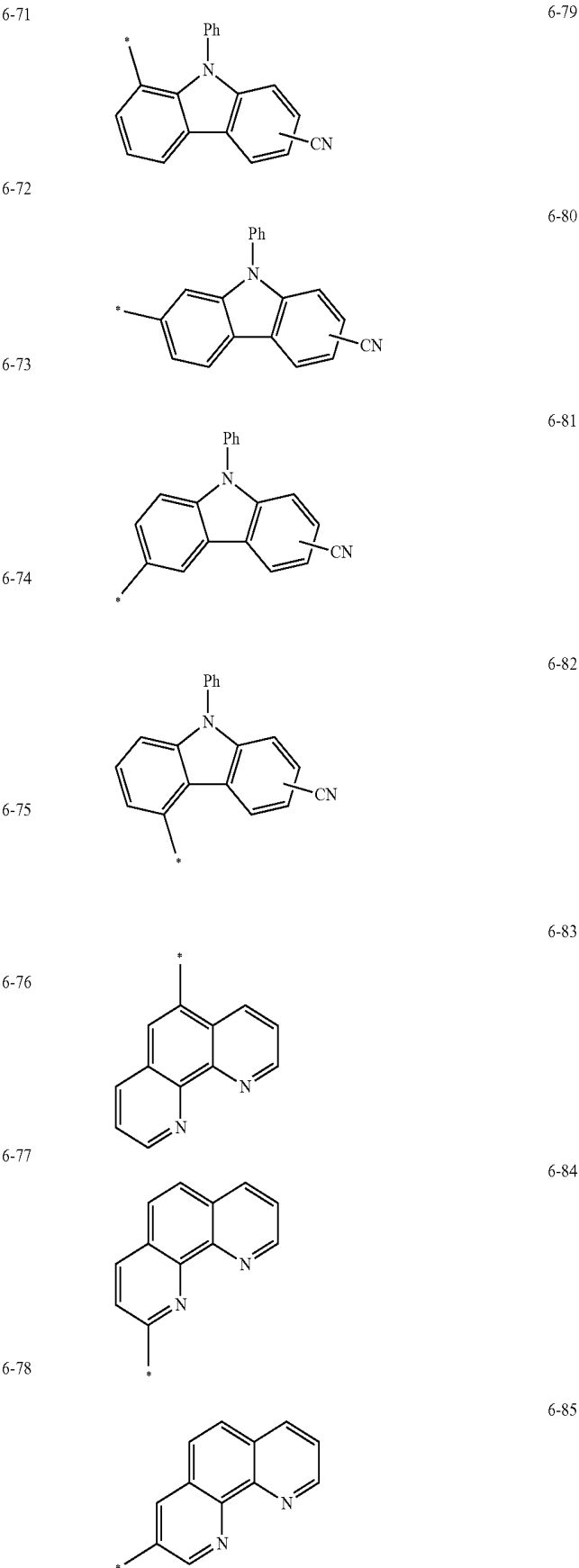


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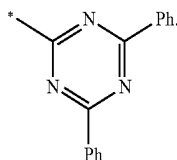
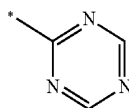
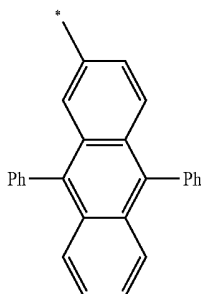
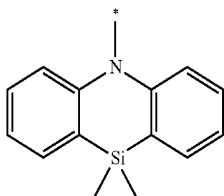
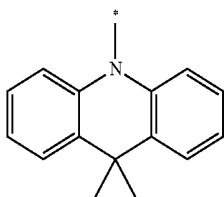
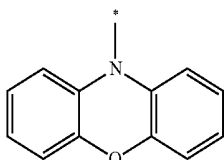
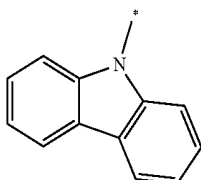
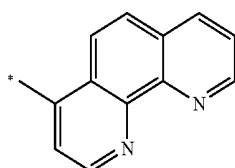
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- [0103]** In Formulae 6-1 to 6-93,
- [0104]** Ph indicates a phenyl group,
- [0105]** Q₁ to Q₃ each indicate a phenyl group, and
- [0106]** * indicates a binding site to a neighboring atom.
- [0107]** In one embodiment, in Formula 2, L₁ may be selected from groups represented by Formulae 4-1 to 4-20, Ar₁ may be selected from groups represented by Formulae 6-1 to 6-93, —Si(Q₁)(Q₂)(Q₃), and —P(=O)(Q₁)(Q₂), and Q₁ to Q₃ may each be a phenyl group, but embodiments of the present disclosure are not limited thereto.
- [0108]** b₁ in Formula 2 may be an integer from 1 to 10. b₁ indicates the number of Ar₁(s), wherein, when b₁ is two or more, two or more Ar₁(s) may be identical to or different from each other.
- [0109]** R₁ and R₂ in Formula 1 may each independently be selected from a group represented by Formula 2, 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 C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), —C(=O)(Q₁), —N(Q₁)(Q₂), —P(=O)(Q₁)(Q₂), —P(=O)₂(Q₁), —P(=S)(Q₁)(Q₂), —P(=S)₂(Q₁), —S(=O)(Q₁)(Q₂), and —S(=O)₂(Q₁)(Q₂), and
- [0110]** at least one of R₁(s) in the number of c₁ and R₂(s) in the number of c₂ may be a group represented by Formula 2.
- [0111]** In one embodiment, R₁ and R₂ in Formula 1 may each independently be selected from a group represented by Formula 2, 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthrolinyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group, but embodiments of the present disclosure are not limited thereto.
- [0112]** In one embodiment, R₁ and R₂ in Formula 1 may each independently be selected from a group represented by Formula 2, 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 methyl group, an ethyl group, a propyl group, an iso-propyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a ter-butyl group, a pentyl group, an iso-amyl group, a hexyl

group, a phenyl group, a biphenyl group, a naphthyl group, and a pyridinyl group, but embodiments of the present disclosure are not limited thereto.

[0113] In Formula 1, c1 may be an integer from 1 to 6, and c2 may be an integer from 1 to 4.

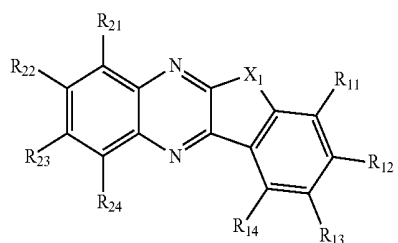
[0114] c1 indicates the number of R₁(s), wherein, when c1 is two or more, two or more R₁(s) may be identical to or different from each other. c2 indicates the number of R₂(S), wherein, when c2 is two or more, two or more R₂(s) may be identical to or different from each other.

[0115] In one embodiment, in Formula 1, at least one of R₁(s) in the number of c1 may be a group represented by Formula 2;

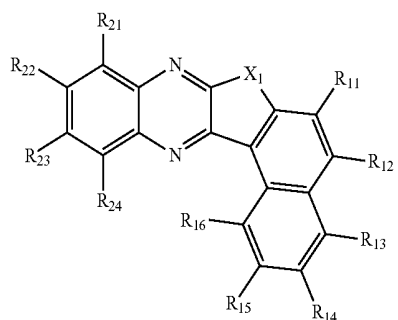
[0116] at least one of R₂(S) in the number of c2 may be a group represented by Formula 2; or

[0117] at least one of R₁(s) in the number of c1 and at least one of R₂(s) in the number of c2 may be a group represented by Formula 2, but embodiments of the present disclosure are not limited thereto.

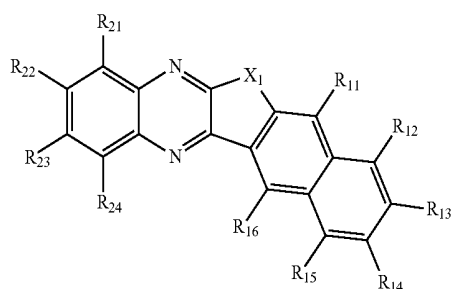
[0118] In one embodiment, the condensed cyclic compound represented by Formula 1 may be represented by one of Formulae 1-1 to 1-4, but embodiments of the present disclosure are not limited thereto:



<Formula 1-1>



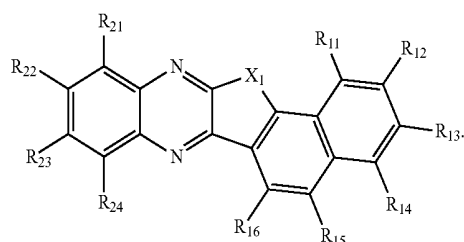
<Formula 1-2>



<Formula 1-3>

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<Formula 1-4>



[0119] In Formulae 1-1 to 1-4,

[0120] X₁ may be defined the same as that of Formula 1,

[0121] R₁₁ to R₁₆ may be defined the same as R₁ of Formula 1,

[0122] R₂₁ to R₂₄ may be defined the same as R₂ of Formula 1,

[0123] at least one of R₁₁ to R₁₄ and R₂₁ to R₂₄ in Formula 1-1 may be a group represented by Formula 2, and

[0124] at least one of R₁₁ to R₁₆ and R₂₁ to R₂₄ in Formulae 1-2 to 1-4 may be a group represented by Formula 2.

[0125] In one embodiment, the condensed cyclic compound represented by Formula 1 may be represented by Formula 1-1 or 1-2, but embodiments of the present disclosure are not limited thereto.

[0126] In one embodiment, at least one of R₁₁ to R₁₄ in Formula 1-1 may be a group represented by Formula 2; or

[0127] at least one of R₁₁ to R₁₆ in Formulae 1-2 to 1-4 may be a group represented by Formula 2, but embodiments of the present disclosure are not limited thereto.

[0128] In one or more embodiments, at least one of R₁₁ and R₁₃ in Formula 1-1 may be a group represented by Formula 2; or

[0129] at least one of R₁₁ and R₁₄ in Formulae 1-2 to 1-4 may be a group represented by Formula 2, but embodiments of the present disclosure are not limited thereto.

[0130] In one or more embodiments,

[0131] i) R₁₃ in Formula 1-1 may be a group represented by Formula 2,

[0132] ii) R₁₁ and R₁₃ in Formula 1-1 may each be a group represented by Formula 2,

[0133] iii) R₁₄ in Formulae 1-2 to 1-4 may be a group represented by Formula 2, or

[0134] iv) R₁₁ and R₁₄ in Formulae 1-2 to 1-4 may be a group represented by Formula 2, but embodiments of the present disclosure are not limited thereto.

[0135] In one embodiment,

[0136] at least one of R₁₁ to R₁₄ and R₂₁ to R₂₄ in Formula 1-1 may be a group represented by Formula 2, and at least one of R₁₁ to R₁₆ and R₂₁ to R₂₄ in Formulae 1-2 to 1-4 may be a group represented by Formula 2,

[0137] L₁ may be selected from groups represented by Formulae 4-1 to 4-20, and

[0138] Ar₁ may be selected from a group represented by Formulae 6-1 to 6-93, —Si(Q₁)(Q₂)(Q₃), and —P(=O)(Q₁)(Q₂), but embodiments of the present disclosure are not limited thereto. Q₁ to Q₃ may each be a phenyl group.

[0139] In one or more embodiments,

[0140] at least one of R₁₁ to R₁₄ and R₂₁ to R₂₄ in Formula 1-1 may be a group represented by Formula 2,

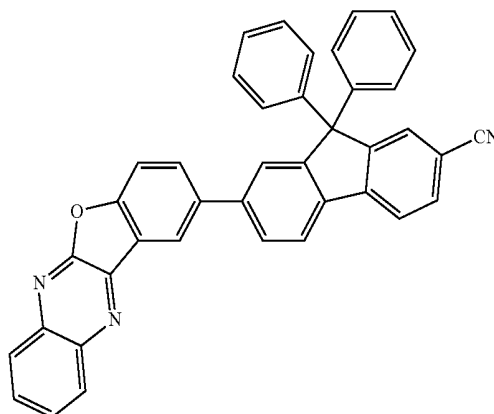
[0141] at least one of R_{11} to R_{16} and R_{21} to R_{24} in Formulae 1-2 to 1-4 may be a group represented by Formula 2, and

[0142] the others of R_{11} to R_{16} and R_{21} to R_{24} 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 methyl group, an ethyl group, a propyl group, an iso-propyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a ter-butyl group, a pentyl group, an iso-amyl group, a hexyl group, a phenyl group, a biphenyl group, a naphthyl group, and a pyridinyl group, but embodiments of the present disclosure are not limited thereto.

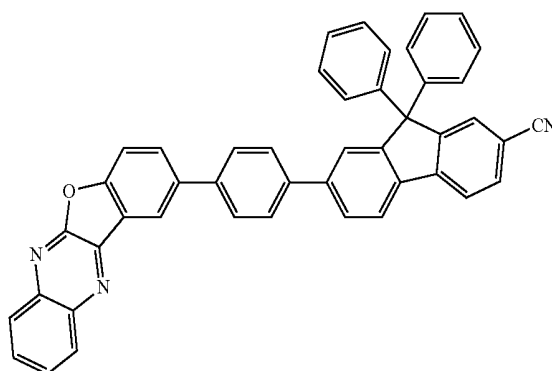
[0143] In one embodiment, the condensed cyclic compound represented by Formula 1 may be selected from Compounds 1 to 66, but embodiments of the present disclosure are not limited thereto:

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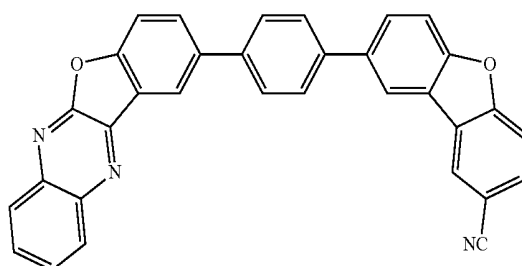
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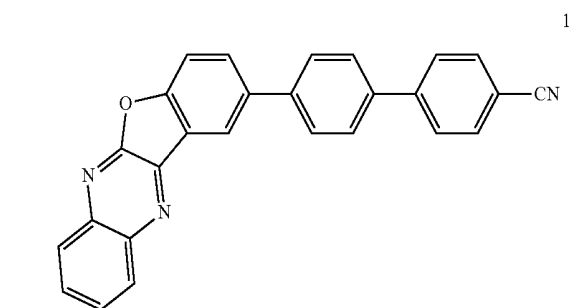
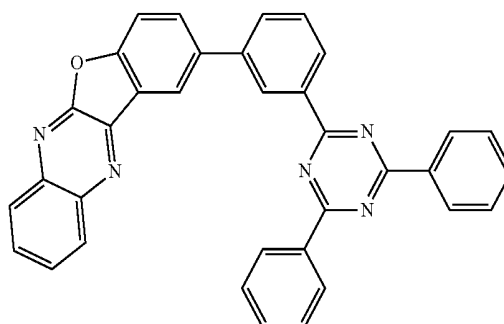
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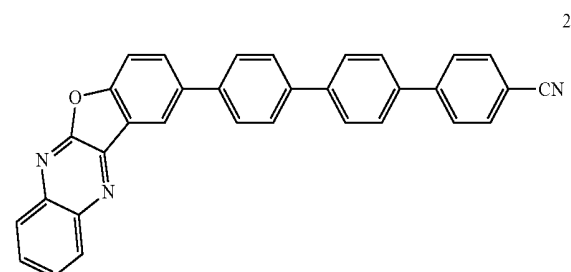
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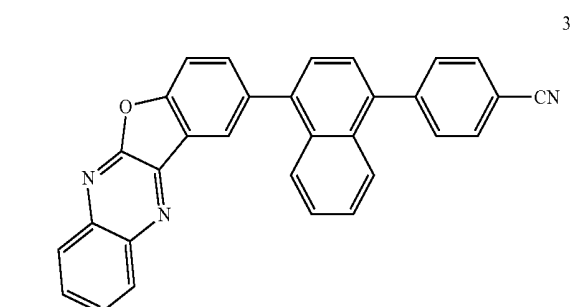
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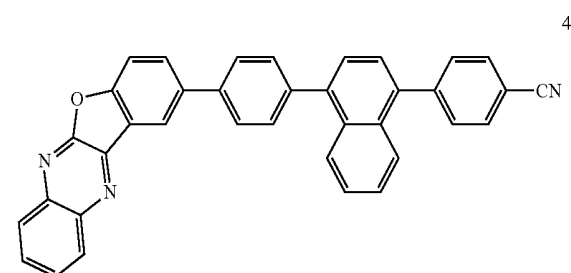
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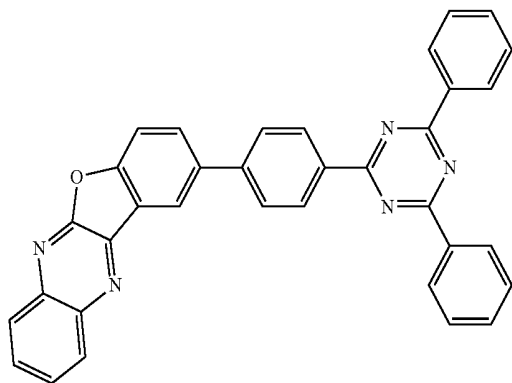
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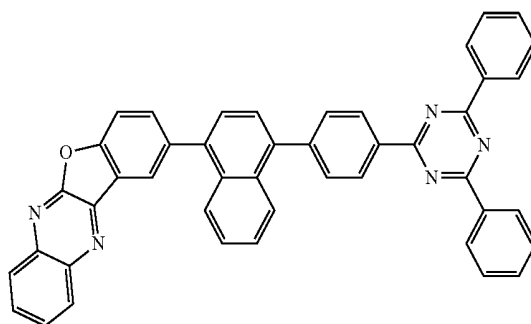
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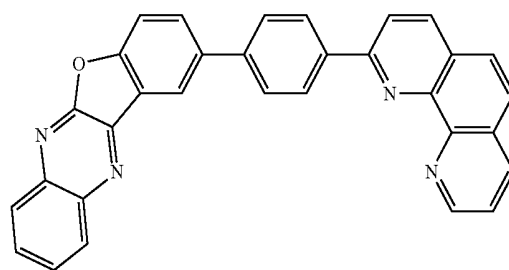


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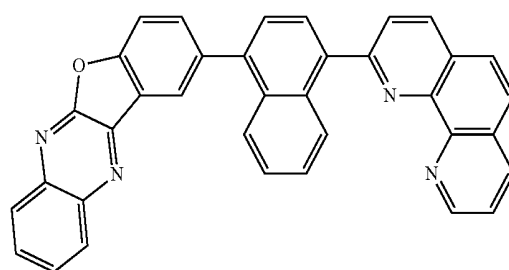
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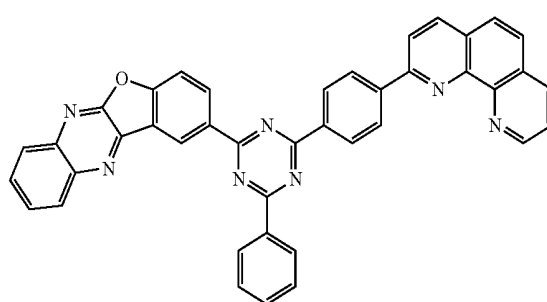
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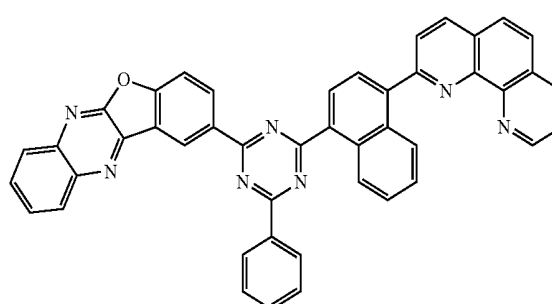
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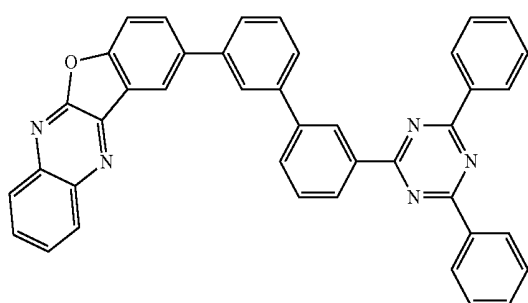
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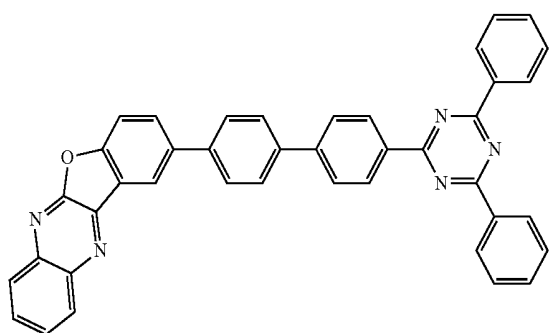
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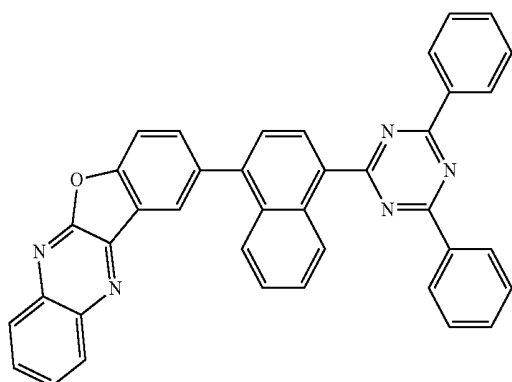
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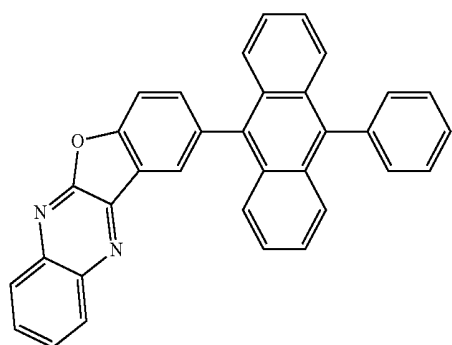
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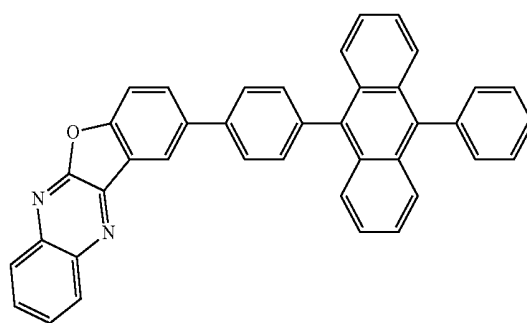


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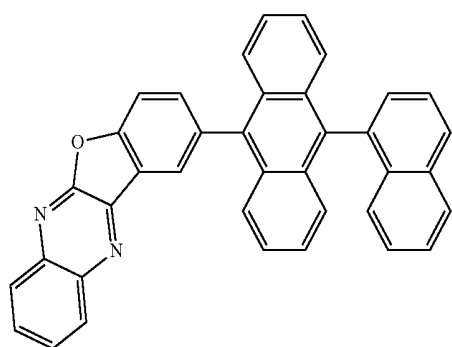


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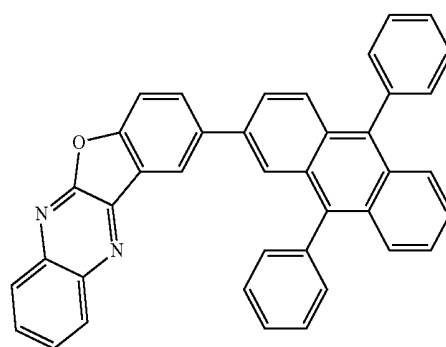
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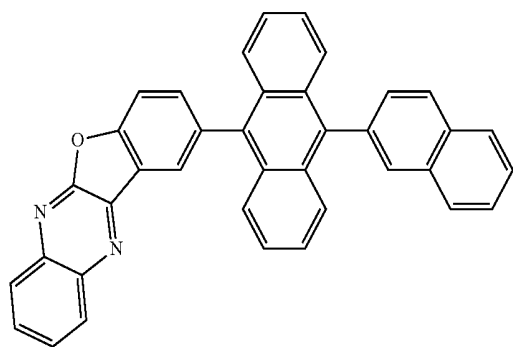
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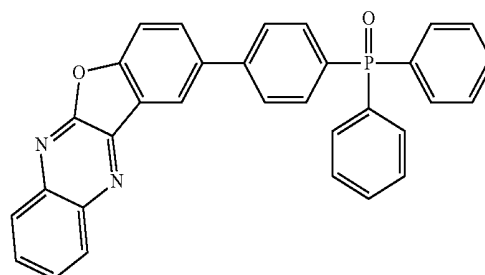
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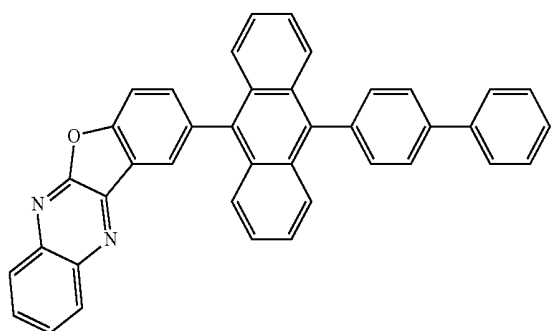
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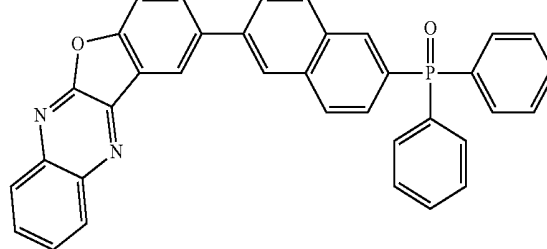
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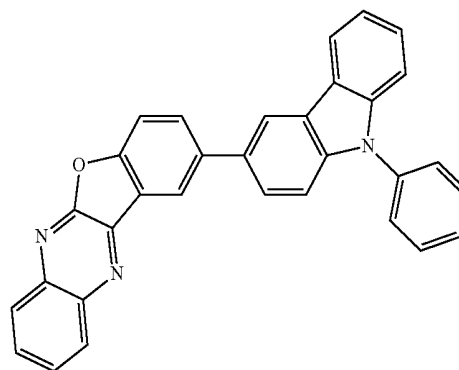
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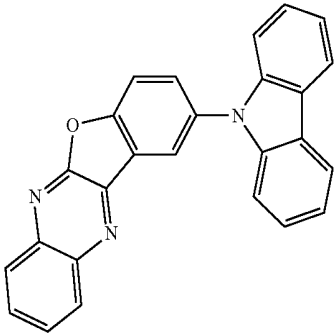


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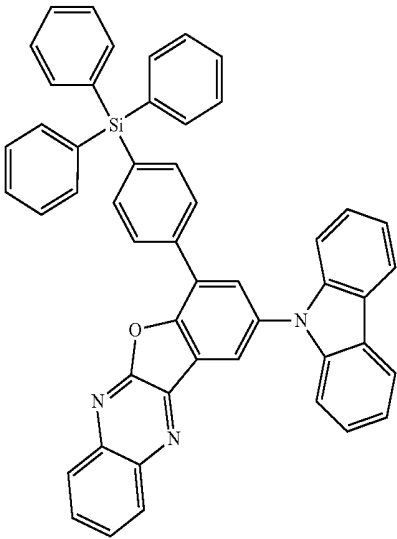
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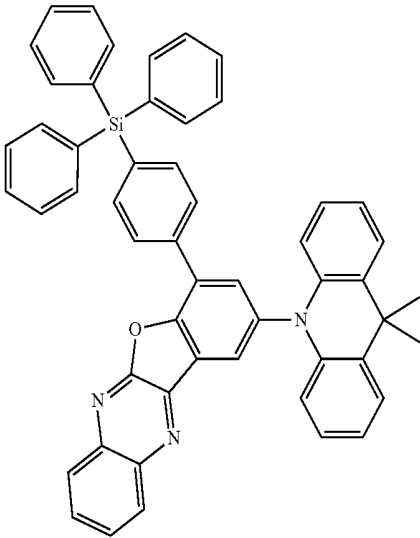
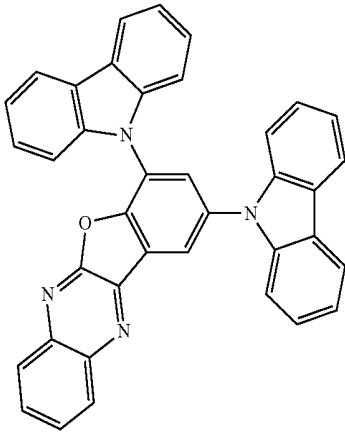
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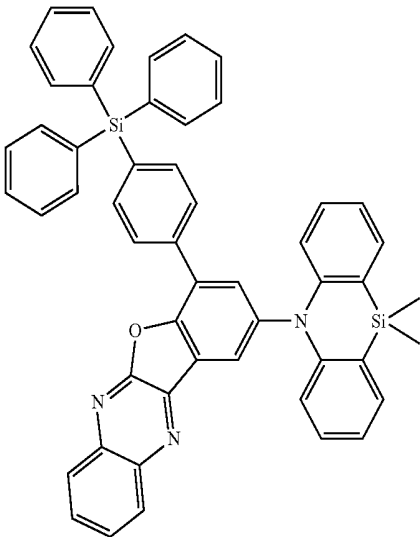
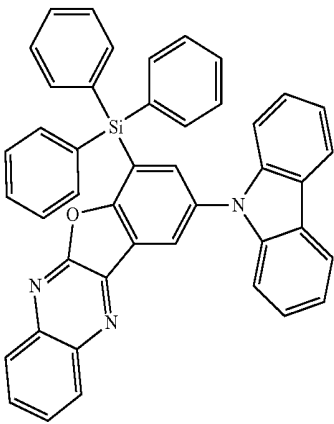
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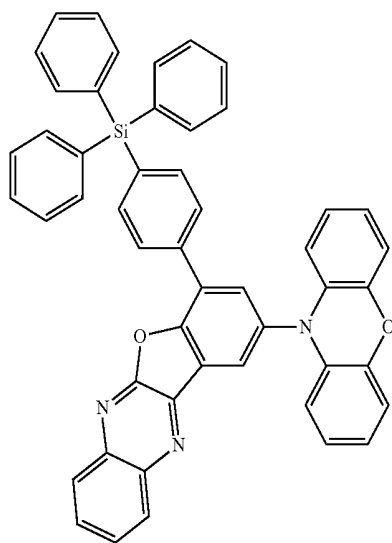
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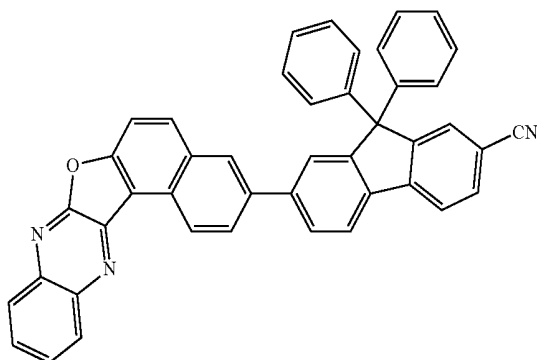
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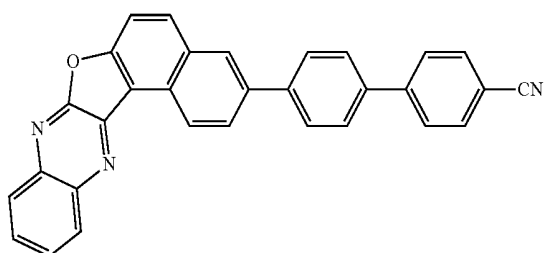


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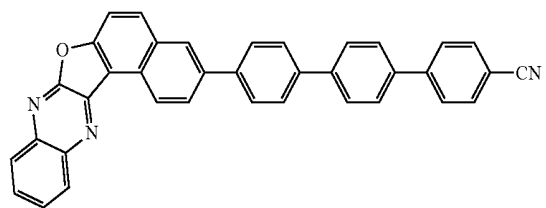
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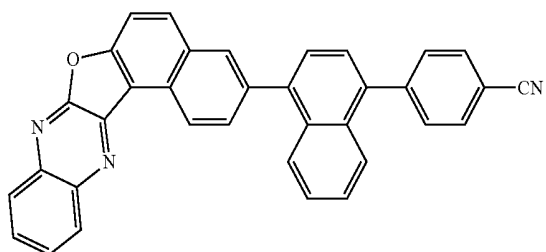
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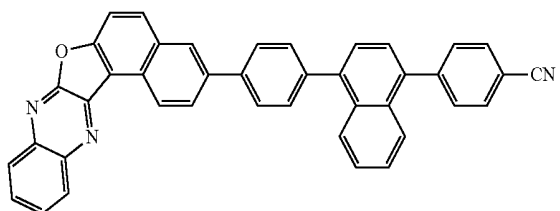
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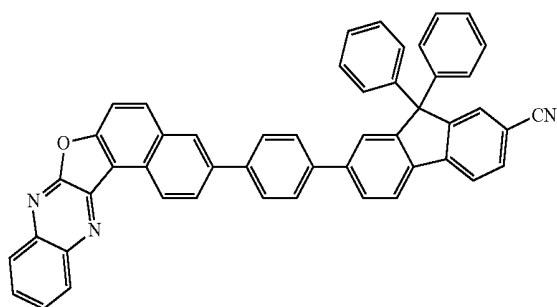
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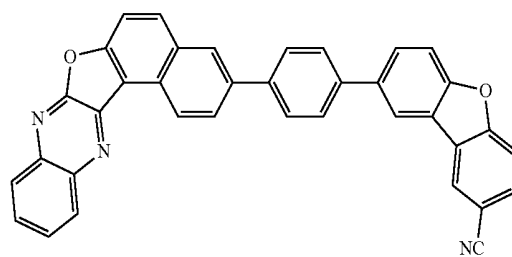
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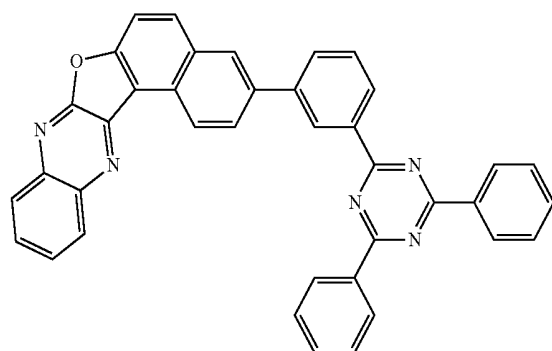
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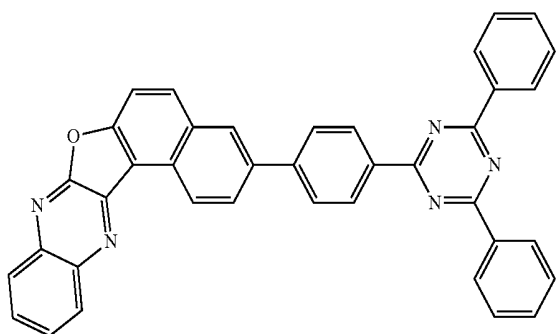


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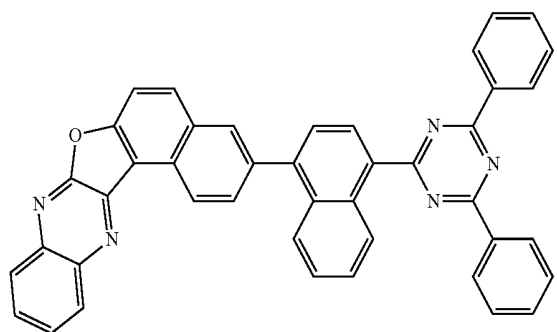


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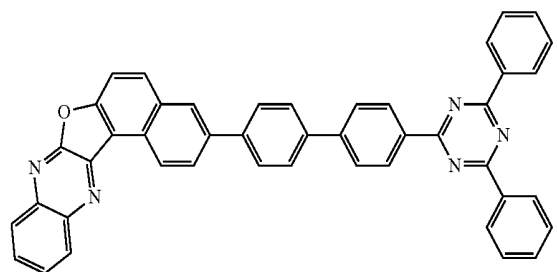
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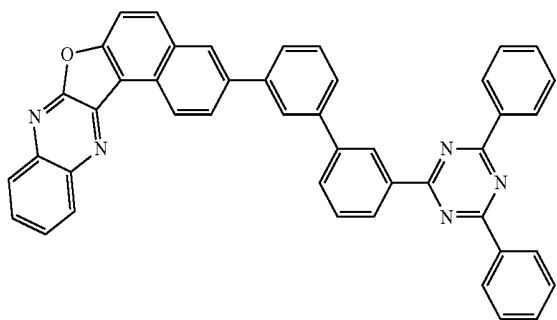
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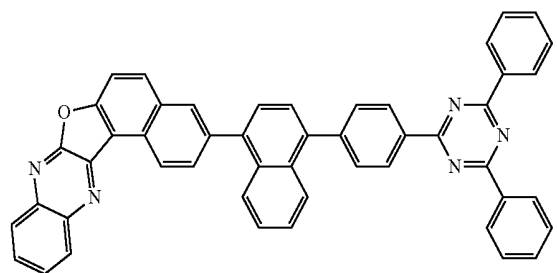
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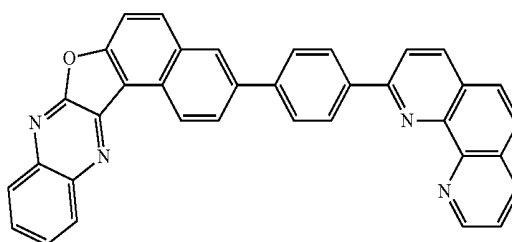


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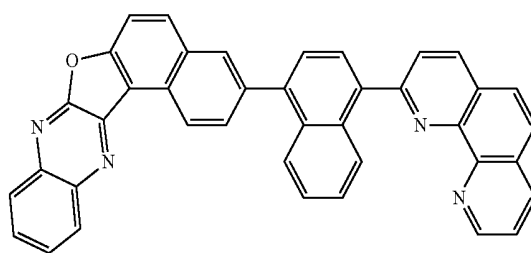


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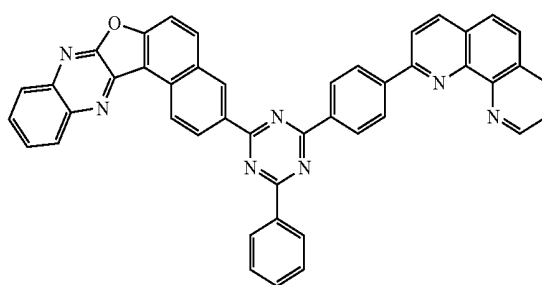
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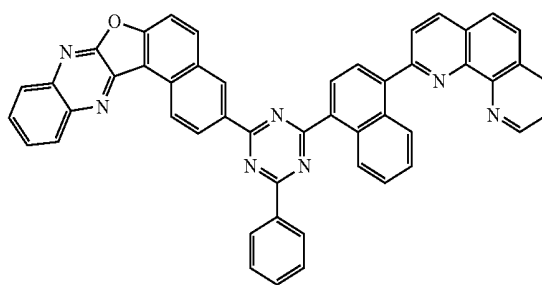
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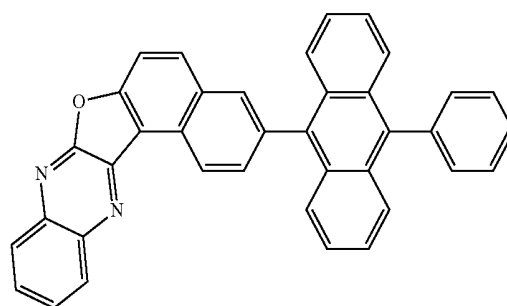
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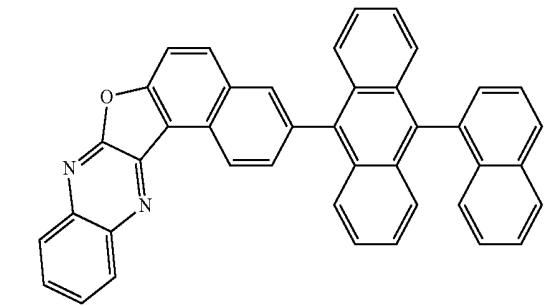


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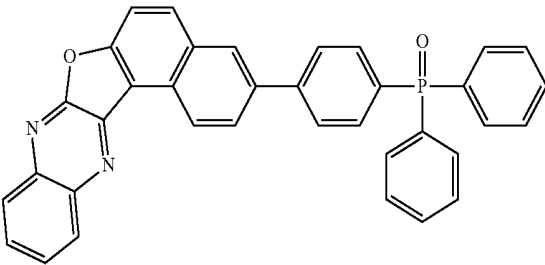
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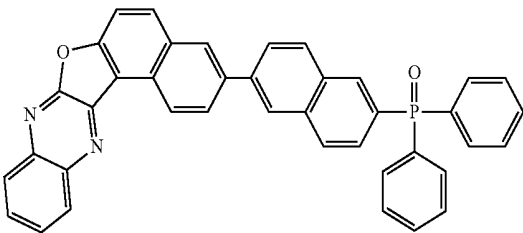
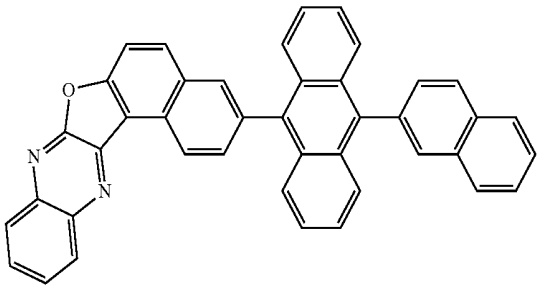
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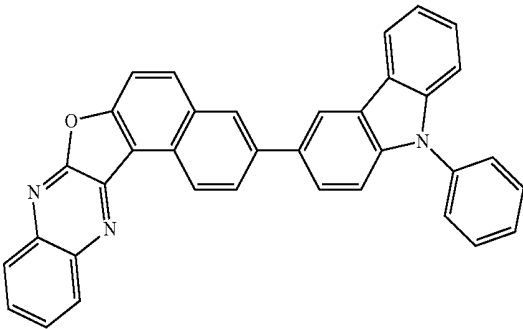
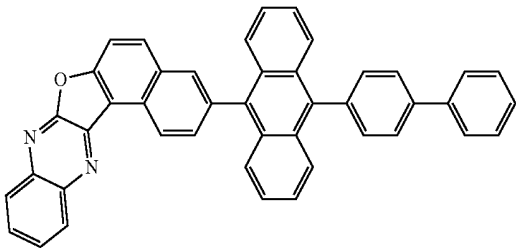
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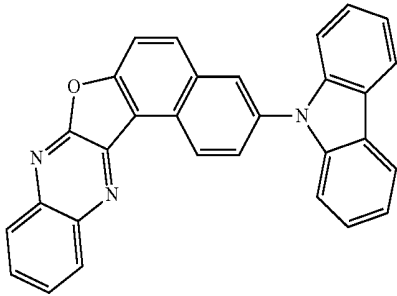
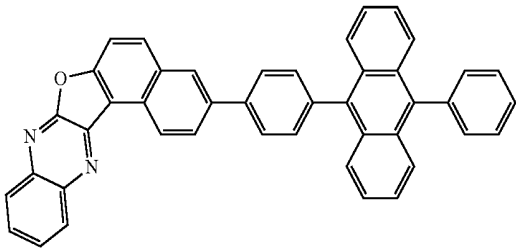
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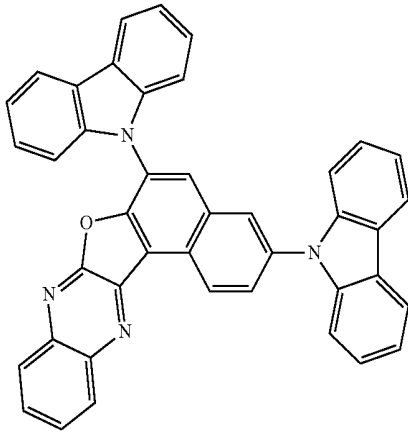
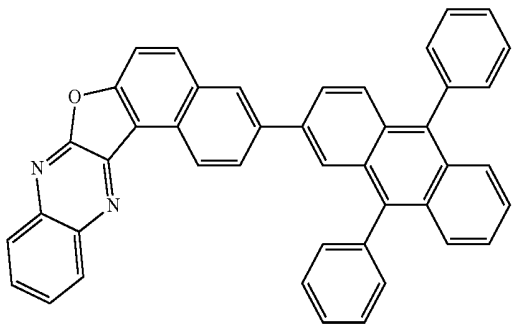
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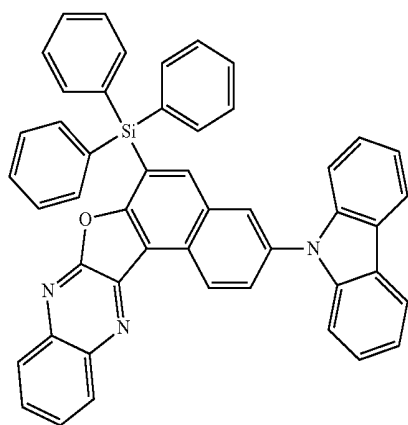


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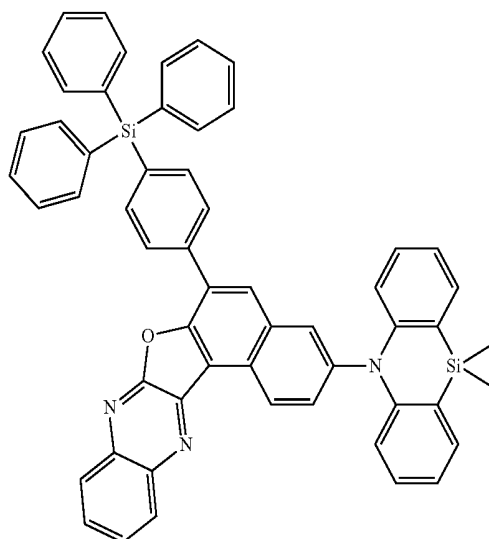


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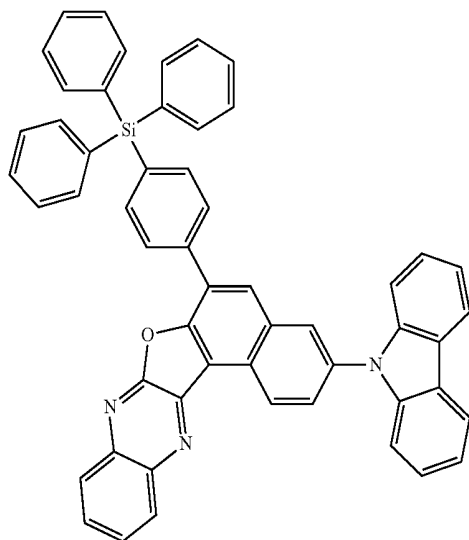


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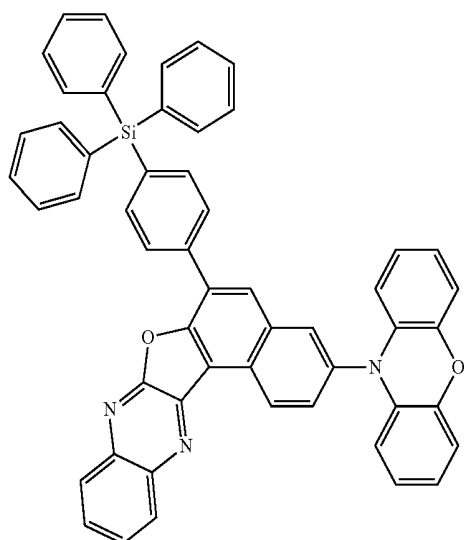
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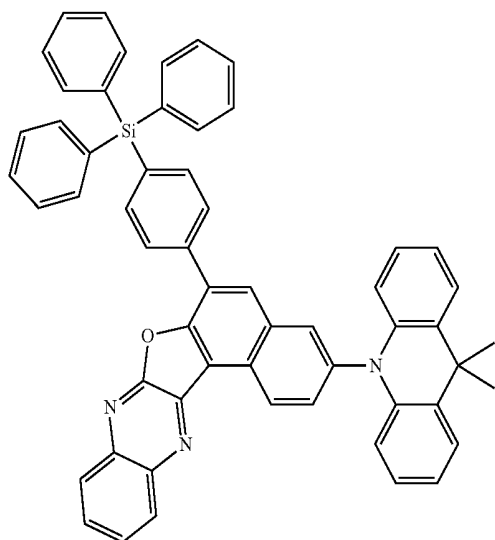
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[0144] In the condensed cyclic compound represented by Formula 1, a hetero ring including an oxygen or sulfur atom may be condensed in a quinoxaline ring. As a result, an electronegative nitrogen atom may be substituted to lower a pi electron density of a molecule, resulting in a structure in which electrons are insufficient. Thus, it may be advantageous for electron transport. Also, the condensed cyclic compound may have a rigid plate-shaped molecular structure, and thus may be advantageous for molecular stacking. Therefore, as the film density of the film including the condensed cyclic compound may increase, the film may have a high charge mobility. Further, the condensed cyclic compound may include the oxygen family (chalcogen), thereby increasing intermolecular attraction. As a result, the film density of the film including the condensed cyclic compound may increase, and the charge transportability of the film may further increase.

[0145] In general, a molecule having a linear rod shape is known as a molecule having a high charge mobility due to an increase in stacking in a bulk film structure. Since at least one substituent represented by Formula 2 may be substituted for a specific core represented by Formula 1, not only the core structure represented by Formula 1 but also the whole

molecules may have a rod shape, thereby increasing molecular stacking. Thus, the electron mobility may increase. Also, when the core is substituted with an electron transport substituent such as triazine, the electron transport characteristics of the condensed cyclic compound may further increase.

[0146] Therefore, an electronic device, for example, an organic light-emitting device, which includes the condensed cyclic compound, may have a low driving voltage, high efficiency, and a long lifespan.

[0147] Synthesis methods for the condensed cyclic compound represented by Formula 1 would be apparent to those of ordinary skill in the art by referring to the following examples.

[0148] At least one condensed cyclic compound represented by Formula 1 may be used or included between a pair of electrodes constituting an organic light-emitting device. For example, the condensed cyclic compound may be included in at least one layer selected from a hole transport region, an electron transport region, and an emission layer. In one or more embodiments, the condensed cyclic compound of Formula 1 may be used as a material for a capping layer located outside a pair of electrodes of an organic light-emitting device.

[0149] Accordingly, provided is an organic light-emitting device including: a first electrode; a second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode, the organic layer including an emission layer, wherein the organic layer includes at least one condensed cyclic compound.

[0150] The expression “(an organic layer) includes at least one condensed cyclic compound” used herein may include a case in which “(an organic layer) includes identical compounds represented by Formula 1” and a case in which “(an organic layer) includes two or more different condensed cyclic compounds.”

[0151] For example, the organic layer may include, as the condensed cyclic compound, only Compound 1. In this regard, Compound 1 may exist in an emission layer of the organic light-emitting device. In one or more embodiments, the organic layer may include, as the condensed cyclic compound, Compound 1 and Compound 2. In this regard, Compound 1 and Compound 2 may exist in an identical layer (for example, Compound 1 and Compound 2 may all exist in an emission layer), or different layers (for example, Compound 1 may exist in an emission layer and Compound 2 may exist in an electron transport layer).

[0152] In one embodiment, the first electrode is an anode, and the second electrode is a cathode, and the organic layer further includes a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode, and the hole transport region includes a hole injection layer, a hole transport layer, an emission auxiliary layer, an electron blocking layer, or any combination thereof, and the electron transport region includes an emission auxiliary layer, a hole blocking layer, an electron control layer, an electron transport layer, an electron injection layer, or any combination thereof.

[0153] In one embodiment, the electron transport region may include the condensed cyclic compound.

[0154] In one or more embodiments, the electron transport region may include an electron transport layer and an electron injection layer, and at least one of the electron transport layer and the electron injection layer may include the condensed cyclic compound.

[0155] For example, the electron transport region may include an electron transport layer, wherein the electron transport layer includes the condensed cyclic compound.

[0156] In one or more embodiments, the electron transport region may include a metal-containing material, and the metal-containing material may be a L_1 complex.

[0157] In one or more embodiments, the emission layer may include the condensed cyclic compound.

[0158] For example, the emission layer may further include a dopant, an amount of the condensed cyclic compound in the emission layer may be greater than that of the dopant, and the dopant may be a phosphorescent dopant or a fluorescent dopant.

[0159] The organic light-emitting device may further include at least one selected from a first capping layer disposed in a pathway along which light generated in an emission layer proceeds toward the outside through the first electrode and a second capping layer disposed in a pathway along which light generated in an emission layer proceeds toward the outside through the second electrode, and the at least one selected from the first capping layer and the second capping layer may include at least one condensed cyclic compound represented by Formula 1.

[0160] For example, the organic light-emitting device may have i) a stacked structure including a first electrode, an organic layer, a second electrode, and a second capping layer which are sequentially stacked in this stated order, ii) a stacked structure including a first capping layer, a first electrode, an organic layer, and a second electrode which are sequentially stacked in this stated order, or iii) a stacked structure including a first capping layer, a first electrode, an organic layer, a second electrode, and a second capping layer which are sequentially stacked in this stated order, and at least one selected from the first capping layer and the second capping layer may include the condensed cyclic compound.

[0161] The term “organic layer” 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.

[0162] [Description of FIG. 1]

[0163] 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.

[0164] 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.

[0165] [First Electrode 110]

[0166] 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.

[0167] 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 forming a first electrode may be selected from materials with a high work function to facilitate hole injection.

[0168] 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_2), zinc oxide (ZnO), and any combinations thereof, but embodiments of the present disclosure are not limited thereto. When the first electrode 110 is a semi-transmissive electrode or a reflective electrode, as a material for forming the first electrode 110, magnesium (Mg), silver (Ag), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), magnesium-silver (Mg—Ag), or any combination thereof may be used. However, the material for forming the first electrode 110 is not limited thereto.

[0169] 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.

[0170] [Organic Layer **150**]

[0171] The organic layer **150** is disposed on the first electrode **110**. The organic layer **150** may include an emission layer.

[0172] 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**.

[0173] [Hole Transport Region in Organic Layer **150**]

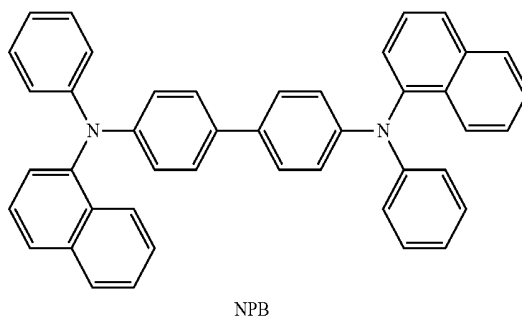
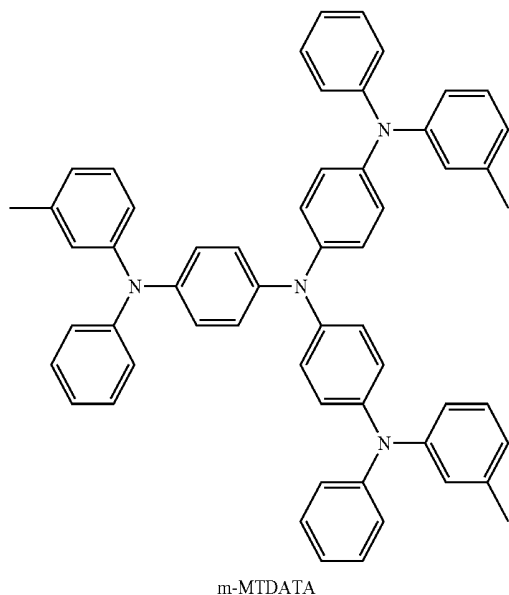
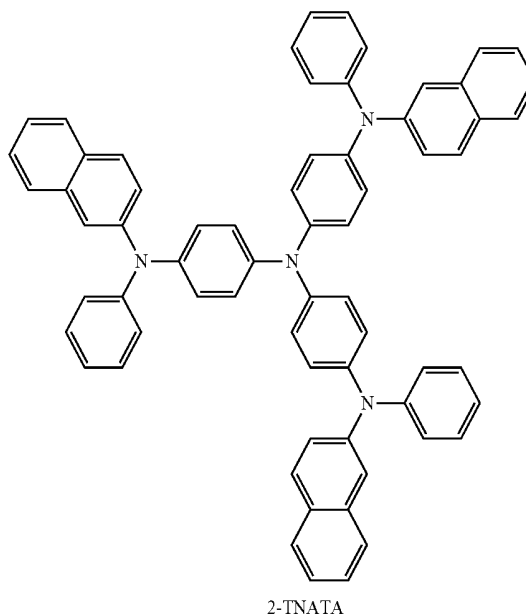
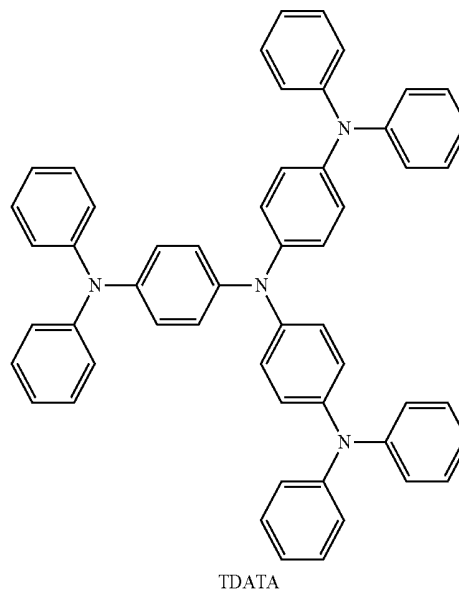
[0174] The hole transport region may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

[0175] 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.

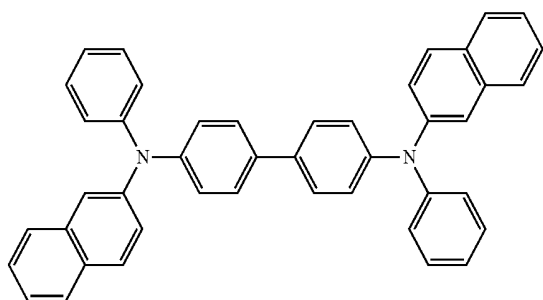
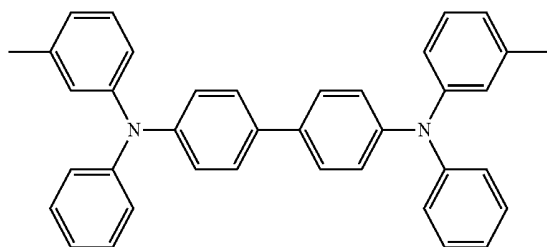
[0176] For example, the hole transport region may have a single-layered structure including a single layer including a plurality of different materials, or a multi-layered structure having a hole injection layer/hole transport layer structure, a hole injection layer/hole transport layer/emission auxiliary 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.

[0177] The hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB (NPD), P-NPB, TPD, Spiro-TPD, Spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), PEDOT/PSS (poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate)), 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:

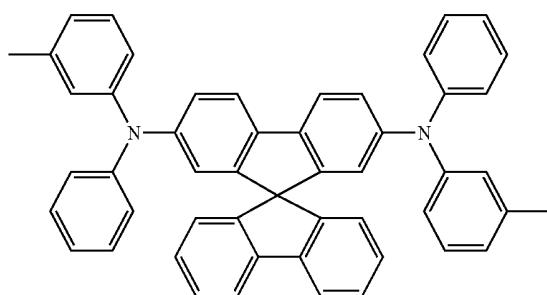
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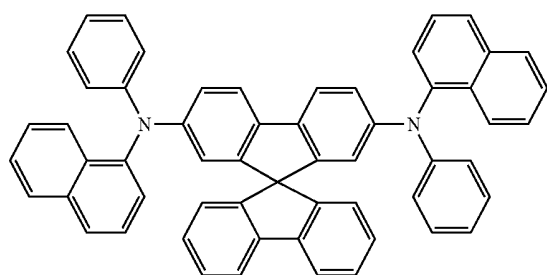
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 β -NPB

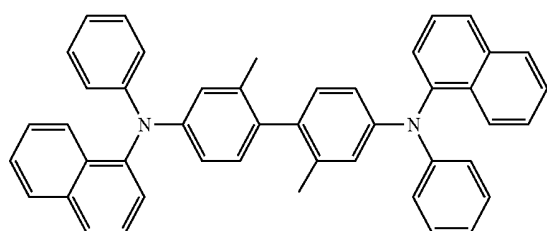
TPD



Spiro-TPD

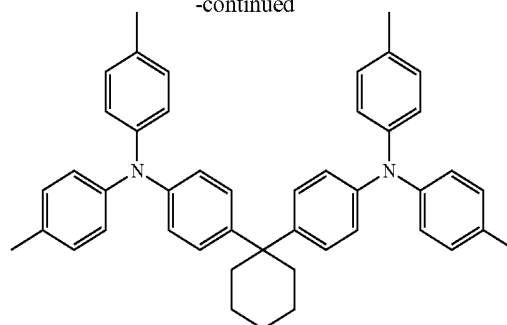


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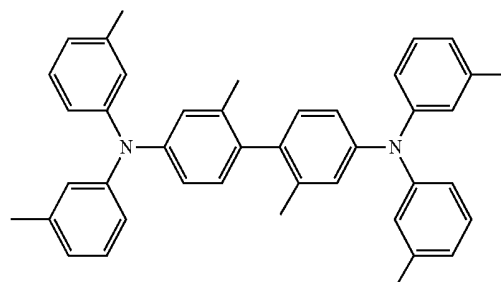


methylated NPB

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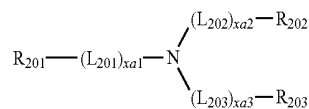


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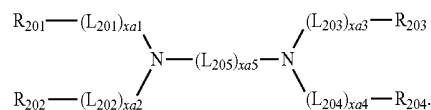


HMTPD

<Formula 201>



<Formula 202>



[0178] In Formulae 201 and 202,

[0179] L_{201} to L_{204} may each independently be selected from a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_1 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

[0180] L_{205} may be selected from $*-O-*$, $*-S-*$, $*-N(Q_{201})-*$, a substituted or unsubstituted C_1 - C_{20} alkylene group, a substituted or unsubstituted C_2 - C_{20} alkenylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_1 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

[0181] $xa1$ to $xa4$ may each independently be an integer from 0 to 3,

[0182] xa5 may be an integer from 1 to 10, and

[0183] R₂₀₁ to R₂₀₄ and Q₂₀₁ may each independently be selected from a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0184] For example, in Formula 202, R₂₀₁ and R₂₀₂ may optionally be linked via a single bond, a dimethyl-methylene group, or a diphenyl-methylene group, and R₂₀₃ and R₂₀₄ may optionally be linked via a single bond, a dimethyl-methylene group, or a diphenyl-methylene group.

[0185] In one or more embodiments, regarding Formulae 201 and 202,

[0186] L₂₀₁ to L₂₀₅ may each independently be selected from:

[0187] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a 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 benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, and a pyridinylenylene group; and

[0188] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a 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 benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, and a pyridinylenylene 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ 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 C₁-C₁₀ 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(Q₃₁)(Q₃₂)(Q₃₃), and —N(Q₃₁)(Q₃₂), and

[0189] Q₃₁ to Q₃₃ may each independently be selected from a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0190] In one or more embodiments, xa1 to xa4 may each independently be 0, 1, or 2.

[0191] In one or more embodiments, xa5 may be 1, 2, 3, or 4.

[0192] In one or more embodiments, R₂₀₁ to R₂₀₄ and Q₂₀₁ may each independently be selected from:

[0193] 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

[0194] 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 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

C₁-C₂₀ alkyl group, a C₁-C₂₀ 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 C₁-C₁₀ 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(Q₃₁)(Q₃₂)(Q₃₃) and —N(Q₃₁)(Q₃₂), and

[0195] Q₃₁ to Q₃₃ are the same as described above.

[0196] In one or more embodiments, in Formula 201, at least one of R₂₀₁ to R₂₀₃ may each independently be selected from:

[0197] a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

[0198] 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ 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 C₁-C₁₀ 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,

[0199] but embodiments of the present disclosure are not limited thereto.

[0200] In one or more embodiments, in Formula 202, i) R₂₀₁ and R₂₀₂ may be linked via a single bond and/or ii) R₂₀₃ and R₂₀₄ may be linked via a single bond.

[0201] In one or more embodiments, in Formula 202, at least one of R₂₀₁ to R₂₀₄ may be selected from:

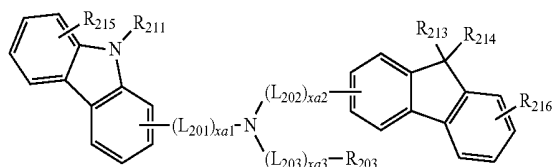
[0202] a carbazolyl group; and

[0203] 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ 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 C₁-C₁₀ 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;

[0204] but embodiments of the present disclosure are not limited thereto.

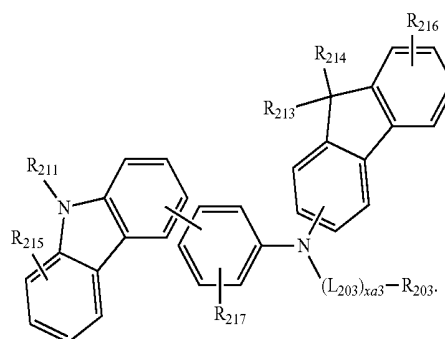
[0205] The compound represented by Formula 201 may be represented by Formula 201A:

<Formula 201A>



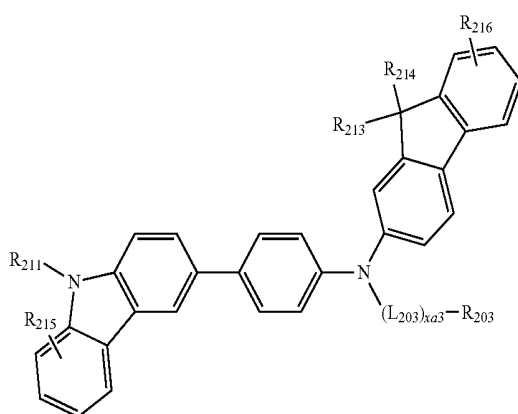
[0206] In one embodiment, the compound represented by Formula 201 may be represented by Formula 201A(1) below, but embodiments of the present disclosure are not limited thereto:

<Formula 201A(1)>



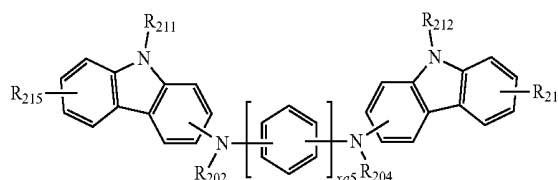
[0207] In one embodiment, the compound represented by Formula 201 may be represented by Formula 201A-1 below, but embodiments of the present disclosure are not limited thereto:

<Formula 201A-1>



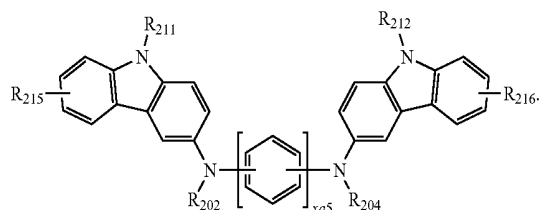
[0208] In one embodiment, the compound represented by Formula 202 may be represented by Formula 202A:

<Formula 202A>



[0209] In one embodiment, the compound represented by Formula 202 may be represented by Formula 202A-1:

<Formula 202A-1>



[0210] In Formulae 201A, 201A(1), 201A-1, 202A, and 202A-1,

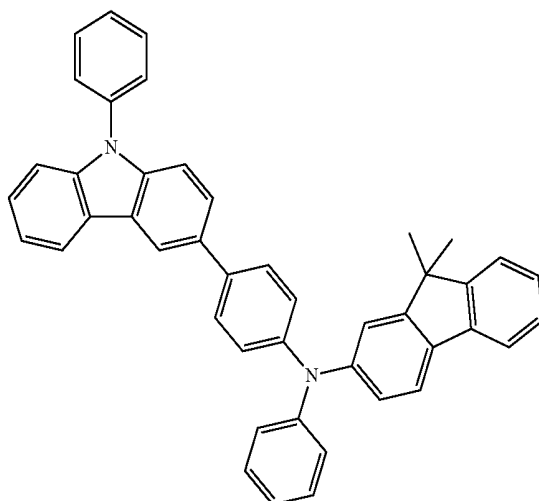
[0211] L_{201} to L_{203} , $xa1$ to $xa3$, $xa5$, and R_{202} to R_{204} are the same as described above,

[0212] R_{211} and R_{212} may be understood by referring to the description provided herein in connection with R_{203} , and

[0213] 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.

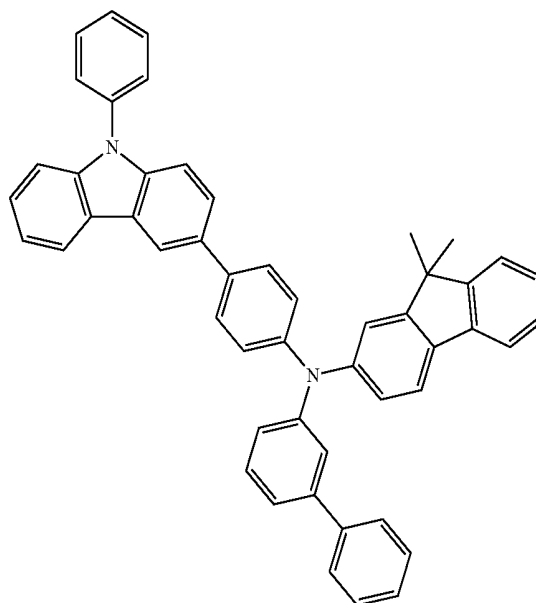
[0214] The hole transport region may include at least one compound selected from Compounds HT1 to HT39, but embodiments of the present disclosure are not limited thereto:

HT1

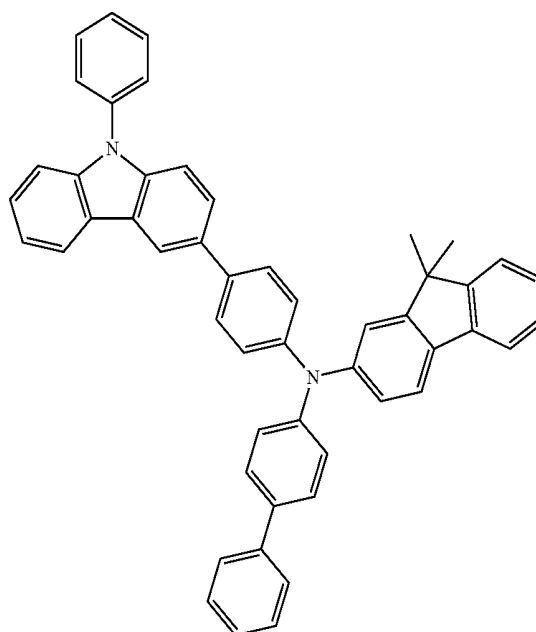


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HT2



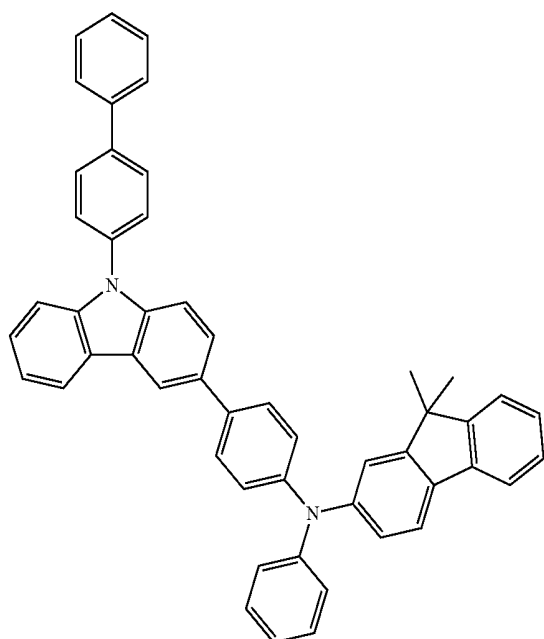
HT3



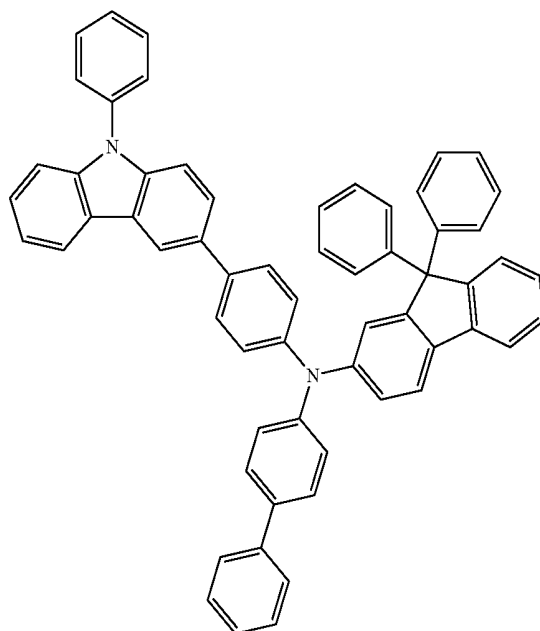
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HT4

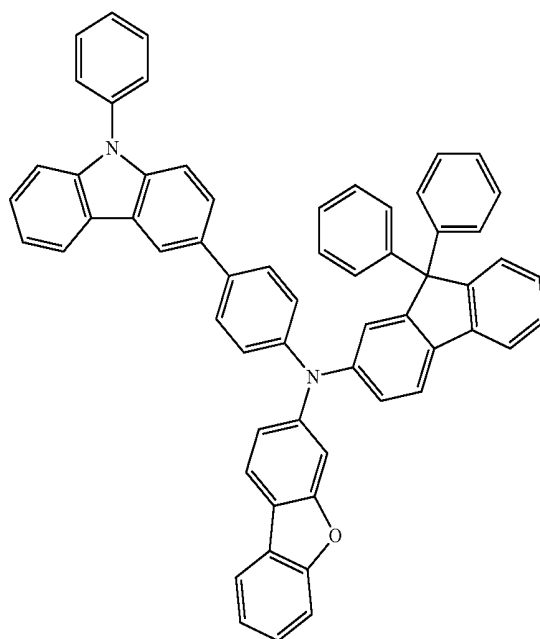
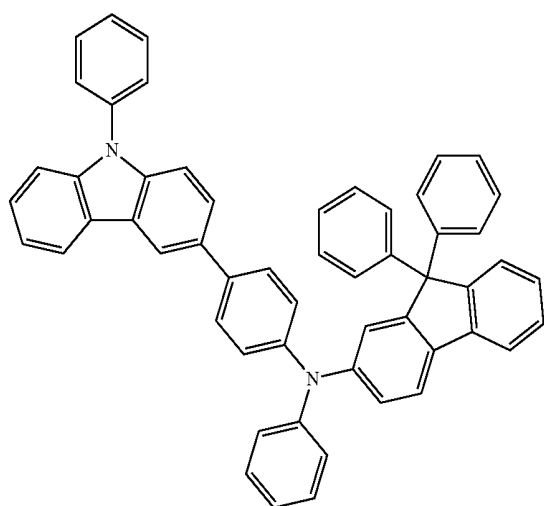


HT6



HT7

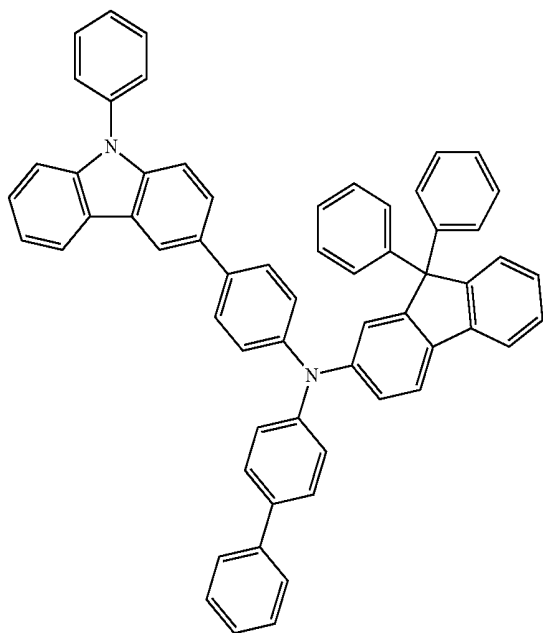
HT5



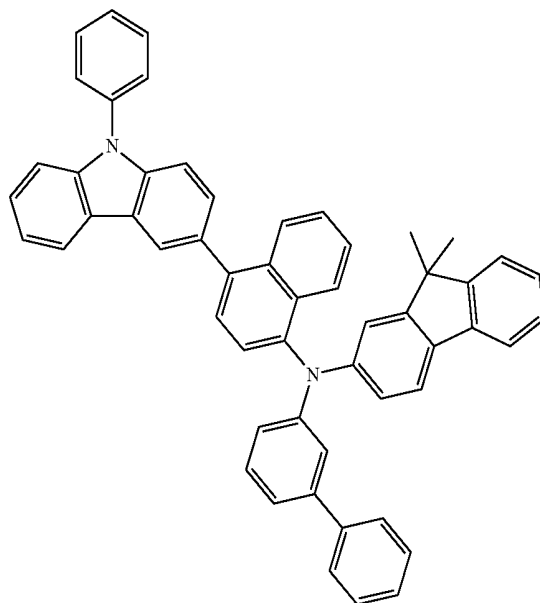
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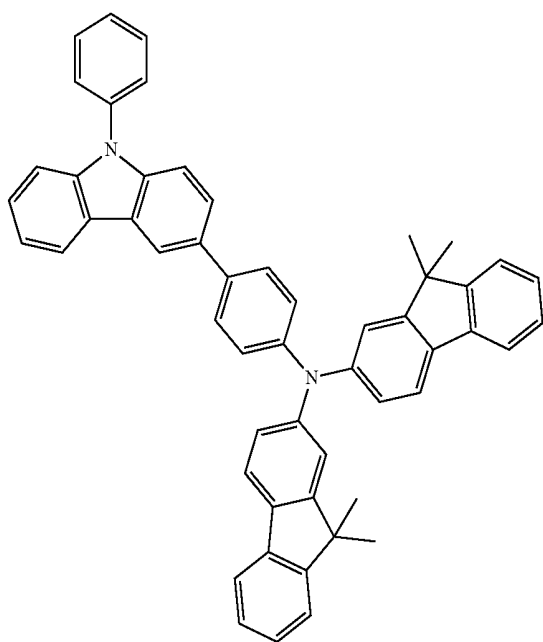
HT8



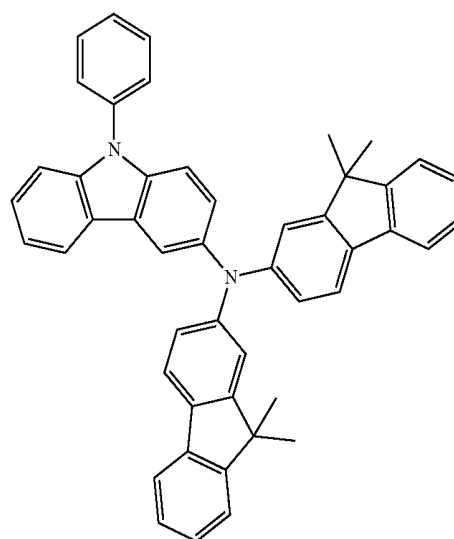
HT10



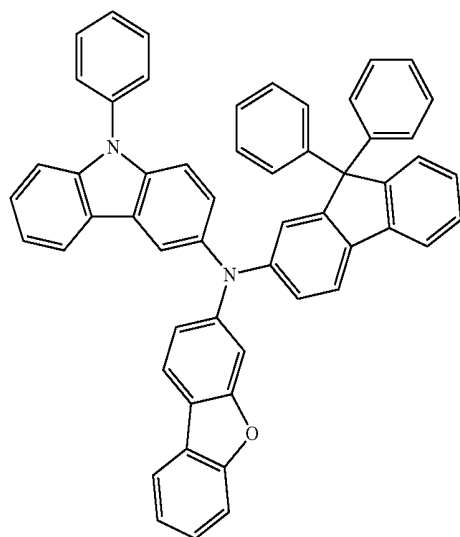
HT9



HT11

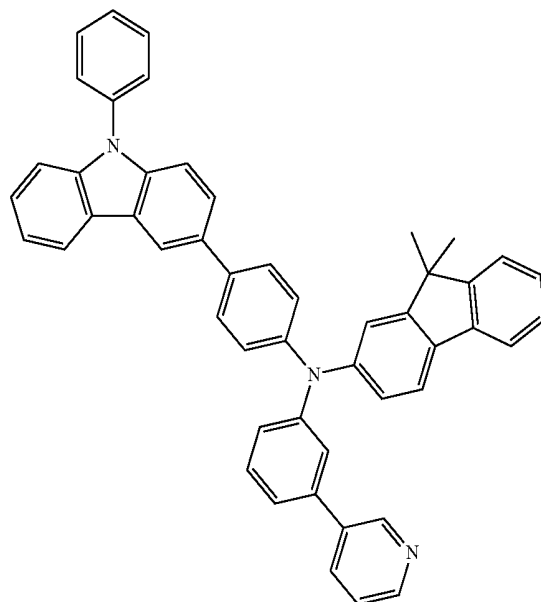


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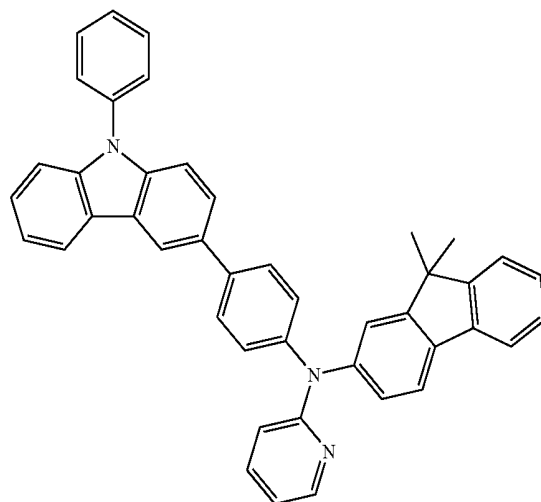
HT12

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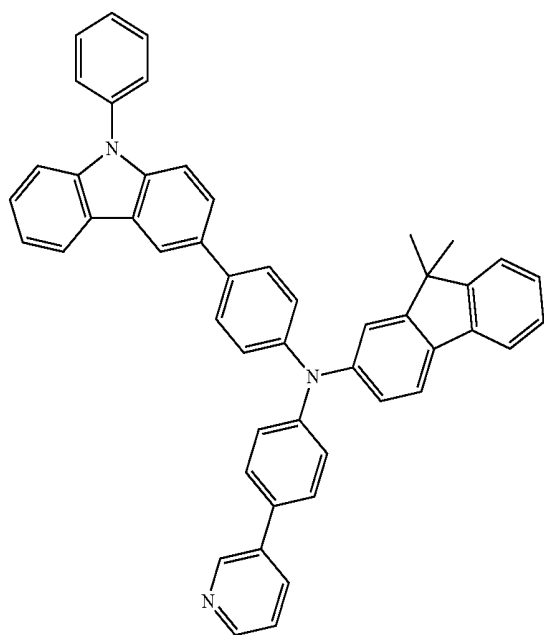


HT14

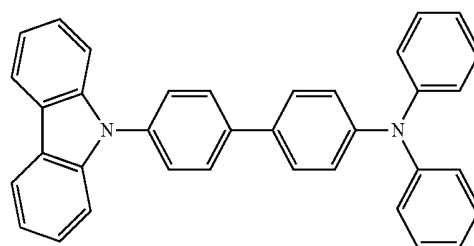
HT15



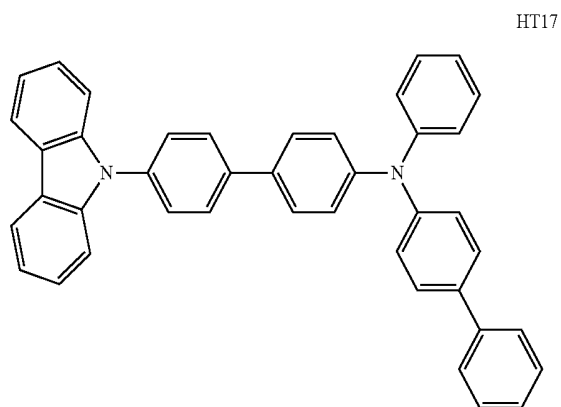
HT13



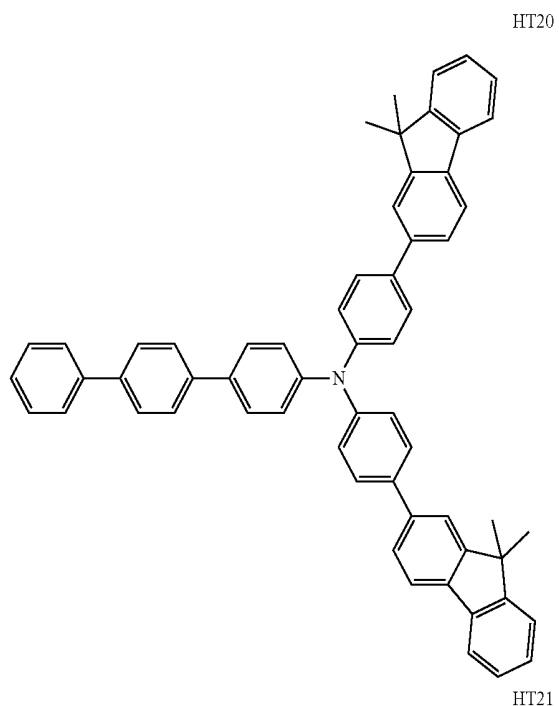
HT16



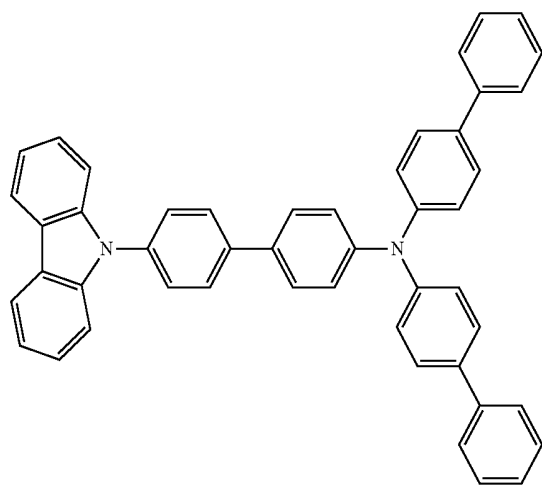
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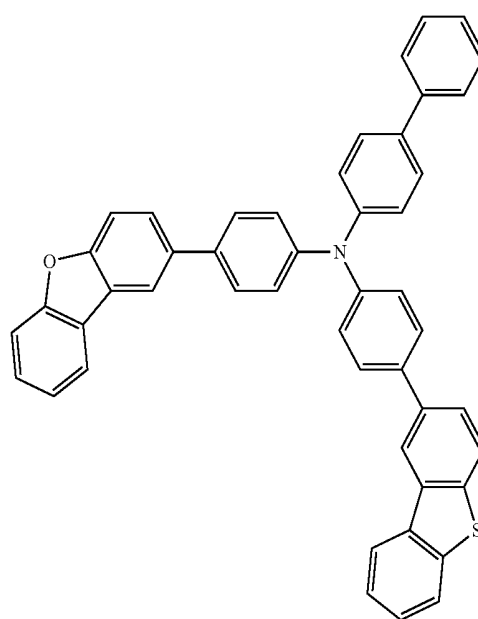
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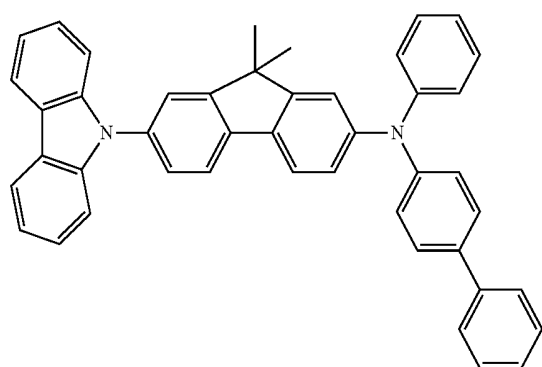
HT18



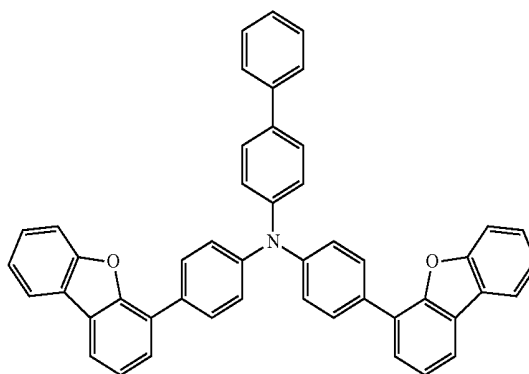
HT21



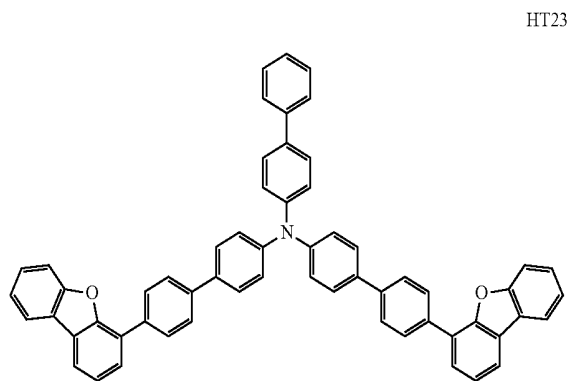
HT19



HT22

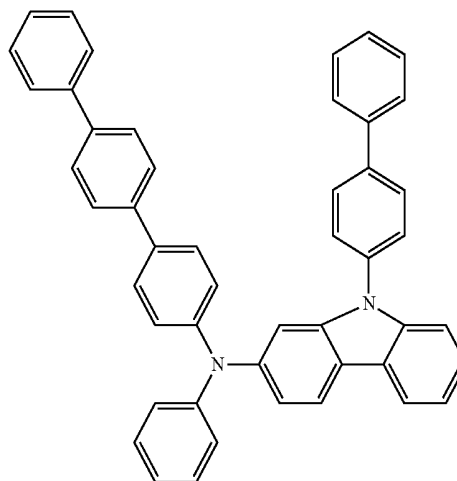


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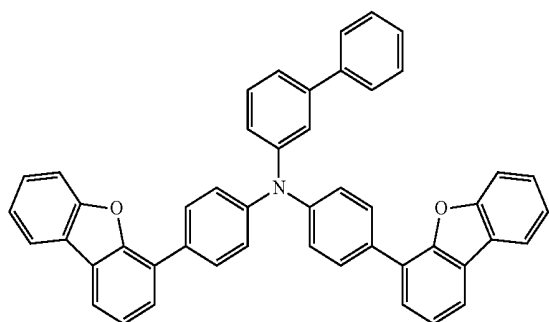


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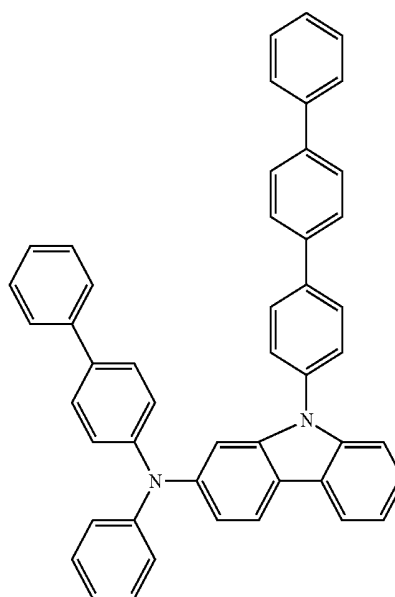
HT26



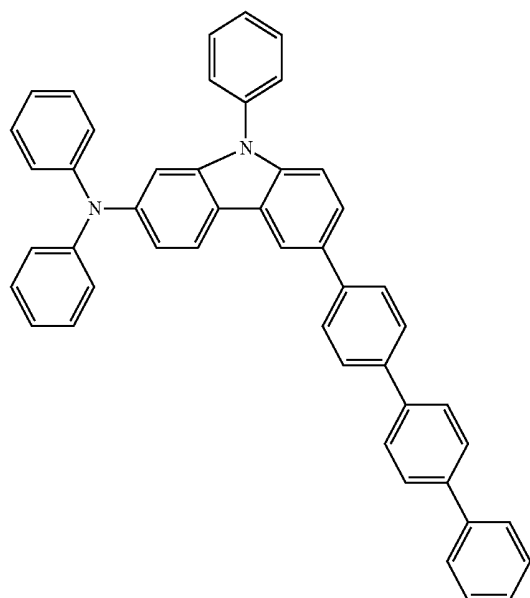
HT24



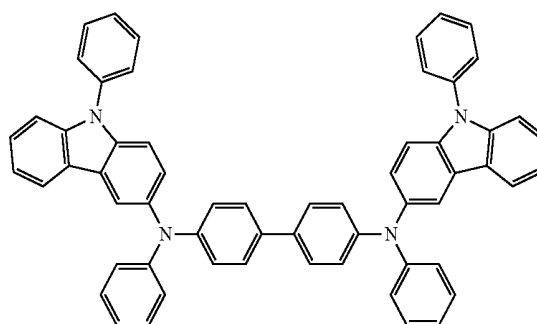
HT27



HT25

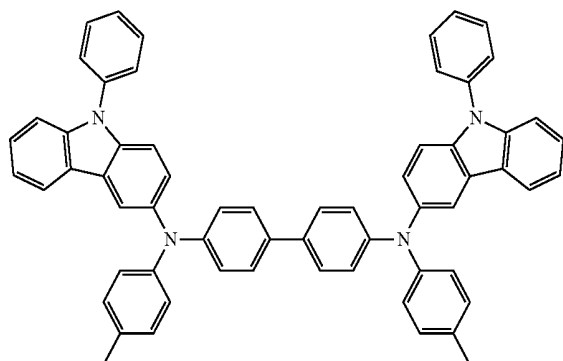


HT28



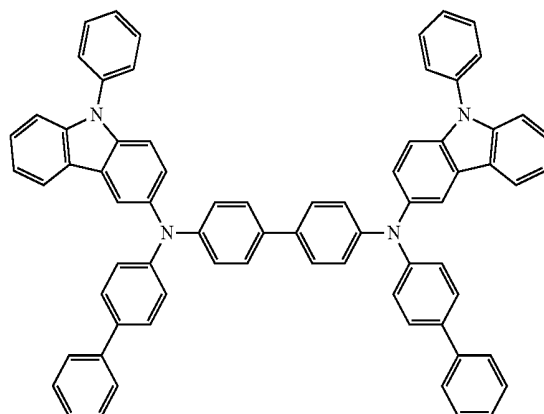
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HT29

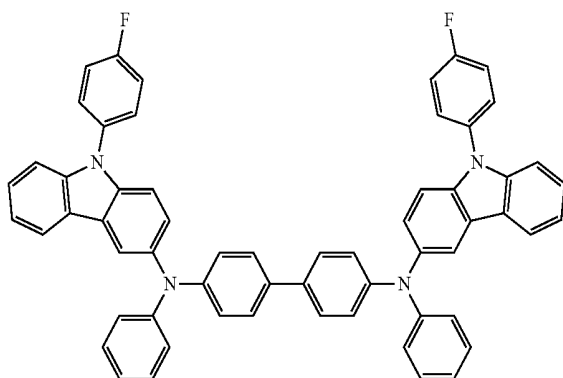


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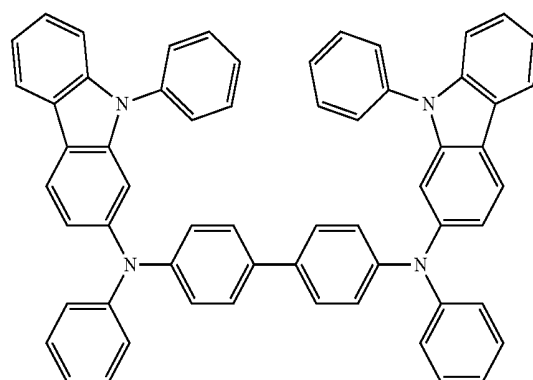
HT33



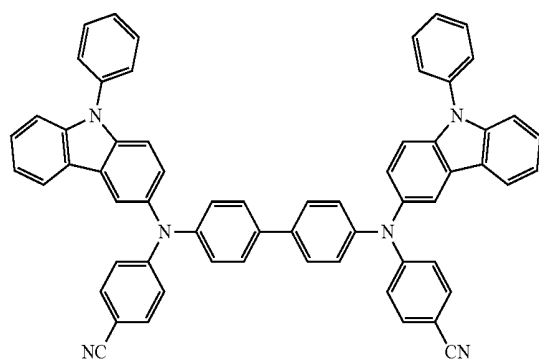
HT30



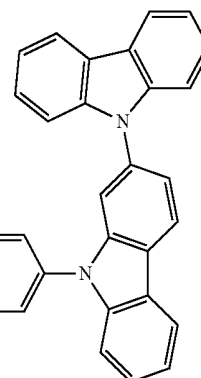
HT34



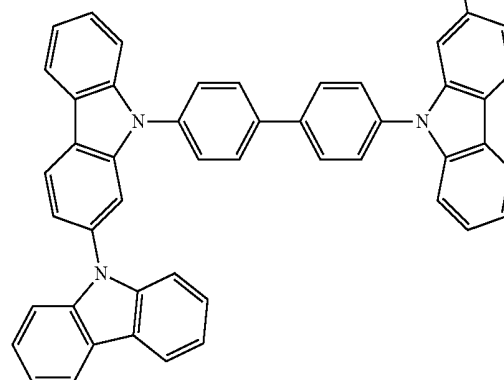
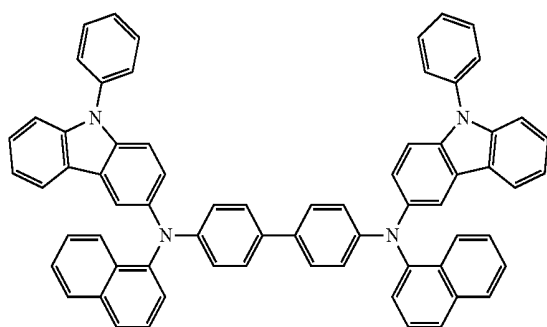
HT31



HT35

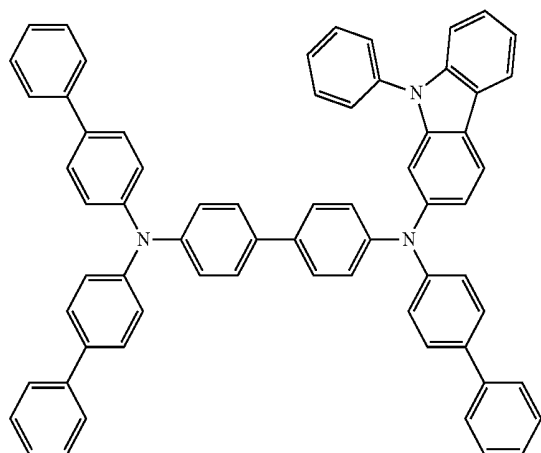


HT32



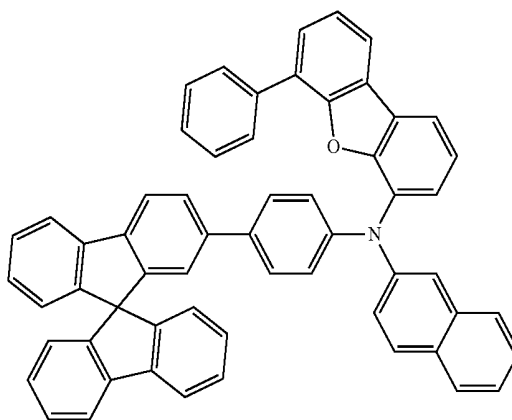
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HT36

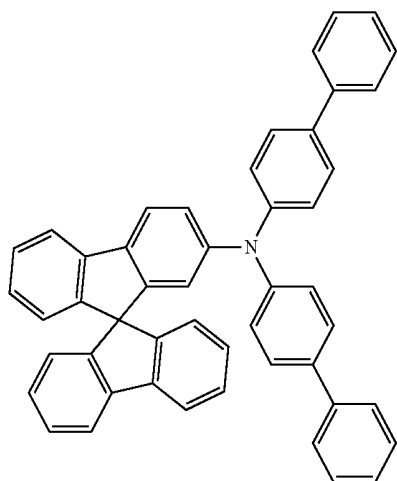


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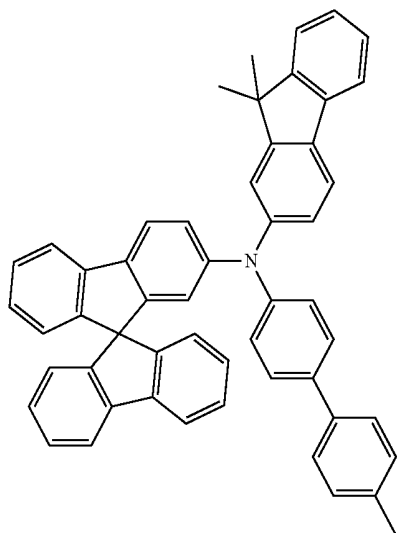
HT39



HT37



HT38



[0215] A thickness of the hole transport region may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å. When the hole transport region includes at least one of a hole injection layer and a hole transport layer, the thickness of the hole injection layer may be in a range of about 100 Å to about 9,000 Å, and for example, about 100 Å to about 1,000 Å, and the thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, and for example, about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are within these ranges, satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

[0216] 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.

[0217] [p-Dopant]

[0218] 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.

[0219] The charge-generation material may be, for example, a p-dopant.

[0220] In one embodiment, the p-dopant may have a lowest unoccupied molecular orbital (LUMO) energy level (eV) of -3.5 eV or less.

[0221] 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.

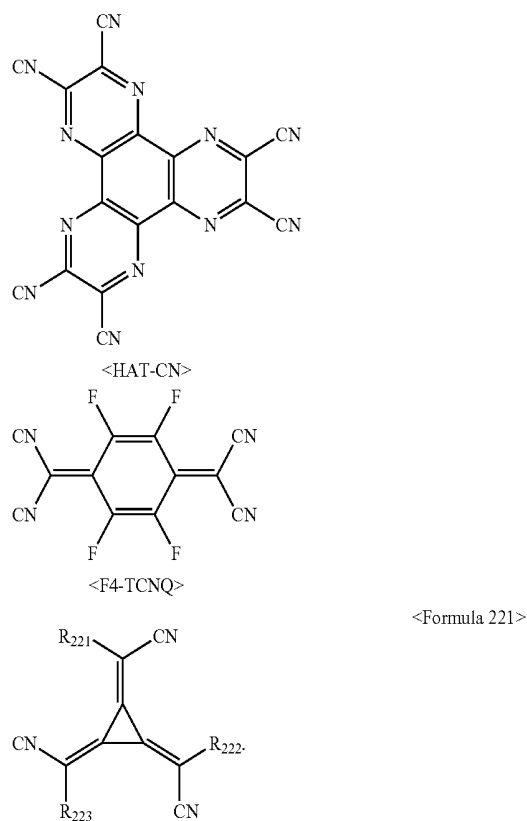
[0222] For example, the p-dopant may include at least one selected from:

[0223] a quinone derivative, such as tetracyanoquinodimethane (TCNQ) and 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ);

[0224] a metal oxide, such as tungsten oxide or molybdenum oxide;

[0225] 1,4,5,8,9,11-hexaazatriphenylene-hexacarbonitrile (HAT-CN); and

[0226] a compound represented by Formula 221,
[0227] but embodiments of the present disclosure are not limited thereto:



[0228] In Formula 221,

[0229] 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} 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_{221} to R_{223} may have at least one substituent selected from a cyano group, —F, —Cl, —Br, —I, a C_1 - C_{20} alkyl group substituted with —F, a C_1 - C_{20} alkyl group substituted with —Cl, a C_1 - C_{20} alkyl group substituted with —Br, and a C_1 - C_{20} alkyl group substituted with —I.

[0230] [Emission Layer in Organic Layer 150]

[0231] 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.

[0232] 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.

[0233] An amount of the dopant may be conventionally 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.

[0234] A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, for example, about 200 Å to about 600 Å. When the thickness of the emission layer is within this range, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

[0235] [Host in Emission Layer]

[0236] In one or more embodiments, the host may include a compound represented by Formula 301 below.



[0237] In Formula 301,

[0238] Ar_{301} may be a substituted or unsubstituted C_5 - C_{60} carbocyclic group or a substituted or unsubstituted C_1 - C_{60} heterocyclic group,

[0239] $xb11$ may be 1, 2, or 3,

[0240] L_{301} may each independently be selected from a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_1 - C_{60} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_1 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group;

[0241] $xb1$ may be an integer from 0 to 5,

[0242] R_{301} 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 substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_{301})(Q_{302})(Q_{303}), —N(Q_{301})(Q_{302}), —B(Q_{301})(Q_{302}), —C(=O)(Q_{301}), —S(=O)₂(Q_{301}), and —P(=O)(Q_{301})(Q_{302}),

[0243] $xb21$ may be an integer from 1 to 5, and

[0244] Q_{301} to Q_{303} 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, a terphenyl group, and a naphthyl group, but embodiments of the present disclosure are not limited thereto.

[0245] In one embodiment, Ar_{301} in Formula 301 may be selected from:

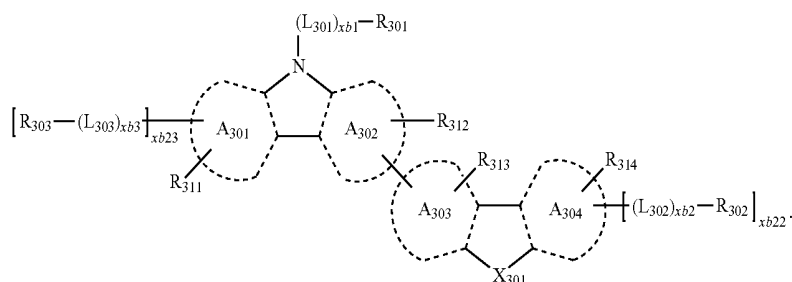
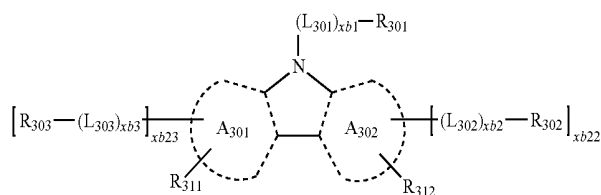
[0246] a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, and a dibenzothiophene group; and

[0247] 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, and a dibenzothiophene group, each substituted with at least one selected from deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$, and $-P(=O)(Q_{31})(Q_{32})$, and

[0248] Q_{31} to Q_{33} 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, a terphenyl group, and a naphthyl group. However, embodiments of the present disclosure are not limited thereto.

[0249] When $xb11$ in Formula 301 is two or more, two or more $Ar_{301}(s)$ may be linked via a single bond.

[0250] In one or more embodiments, the compound represented by Formula 301 may be represented by Formula 301-1 or 301-2:



[0251] In Formulae 301-1 and 301-2,

[0252] A_{301} to A_{304} may each independently be selected from a benzene, a naphthalene, a phenanthrene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a pyridine, a

pyrimidine, an indene, a fluorene, a spiro-bifluorene, a benzofluorene, a dibenzofluorene, an indole, a carbazole, benzocarbazole, dibenzocarbazole, a furan, a benzofuran, a dibenzofuran, a naphthofuran, a benzonaphthofuran, dinaphthofuran, a thiophene, a benzothiophene, a dibenzothiophene, a naphthothiophene, a benzonaphthothiophene group, and a dinaphthothiophene group,

[0253] X_{301} may be O, S, or $N-[(L_{304})_{xb4}-R_{304}]$,

[0254] R_{311} to R_{314} 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 phenyl group, a biphenyl group, a terphenyl group, a naphthyl group $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$, and $-P(=O)(Q_{31})(Q_{32})$,

[0255] $xb22$ and $xb23$ may each independently be 0, 1, or 2,

[0256] L_{301} , $xb1$, R_{301} , and Q_{31} to Q_{33} are the same as described above,

[0257] L_{302} to L_{304} may each independently be the same as described in connection with L_{301} ,

[0258] $xb2$ to $xb4$ may each independently be the same as described in connection with $xb1$, and

[0259] R_{302} to R_{304} may each independently be the same as described in connection with R_{301} .

[0260] For example, in Formulae 301, 301-1, and 301-2, L_{301} to L_{304} may each independently be selected from:

[0261] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a diben-

zofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, a pyridinylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group,

an 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

[0262] 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 hexacenylene group, a pentacenylene 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_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 pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group; and

linyl 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_{31})(Q_{32})(Q_{33}), —N(Q_{31})(Q_{32}), —B(Q_{31})(Q_{32}), —C(=O)(Q_{31}), —S(=O)₂(Q_{31}) and —P(=O)(Q_{31})(Q_{32}), and

[0263] Q_{31} to Q_{33} are the same as described above.

[0264] In one embodiment, in Formulae 301, 301-1, and 301-2, R_{301} to R_{304} may each independently be selected from:

[0265] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group; and

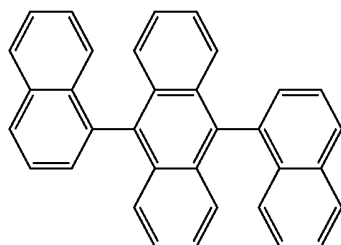
[0266] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an

amidino group, a hydrazino group, a hydrazono group, a C_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 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 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, an azacarbazolyl group, $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$, $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{B}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{C}(=\text{O})(\text{Q}_{31})$, $-\text{S}(=\text{O})_2(\text{Q}_{31})$ and $-\text{P}(=\text{O})(\text{Q}_{31})(\text{Q}_{32})$, and

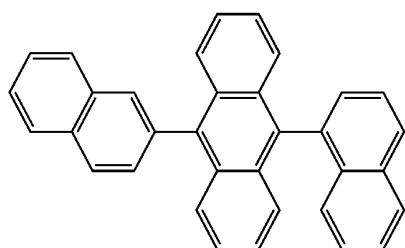
[0267] Q_{31} and Q_{33} are the same as described above.

[0268] In one or more embodiments, the host may include an alkaline earth metal complex. For example, the host may be selected from a Be complex (for example, Compound H55), a Mg complex, and a Zn complex.

[0269] 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:

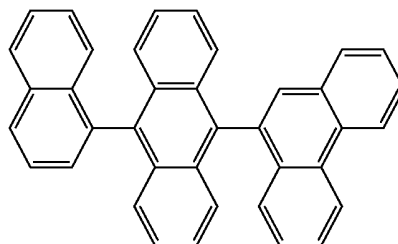


H1

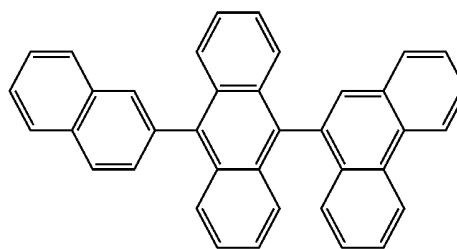


H2

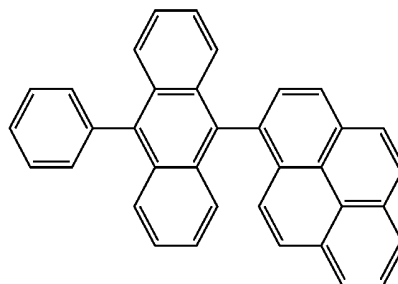
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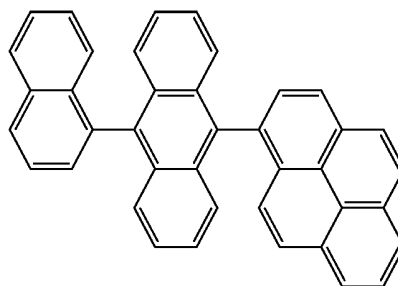
H3



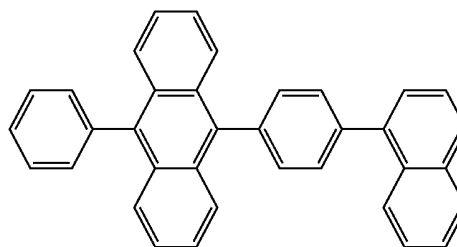
H4



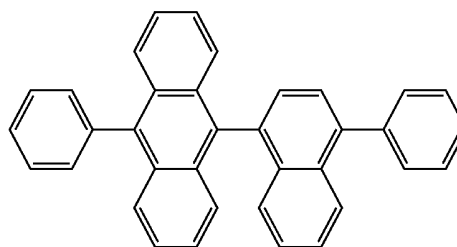
H5



H6



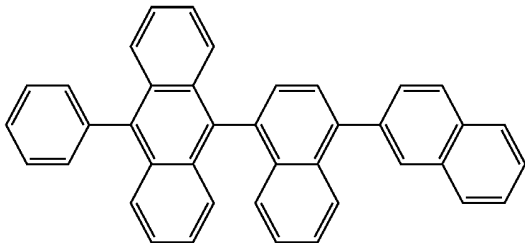
H7



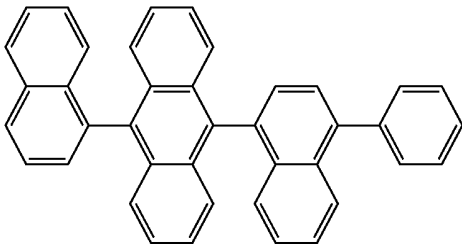
H8

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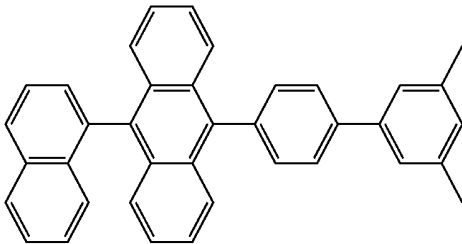
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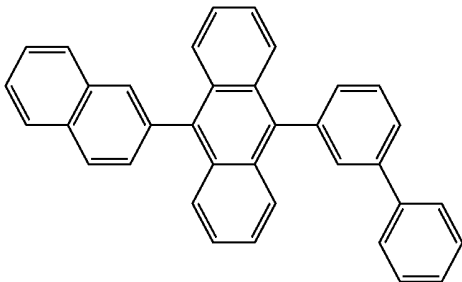
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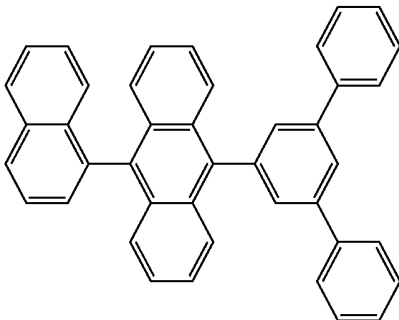
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H12

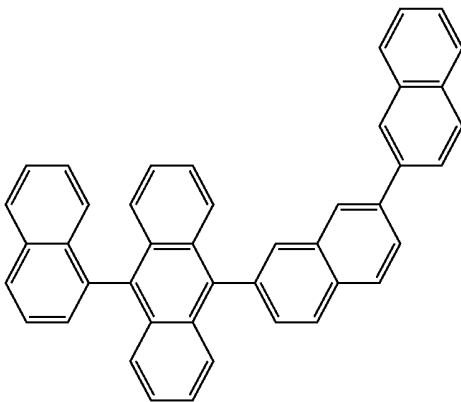


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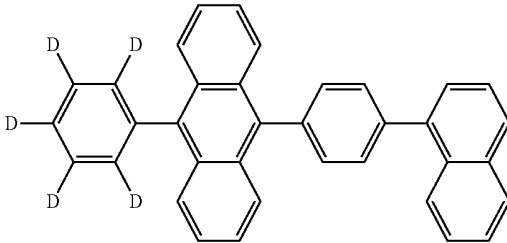


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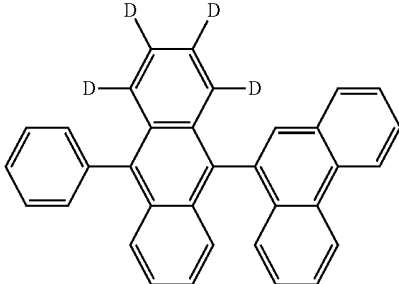
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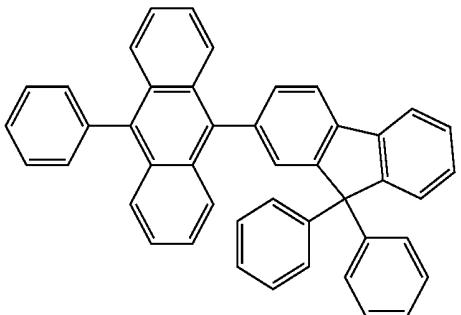
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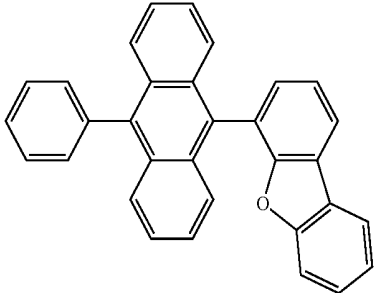
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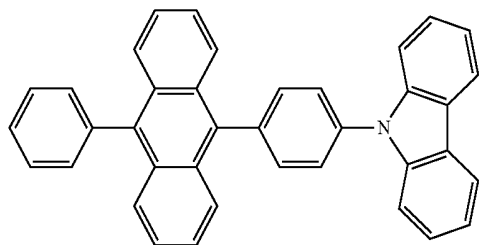
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H18

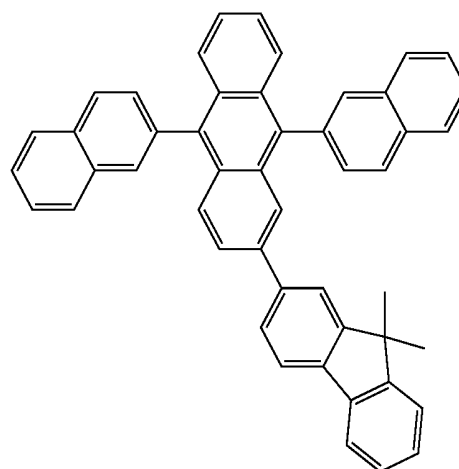


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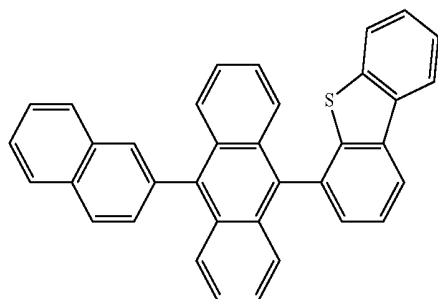


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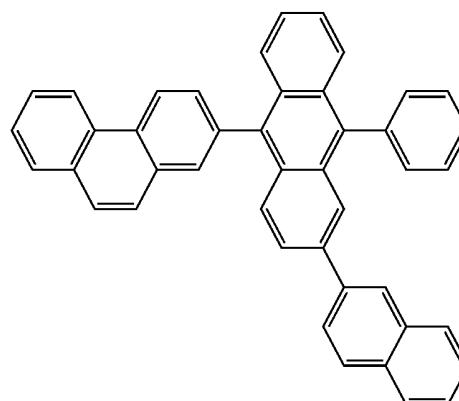
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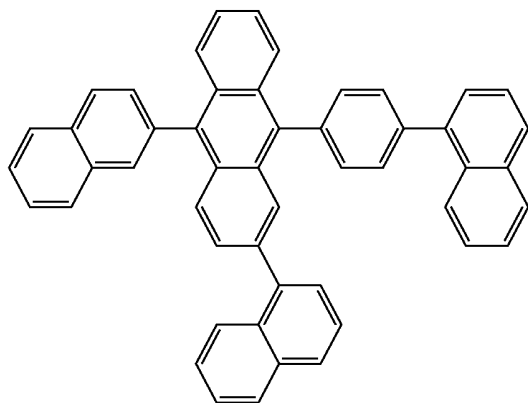
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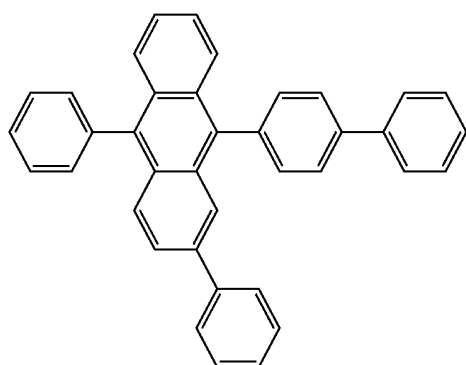
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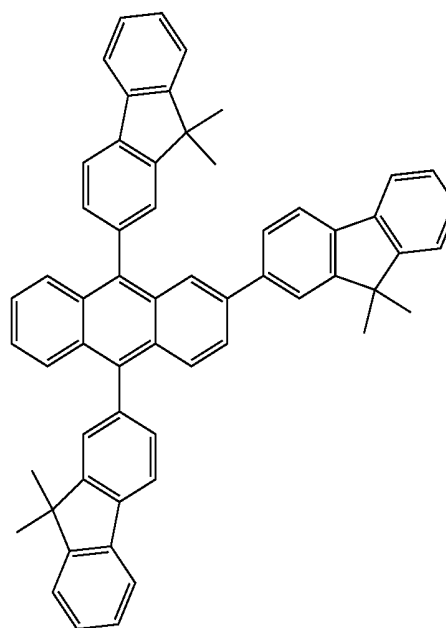
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H21

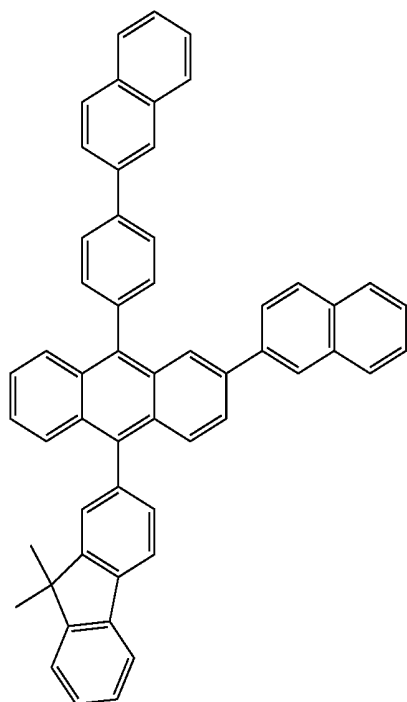


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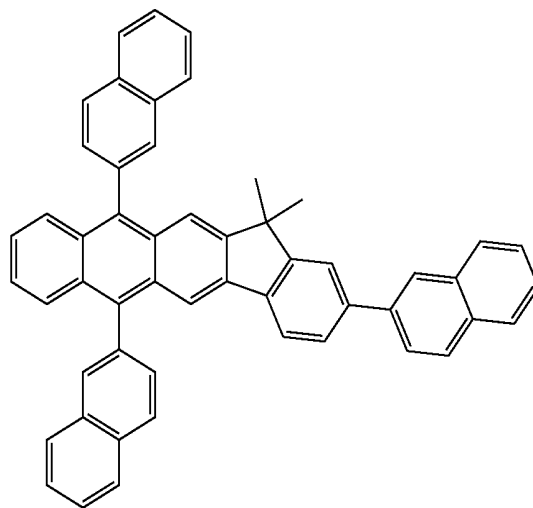
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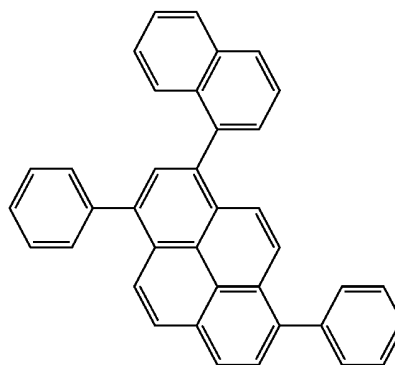
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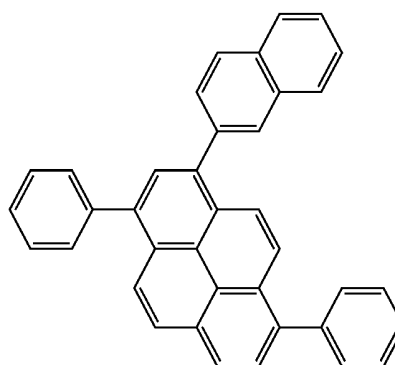


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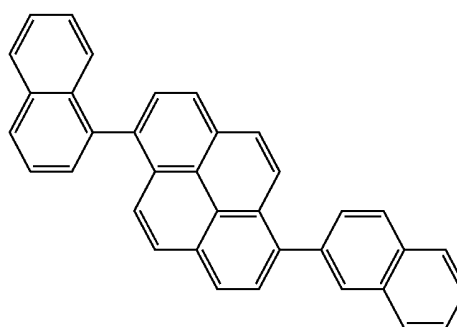
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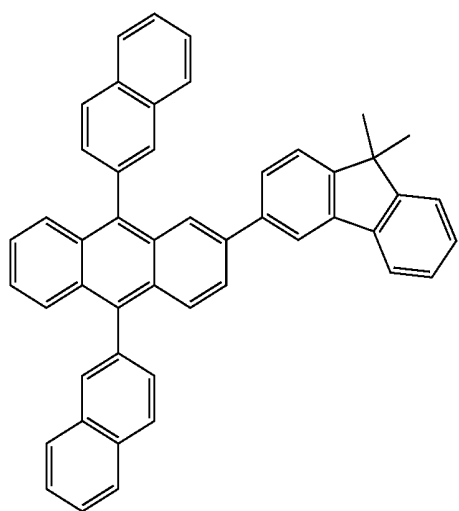
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H31

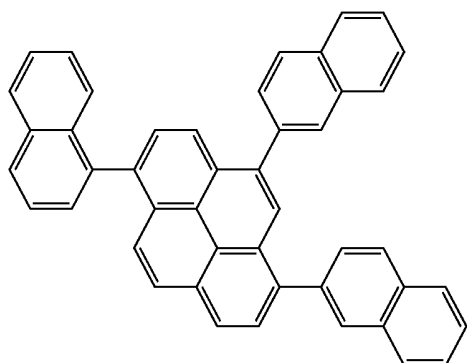


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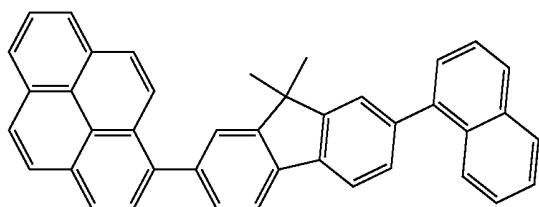


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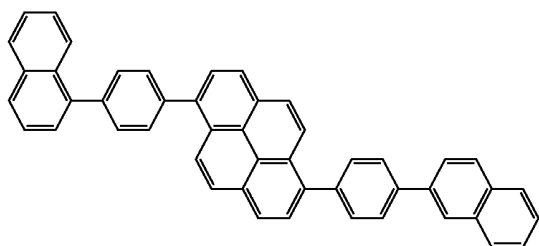
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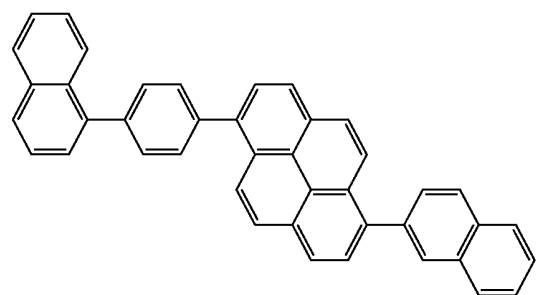
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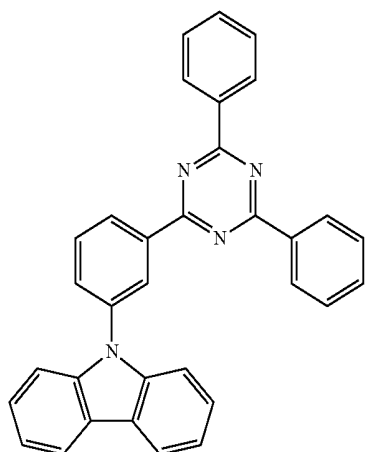
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H35

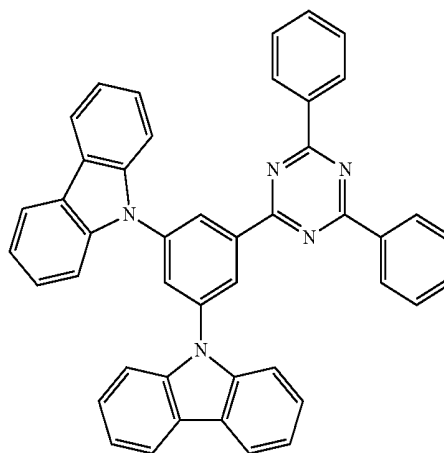


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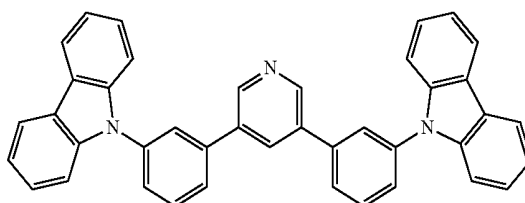


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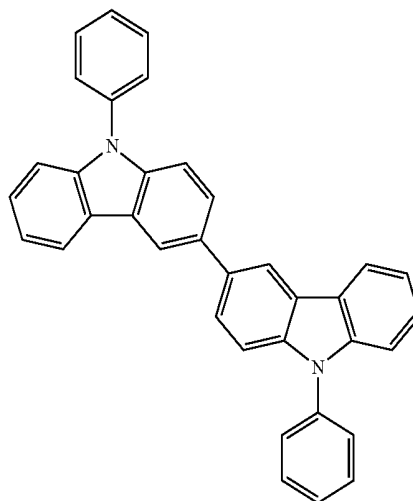
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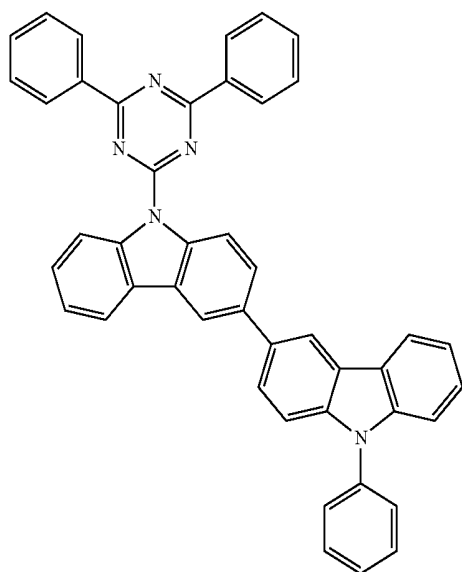
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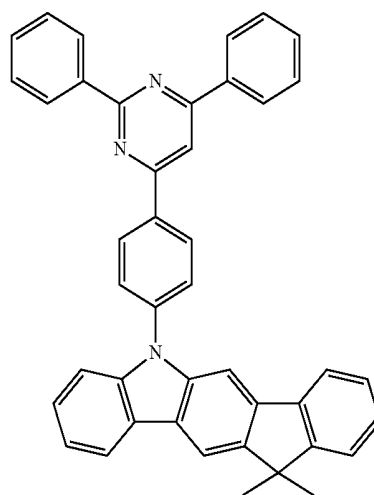


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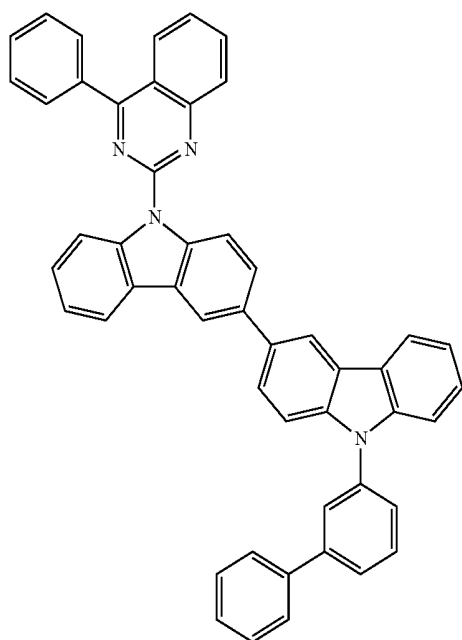


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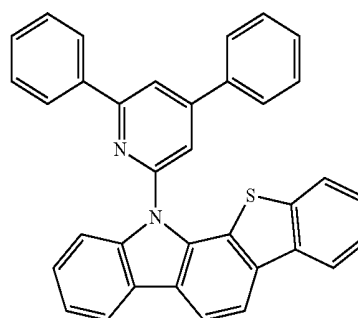
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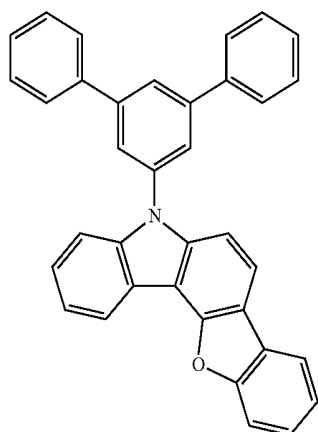
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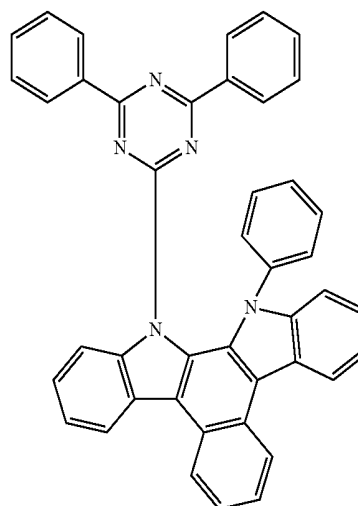
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H44



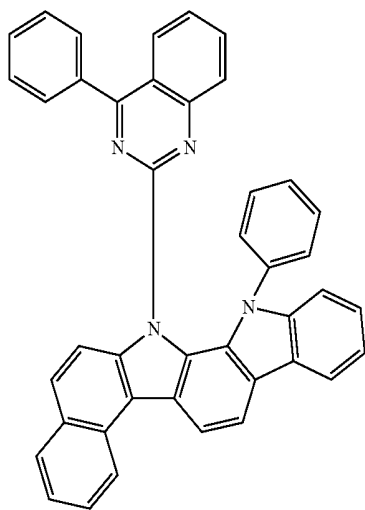
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H45

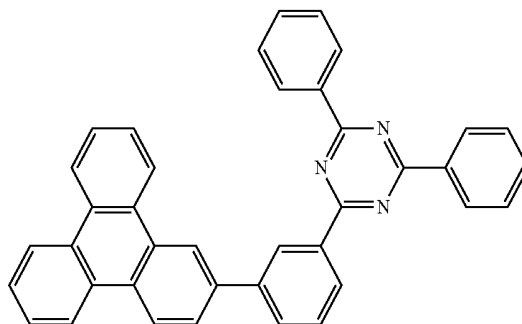
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H46

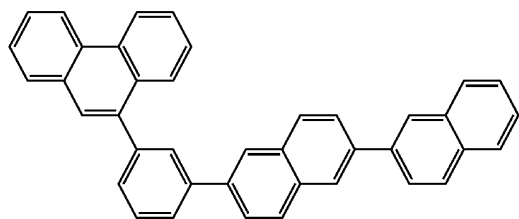


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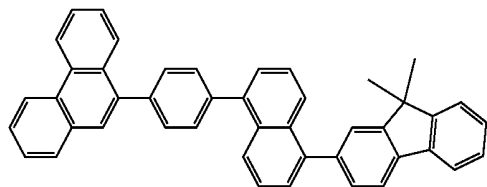
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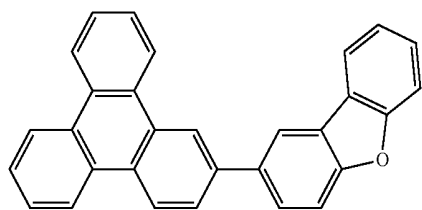
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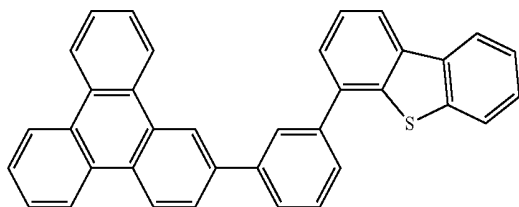
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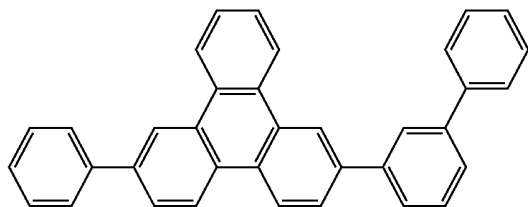
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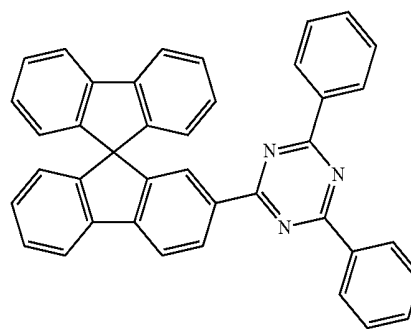
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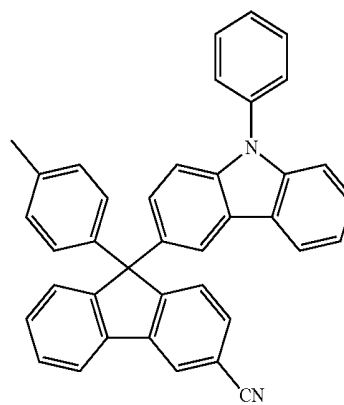
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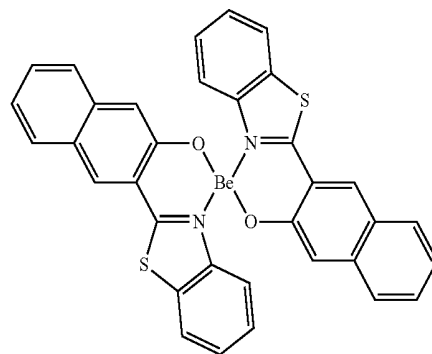
H53



H54

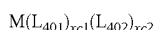


H55



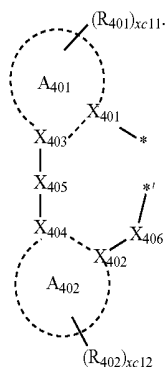
[0270] [Phosphorescent Dopant Included in Emission Layer in Organic Layer 150]

[0271] The phosphorescent dopant may include an organometallic complex represented by Formula 401 below:



<Formula 401>

<Formula 402>



[0272] In Formulae 401 and 402,

[0273] 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),

[0274] 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,

[0275] L_{402} may be an organic ligand, and $xc2$ may be an integer from 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,

[0276] X_{401} to X_{404} may each independently be nitrogen or carbon,

[0277] 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,

[0278] A_{401} and A_{402} may each independently be selected from a C_5 - C_{60} carbocyclic group or a C_1 - C_{60} heterocyclic group,

[0279] 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 $^*C(Q_{411})=^*$, 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,

[0280] X_{406} may be a single bond, O, or S,

[0281] 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_{100} 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_1 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} het-

eroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, 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,

[0282] $xc11$ and $xc12$ may each independently be an integer from 0 to 10, and

[0283] in Formula 402, $*$ and * each indicate a binding site to M of Formula 401.

[0284] 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 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.

[0285] 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 at the same time.

[0286] In one or more embodiments, in Formula 402, R_{401} and R_{402} may each independently be selected from:

[0287] 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, and a C_1 - C_{20} alkoxy group;

[0288] 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 hydrazono group, a phenyl group, a naphthyl group, a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, and a norbornenyl group;

[0289] 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 quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

[0290] 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 quinoxalinyl group, a quinazolinyl 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ 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 quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

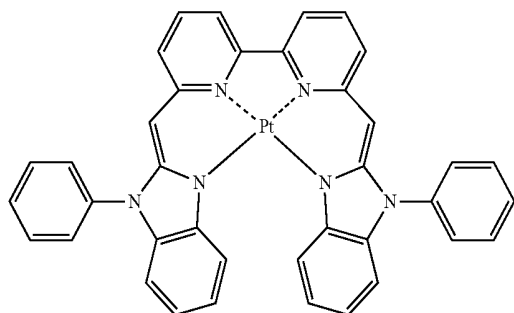
[0291] —Si(Q₄₀₁)(Q₄₀₂)(Q₄₀₃), —N(Q₄₀₁)(Q₄₀₂), —B(Q₄₀₁)(Q₄₀₂), —C(=O)(Q₄₀₁), —S(=O)₂(Q₄₀₁), and —P(=O)(Q₄₀₁)(Q₄₀₂), and

[0292] Q₄₀₁ to Q₄₀₃ may each independently be selected from a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, a phenyl group, a biphenyl group, and a naphthyl group, but are not limited thereto.

[0293] In one or more embodiments, when xc1 in Formula 401 is two or more, two A₄₀₁(s) in two or more L₄₀₁(S) may optionally be linked via X₄₀₇, which is a linking group, or two A₄₀₂(S) in two or more L₄₀₁(s) may optionally be linked via X₄₀₈, which is a linking group (see Compounds PD1 to PD4 and PD7). X₄₀₇ and X₄₀₈ may each independently be a single bond, *—O—*, *—S—*, *—C(=O)—*, *—N(Q₄₁₃)—*, *—C(Q₄₁₃)(Q₄₁₄)—*, or *—C(Q₄₁₃)=C(Q₄₁₄)—* (wherein Q₄₁₃ and Q₄₁₄ may each independently be hydrogen, deuterium, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group), but are not limited thereto.

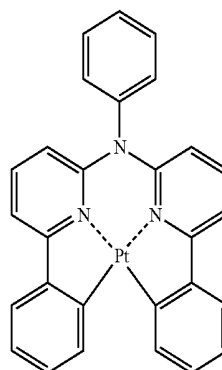
[0294] L₄₀₂ in Formula 401 may be a monovalent, divalent, or trivalent organic ligand. For example, L₄₀₂ may be selected from halogen, diketone (for example, acetylacetonate), carboxylic acid (for example, picolinate), —C(=O), isonitrile, —CN, and phosphorus (for example, phosphine, or phosphite), but embodiments of the present disclosure are not limited thereto.

[0295] 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:

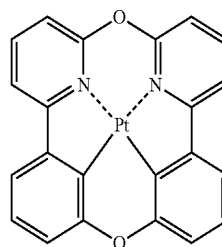


PD1

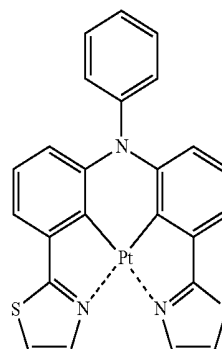
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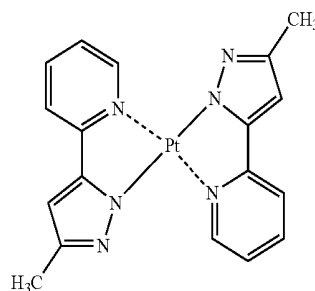
PD2



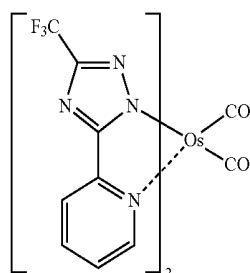
PD3



PD4

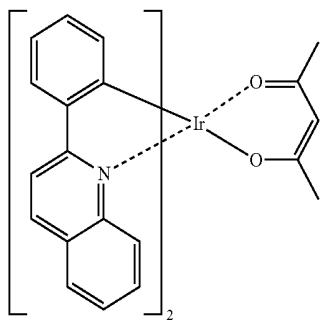
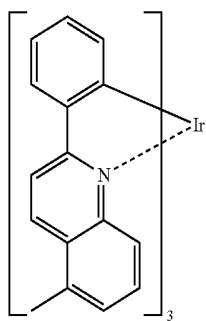
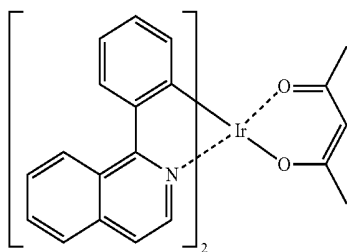
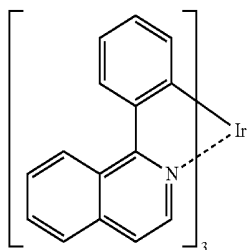
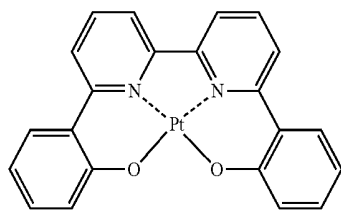


PD5



PD6

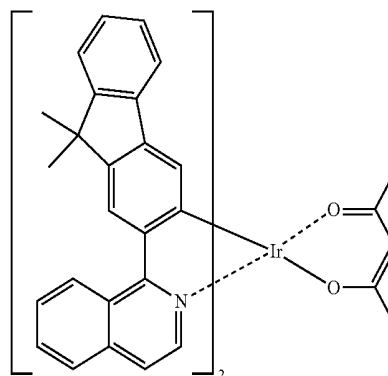
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PD7

PD12

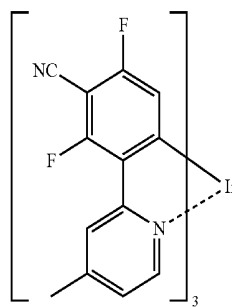
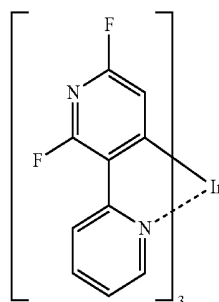
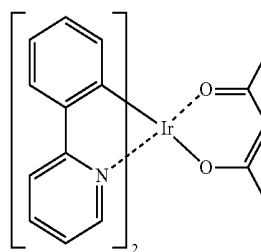
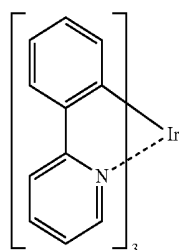


PD8

PD9

PD10

PD11



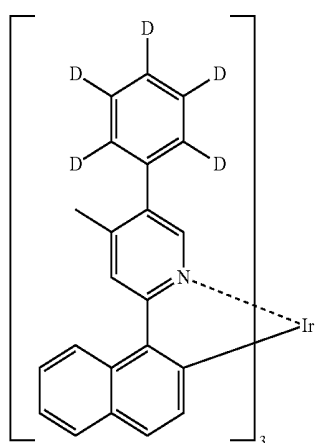
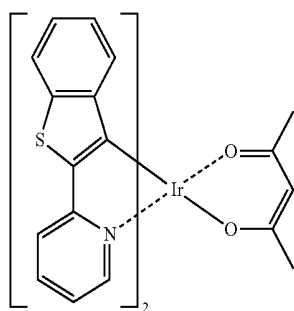
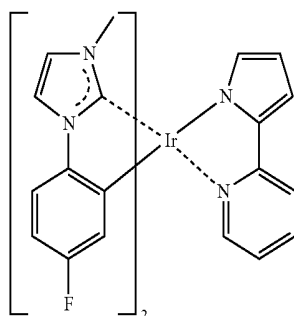
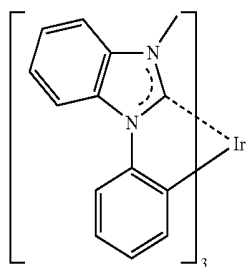
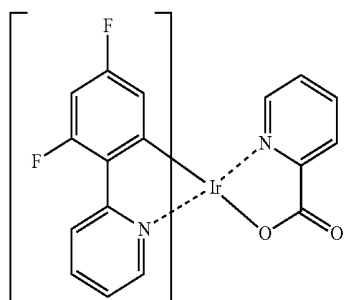
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PD14

PD15

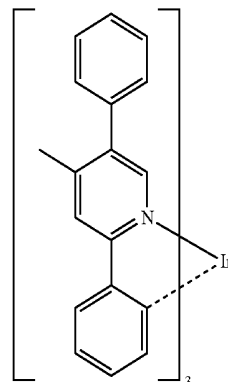
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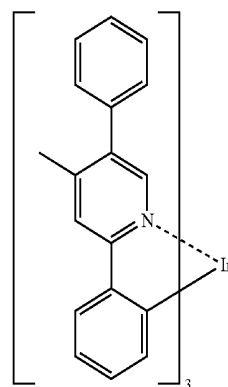
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PD17



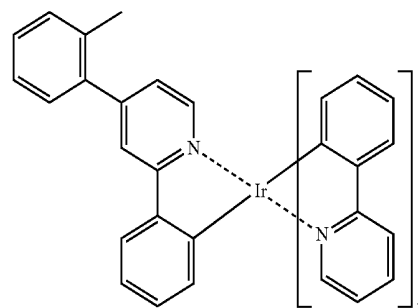
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PD18



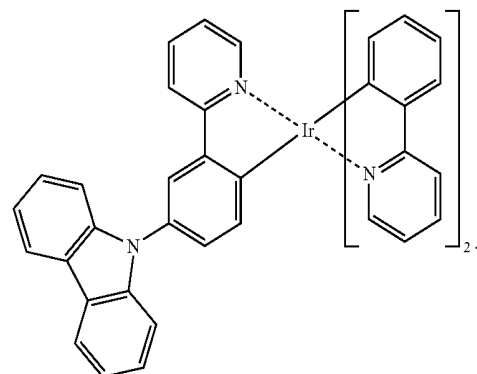
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PD19



PD24

PD20



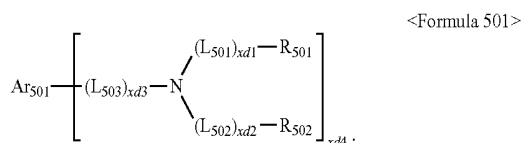
PD25

PD21

[0296] [Fluorescent Dopant in Emission Layer]

[0297] The fluorescent dopant may include an arylamine compound or a styrylamine compound.

[0298] The fluorescent dopant may include a compound represented by Formula 501 below.



[0299] In Formula 501,

[0300] 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,

[0301] L_{501} to 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 $\text{C}_1\text{-C}_{60}$ 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,

[0302] xd1 to xd3 may each independently be an integer of 0 to 3;

[0303] R_{501} and 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 $\text{C}_6\text{-C}_{60}$ 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, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, and

[0304] xd4 may be an integer of 1 to 6.

[0305] In one embodiment, Ar_{501} in Formula 501 may be selected from:

[0306] 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 indenanthracene group, and an indenophenanthrene group; and

[0307] 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 indenanthracene 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 $\text{C}_1\text{-C}_{20}$ alkyl group, a $\text{C}_1\text{-C}_{20}$ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0308] In one or more embodiments, L_{501} to L_{503} in Formula 501 may each independently be selected from:

[0309] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, an indenanthracenylenylene group, and an indenophenanthrenylene 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

group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, a pyridinylenylene group; and

[0310] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, and a pyridinylenylene group, each substituted with at least one selected from deuterium, ---F , ---Cl , ---Br , ---I , a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a $\text{C}_1\text{-C}_{20}$ alkyl group, a $\text{C}_1\text{-C}_{20}$ alkoxy group, a 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 benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group.

[0311] In one or more embodiments, in Formula 501, R_{501} and R_{502} may each independently be selected from:

[0312] 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

[0313] 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

C₁-C₂₀ alkyl group, a C₁-C₂₀ 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(Q₃₁)(Q₃₂)(Q₃₃), and

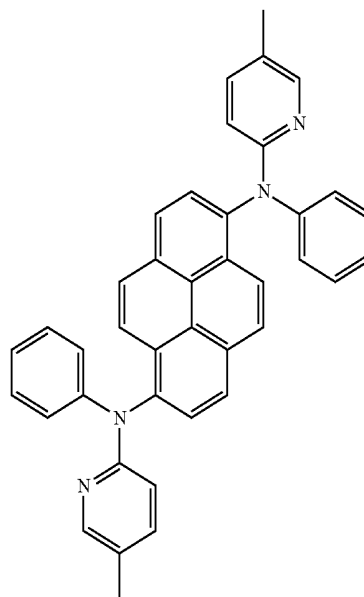
[0314] Q₃₁ to Q₃₃ may each be selected from a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0315] In one or more embodiments, xd4 in Formula 501 may be 2, but embodiments of the present disclosure are not limited thereto.

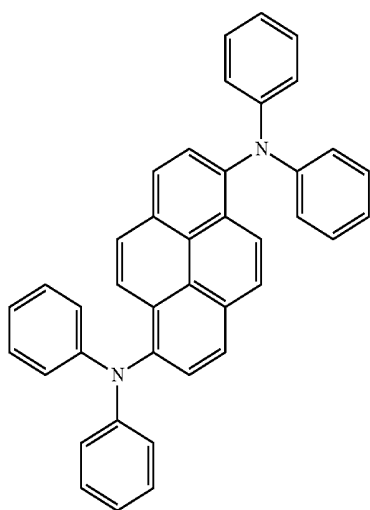
[0316] For example, the fluorescent dopant may be selected from Compounds FD1 to

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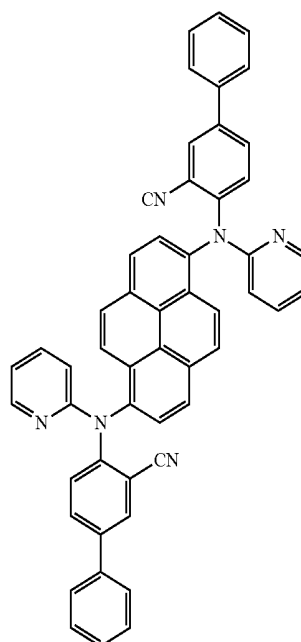
FD3



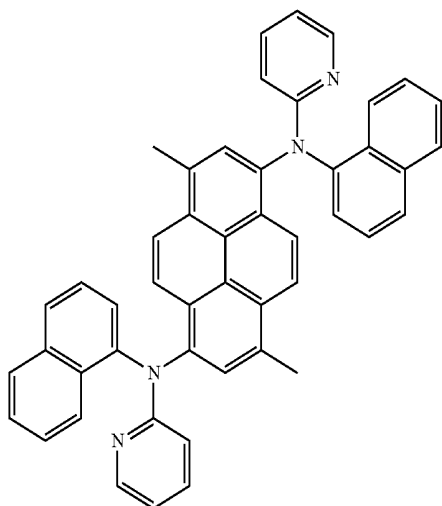
FD1



FD4

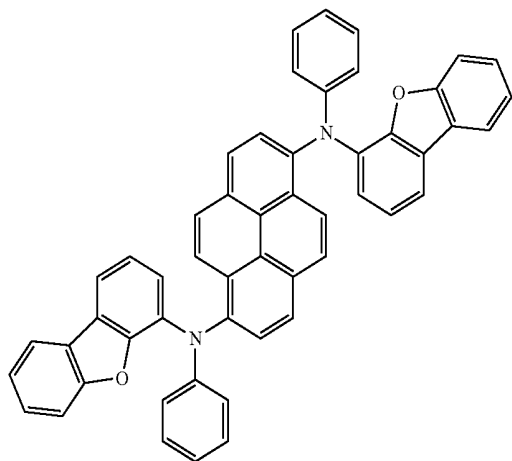


FD2



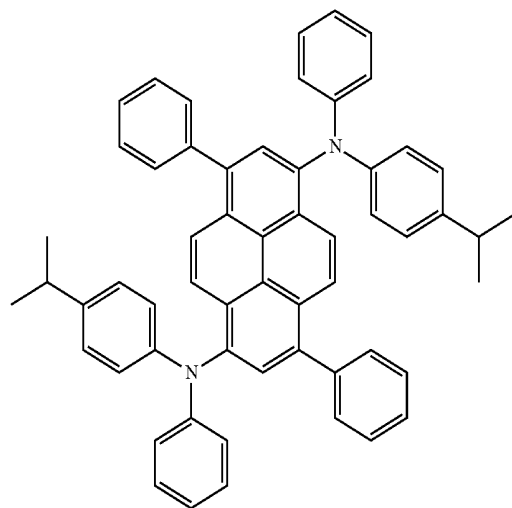
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FD5

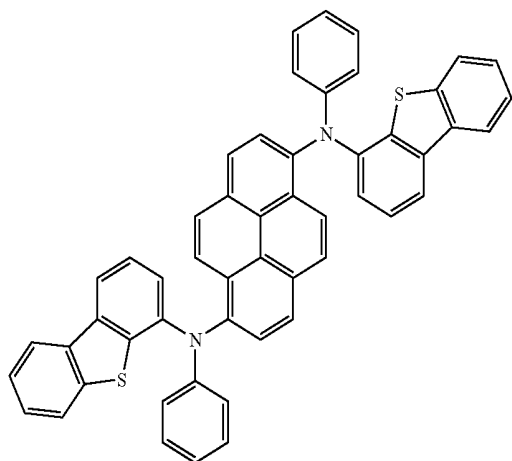


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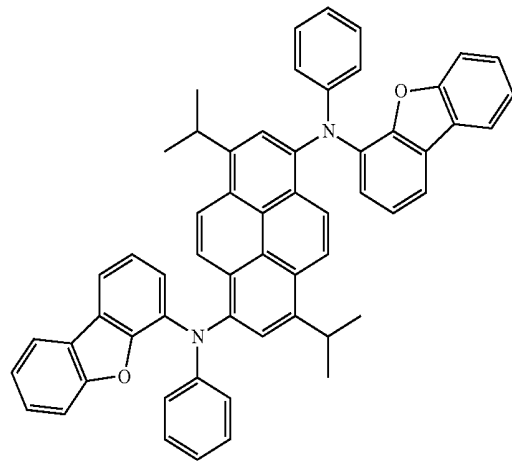
FD8



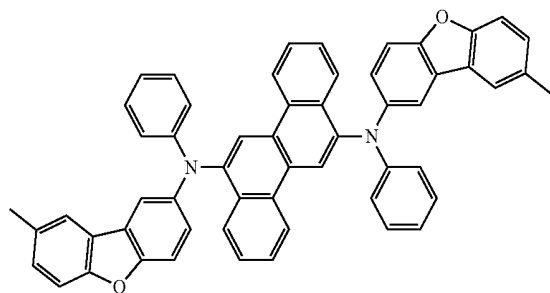
FD6



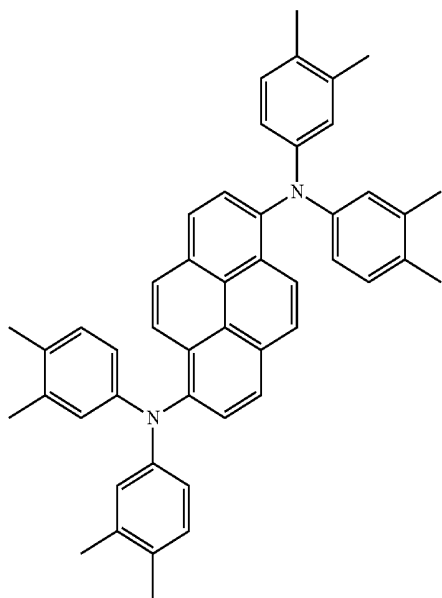
FD9



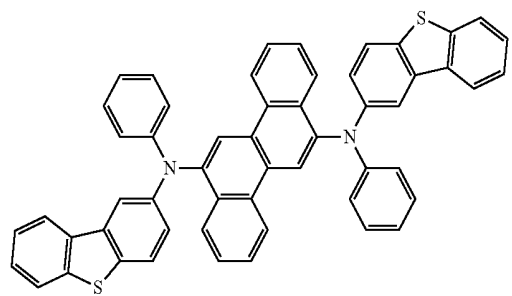
FD10



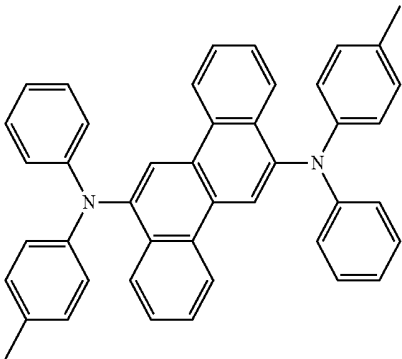
FD7



FD11

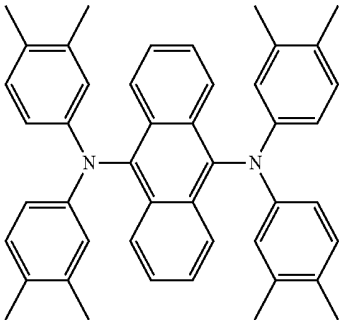


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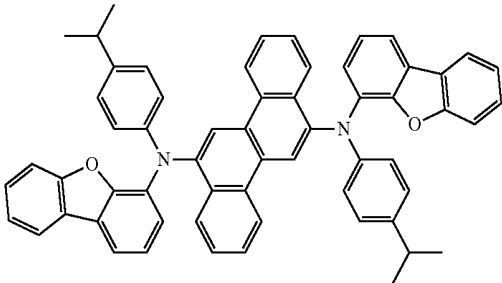


FD12

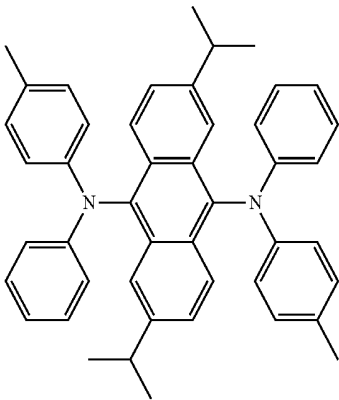
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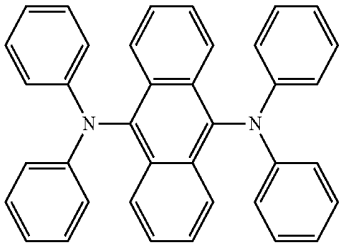
FD17



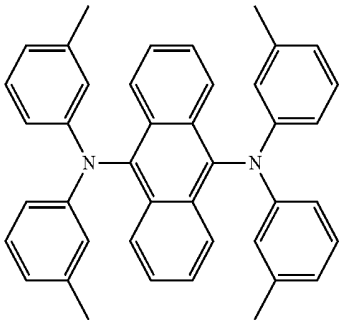
FD13



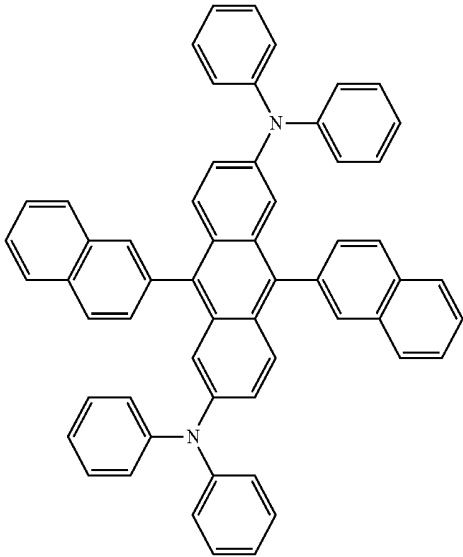
FD18



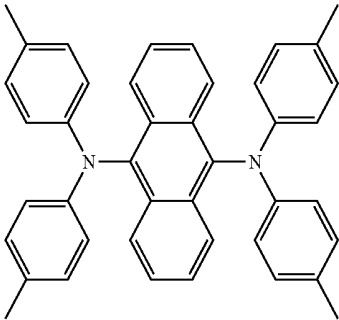
FD14



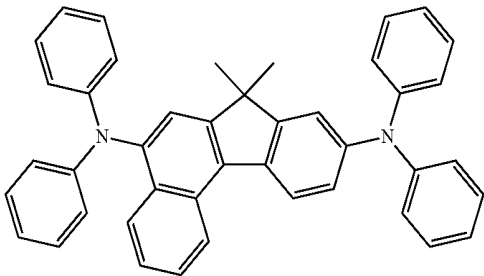
FD15



FD19

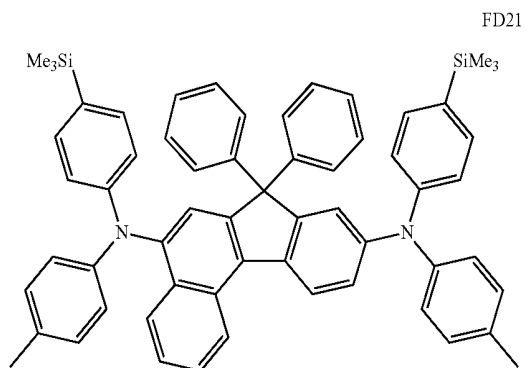


FD16



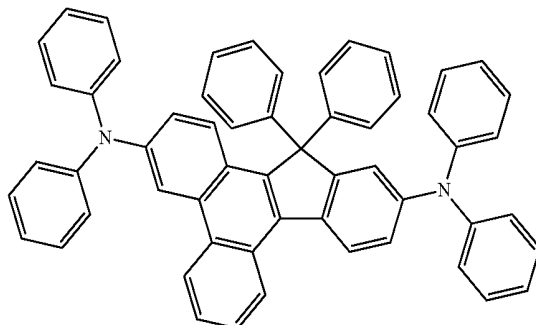
FD20

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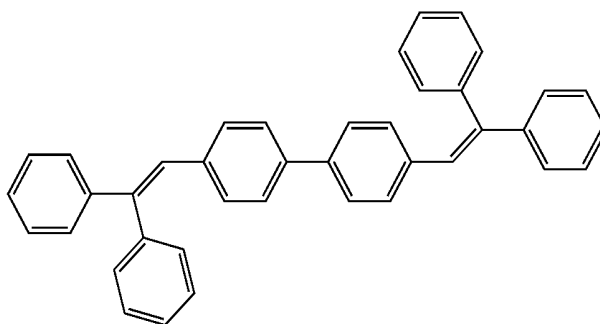
FD21

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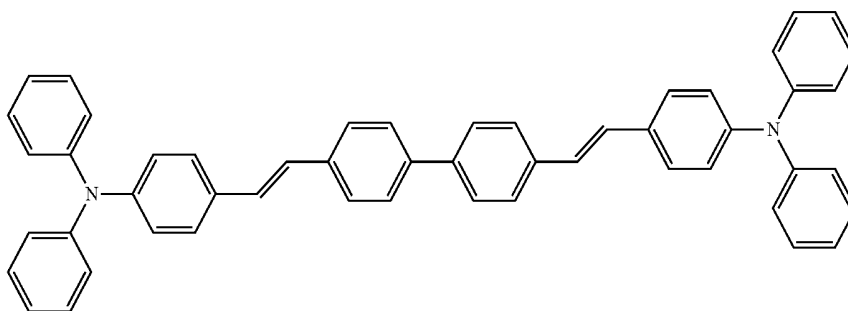


FD22

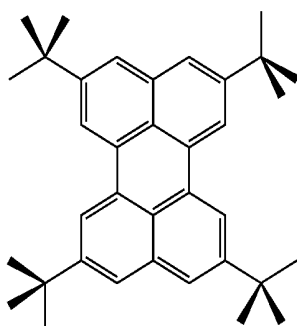
[0317] In one or more embodiments, the fluorescent dopant may be selected from the following compounds, but embodiments of the present disclosure are not limited thereto.



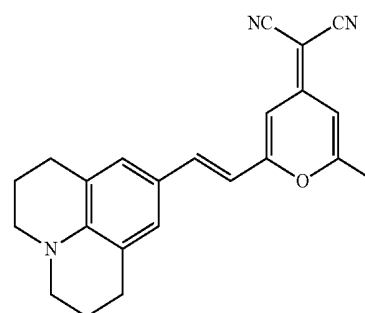
DPVBi



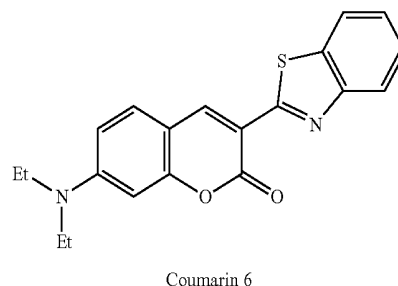
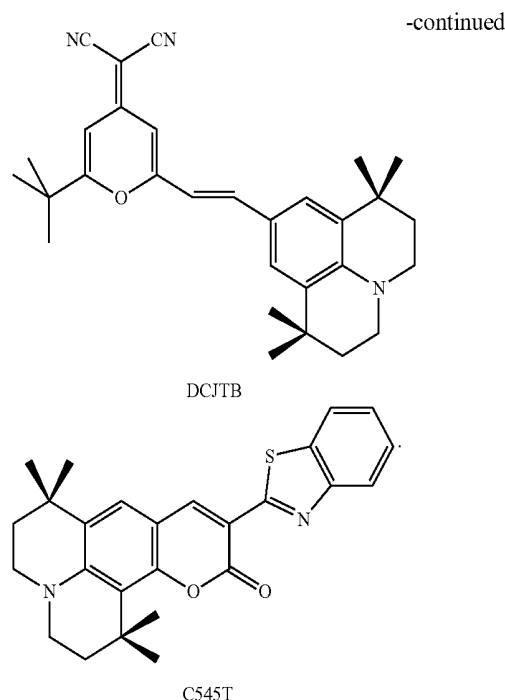
DPAVB



TBPe



DCM



[0318] [Electron Transport Region in Organic Layer 150]

[0319] 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.

[0320] 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.

[0321] 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.

[0322] 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 π electron-depleted nitrogen-containing ring.

[0323] The “ π electron-depleted nitrogen-containing ring” indicates a C_1 - C_{60} heterocyclic group having at least one $*-N=*'$ moiety as a ring-forming moiety.

[0324] For example, the “ π electron-depleted nitrogen-containing ring” may be i) a 5-membered to 7-membered heteromonocyclic group having at least one $*-N=*'$ moiety, ii) a heteropolycyclic group in which two or more 5-membered to 7-membered heteromonocyclic groups each having at least one $*-N=*'$ moiety are condensed with each other, or iii) a heteropolycyclic group in which at least

one of 5-membered to 7-membered heteromonocyclic groups, each having at least one $*-N=*'$ moiety, is condensed with at least one C_5 - C_{60} carbocyclic group.

[0325] Examples of the π 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 quinoxaline, 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, a thiadiazole, an imidazopyridine, an imidazopyrimidine, and an azacarbazole, but are not limited thereto.

[0326] The electron transport region may include a condensed cyclic compound represented by Formula 1.

[0327] For example, the electron transport region may further include, in addition to the condensed cyclic compound represented by Formula 1, a compound represented by Formula 601.



[0328] In Formula 601,

[0329] Ar_{601} may be a substituted or unsubstituted C_5 - C_{60} carbocyclic group or a substituted or unsubstituted C_1 - C_{60} heterocyclic group,

[0330] $xe11$ may be 1, 2, or 3,

[0331] L_{601} may each independently be selected from a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_1 - C_{60} heteroarylene group, a substituted or unsubstituted divalent

non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group;

[0332] xe1 may be an integer from 0 to 5,

[0333] R₆₀₁ may be selected from a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₆₀₁)(Q₆₀₂)(Q₆₀₃), —C(=O)(Q₆₀₁), —S(=O)₂(Q₆₀₁), and —P(=O)(Q₆₀₁)(Q₆₀₂),

[0334] Q₆₀₁ to Q₆₀₃ may each independently be a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group, and

[0335] xe21 may be an integer from 1 to 5.

[0336] In one embodiment, at least one of Ar₆₀₁(s) in the number of xe11 and/or at least one of R₆₀₁(s) in the number of xe21 may include the π electron-depleted nitrogen-containing ring.

[0337] In one embodiment, ring Ar₆₀₁ in Formula 601 may be selected from:

[0338] 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

[0339] 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, —Si(Q₃₁)(Q₃₂)(Q₃₃), —S(=O)₂(Q₃₁), and —P(=O)(Q₃₁)(Q₃₂), and

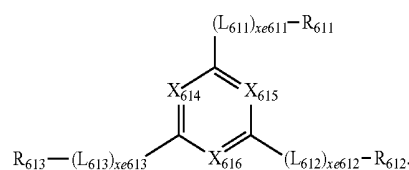
[0340] Q₃₁ to Q₃₃ may each independently be selected from a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0341] When xe11 in Formula 601 is two or more, two or more Ar₆₀₁(s) may be linked via a single bond.

[0342] In one or more embodiments, Ar₆₀₁ in Formula 601 may be an anthracene group.

[0343] In one or more embodiments, a compound represented by Formula 601 may be represented by Formula 601-1:

<Formula 601-1>



[0344] In Formula 601-1,

[0345] X₆₁₄ may be N or C(R₆₁₄), X₆₁₅ may be N or C(R₆₁₅), X₆₁₆ may be N or C(R₆₁₆), and at least one selected from X₆₁₄ to X₆₁₆ may be N,

[0346] L₆₁₁ to L₆₁₃ may each independently be the same as described in connection with L₆₀₁,

[0347] xe611 to xe613 may each independently be the same as described in connection with xe1,

[0348] R₆₁₁ to R₆₁₃ may each independently be the same as described in connection with R₆₀₁, and

[0349] R₆₁₄ to R₆₁₆ 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0350] In one embodiment, L₆₀₁ and L₆₁₁ to L₆₁₃ in Formulae 601 and 601-1 may each independently be selected from:

[0351] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a diben-

zofuranylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylene group, a pyridinylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a thiadiazolylenylene group, an oxadiazolylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a triazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzimidazolylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an imidazopyridinylenylene group, an imidazopyrimidinylenylene group, and an azacarbazolylenylene group; and

[0352] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylene group, a pyridinylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a thiadiazolylenylene group, an oxadiazolylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a triazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzimidazolylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an imidazopyridinylenylene group, an imidazopyrimidinylenylene group, and an azacarbazolylenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ 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 carbazoyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazoyl group, a dibenzocarbazoyl 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 quinolyl group, an isoquinolyl group, a benzoquinolyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl 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 azacarbazoyl group, but are not limited thereto,

group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolyl group, an isoquinolyl group, a benzoquinolyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl 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 azacarbazoyl group, but are not limited thereto,

[0353] but embodiments of the present disclosure are not limited thereto.

[0354] In one or more embodiments, in Formulae 601 and 601-1, xe1 and xe611 to xe613 may each independently be 0, 1, or 2.

[0355] In one or more embodiments, in Formulae 601 and 601-1, R₆₀₁ and R₆₁₁ to R₆₁₃ may each independently be selected from:

[0356] 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 carbazoyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazoyl group, a dibenzocarbazoyl 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 quinolyl group, an isoquinolyl group, a benzoquinolyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl 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 azacarbazoyl group;

[0357] 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 carbazoyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazoyl group, a dibenzocarbazoyl 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 quinolyl group, an isoquinolyl group, a benzoquinolyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalyl group, a quinazolyl group, a cinnolyl 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 azacarbazoyl group, but are not limited thereto,

phenanthrolyl group, a phenaziny 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ 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 benzofuran group, a benzothiophenyl group, a dibenzofuran 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 phenanthrolyl group, a phenaziny 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

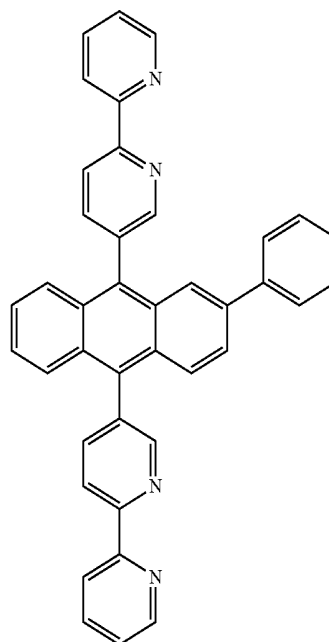
[0358] —S(=O)₂(Q₆₀₁), and —P(=O)(Q₆₀₁)(Q₆₀₂), and

[0359] Q₆₀₁ and Q₆₀₂ are the same as described above.

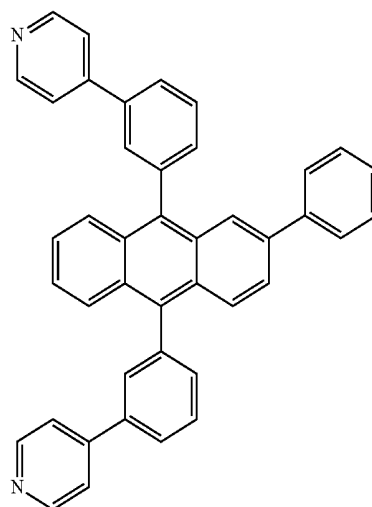
[0360] The electron transport region may include at least one compound selected from Compounds ET1 to ET36, but embodiments of the present disclosure are not limited thereto:

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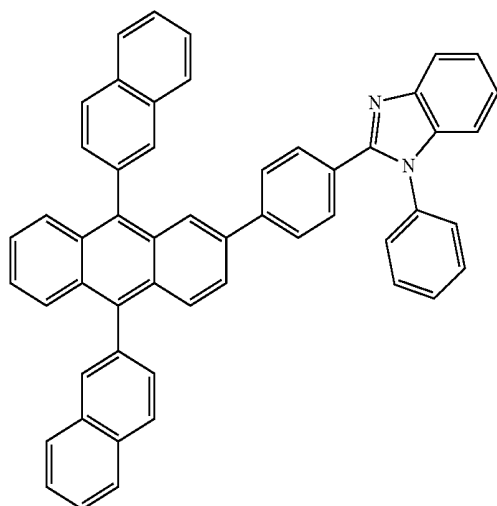
ET2



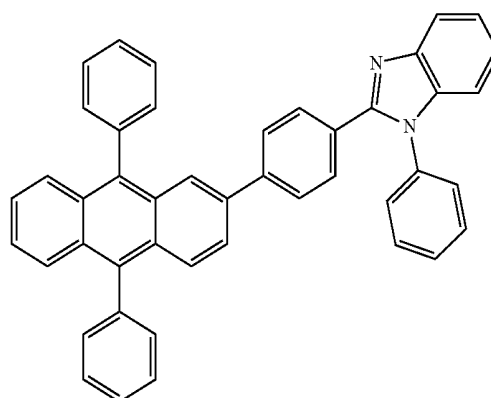
ET3



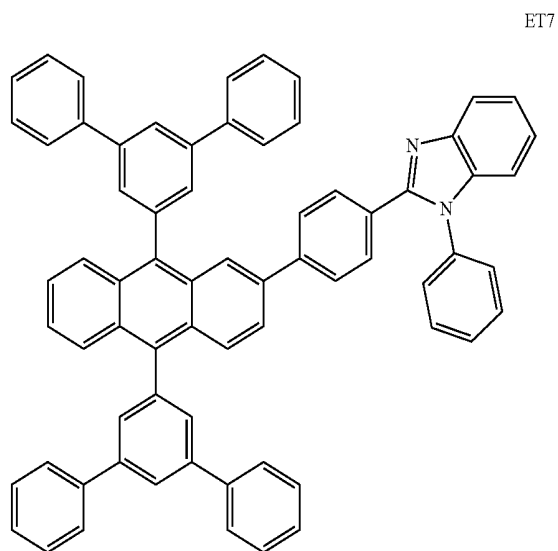
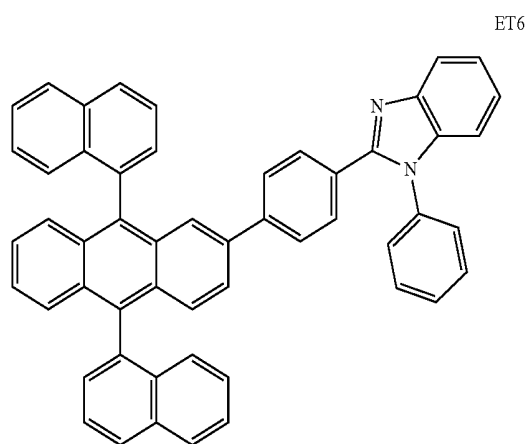
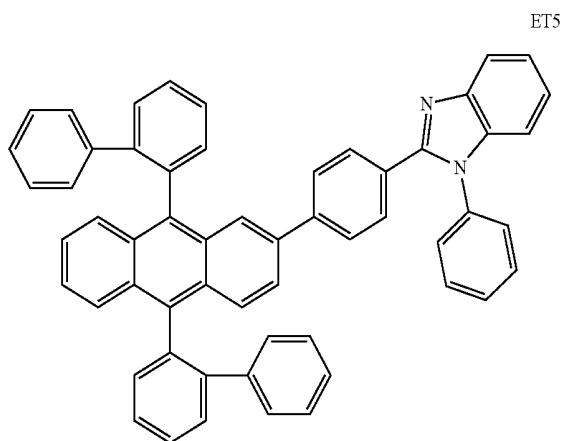
ET1



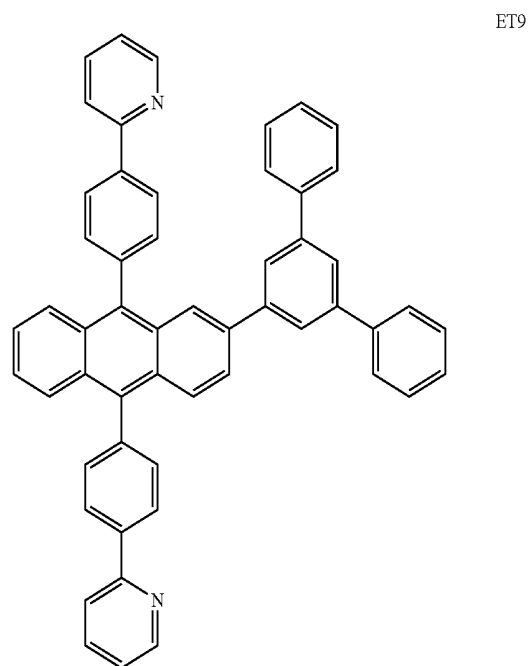
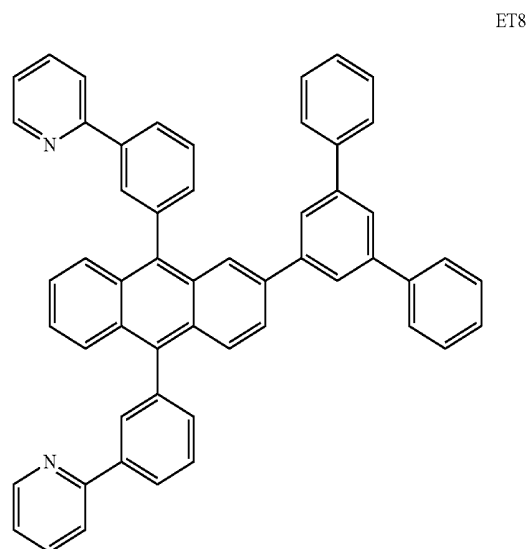
ET4



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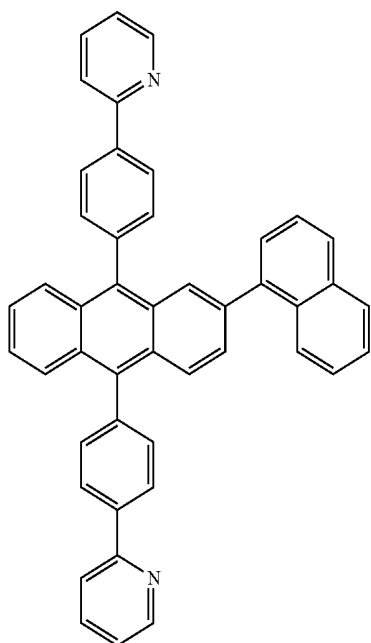


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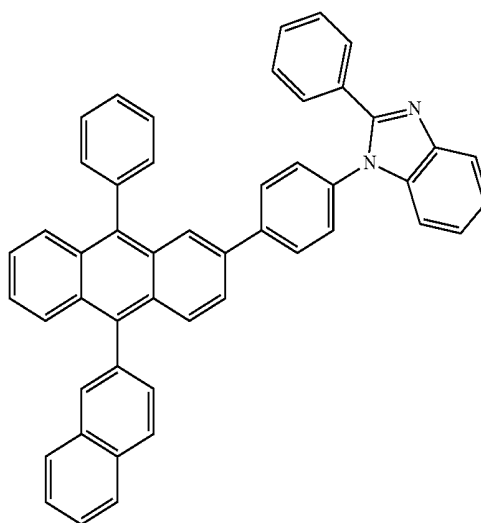
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ET10

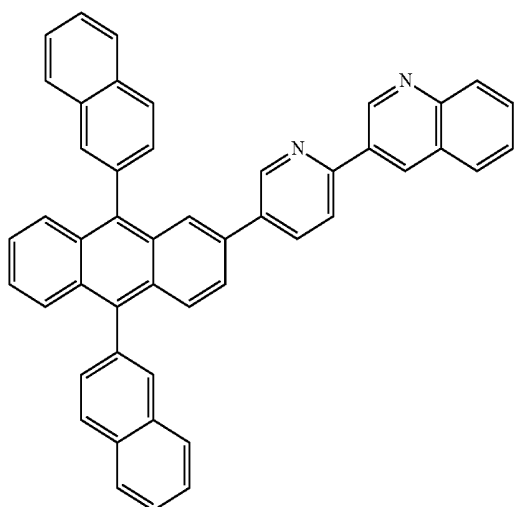


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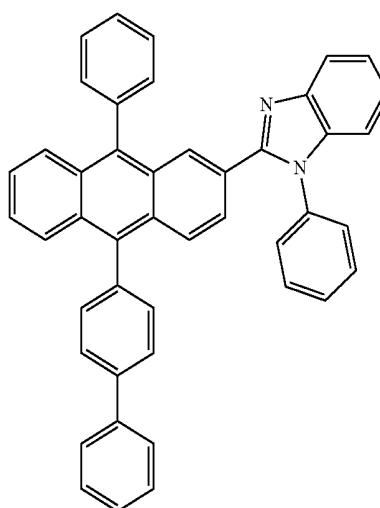
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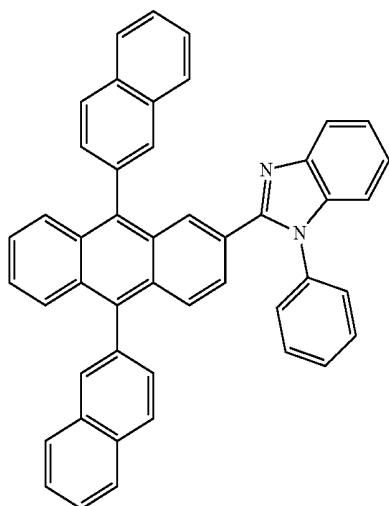
ET11



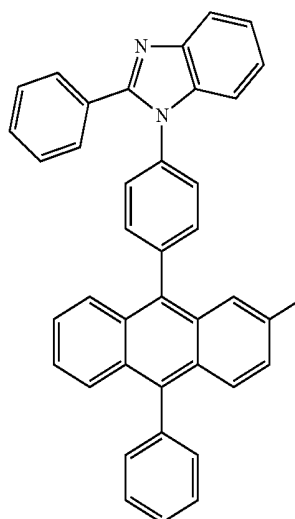
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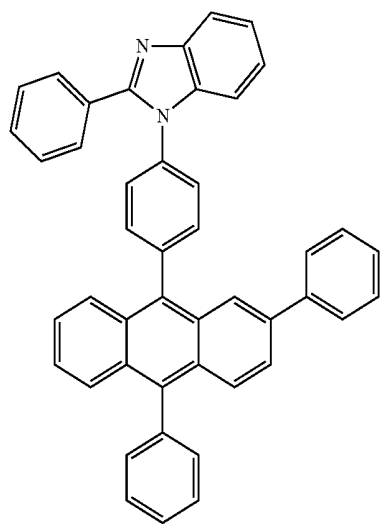
ET12



ET15

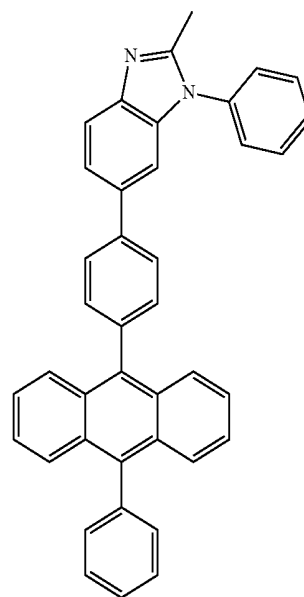


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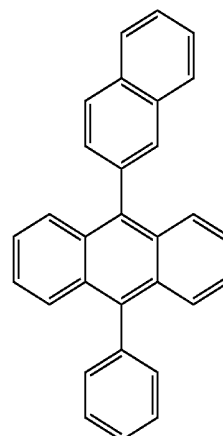
ET16

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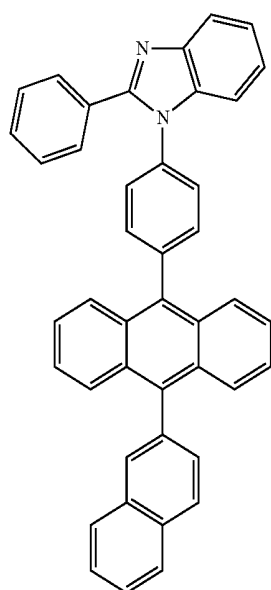
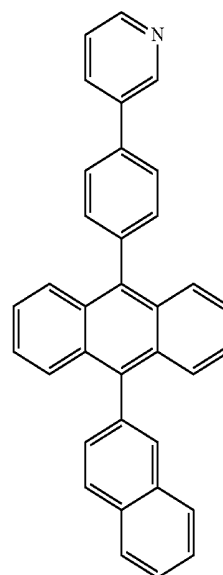
ET18

ET19

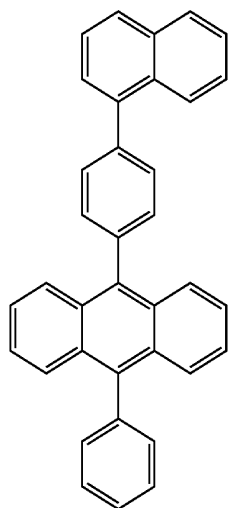


ET17

ET20

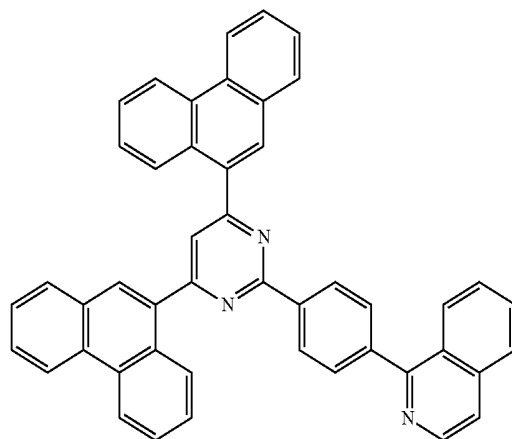


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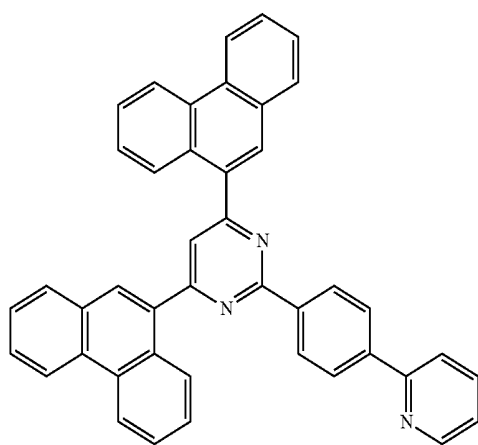


ET21

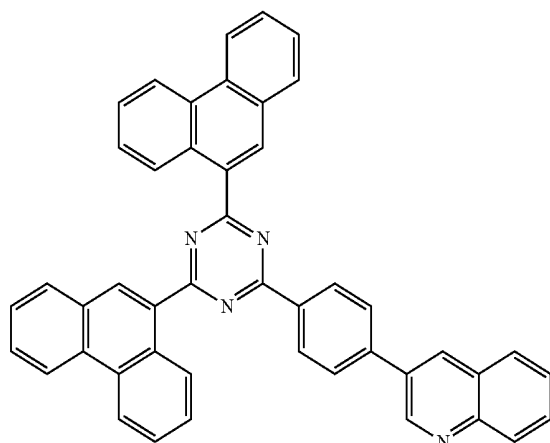
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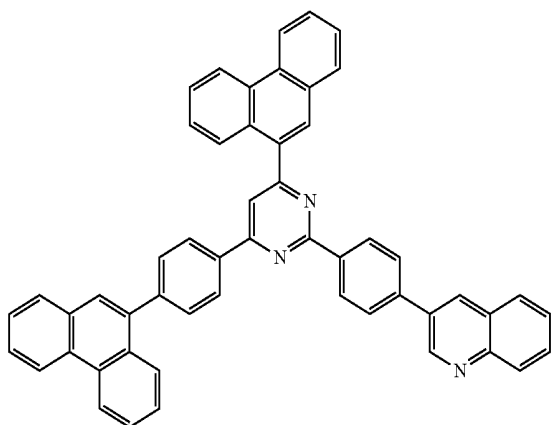
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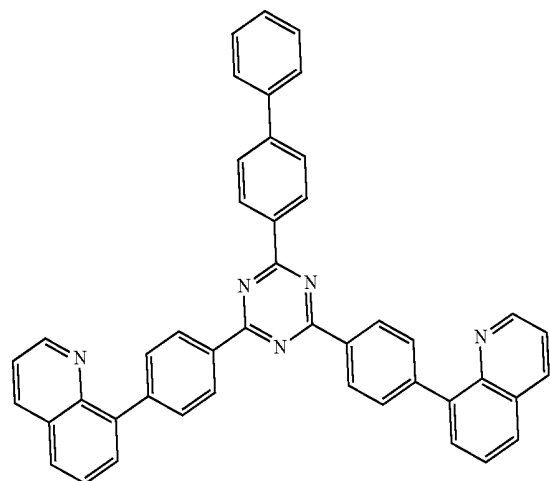
ET22



ET25



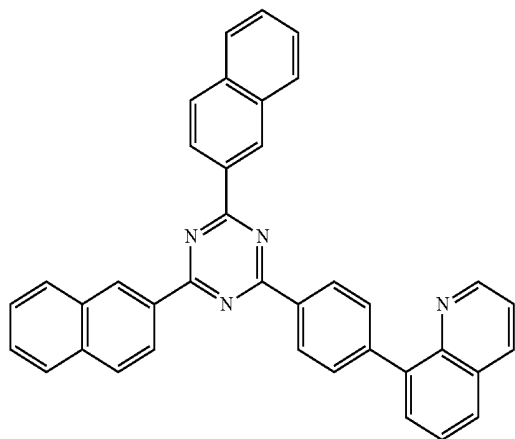
ET23



ET26

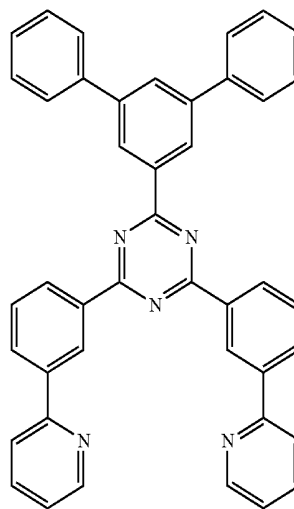
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ET27

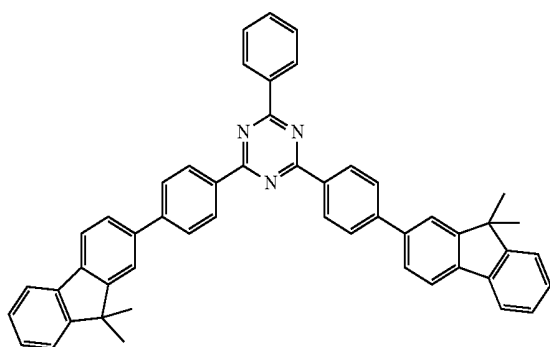


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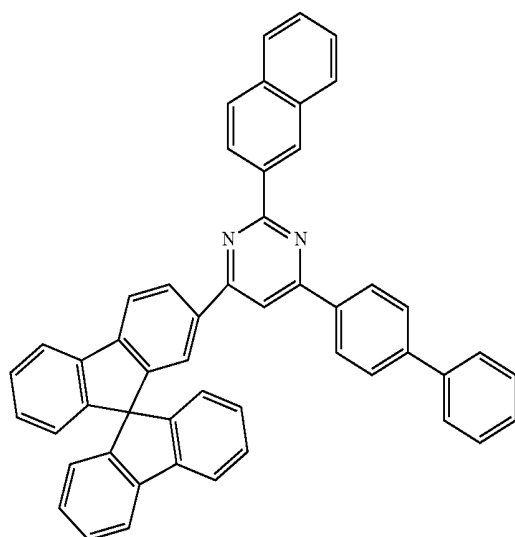
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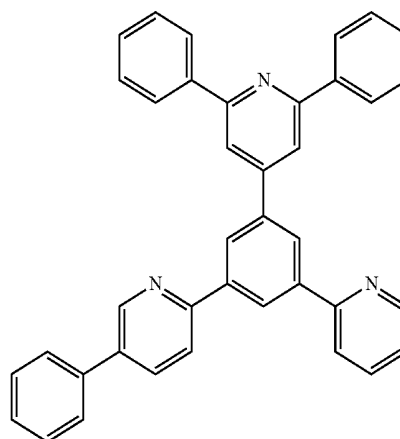
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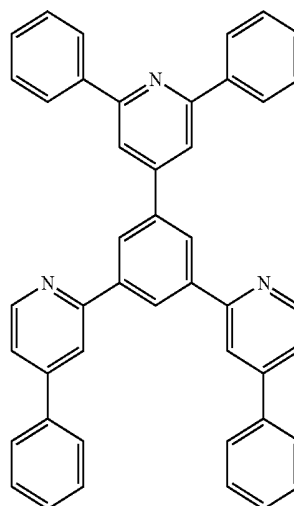
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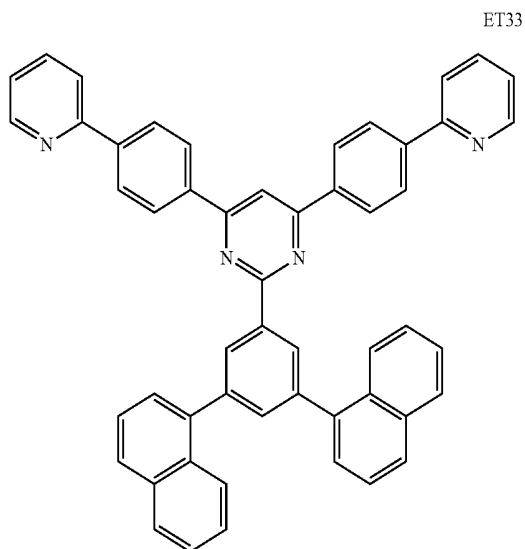
ET31



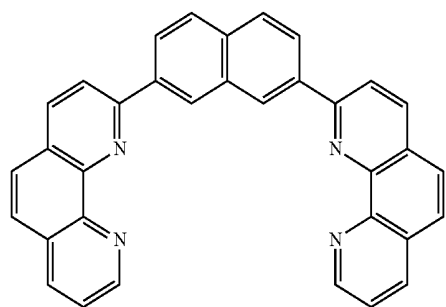
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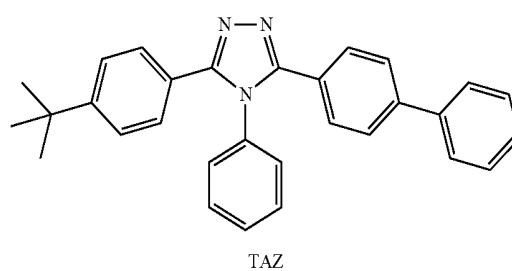
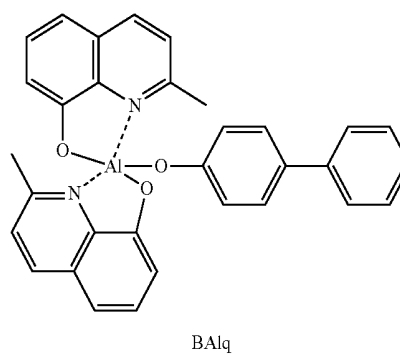
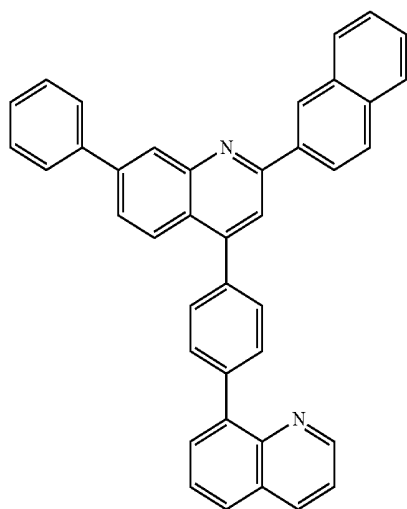
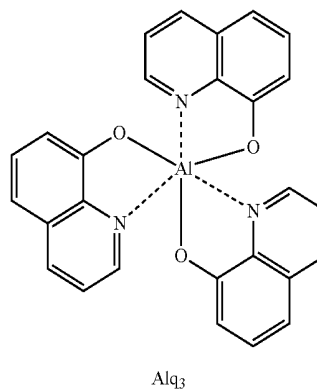
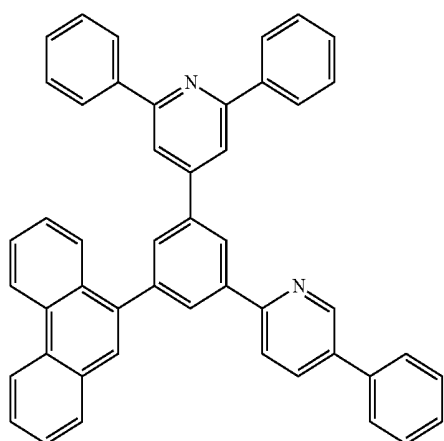
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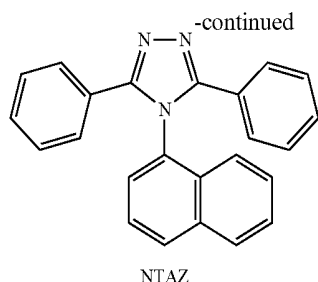


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[0361] In one or more embodiments, the electron transport region may include at least one compound selected from 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), Alq₃, BAlq, 3-(biphenyl-4-yl)-5-(4-tert-butylphenyl)-4-phenyl-4H-1,2,4-triazole (TAZ), and NTAZ:





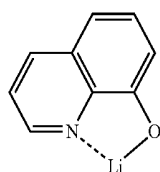
[0362] The thickness of the buffer layer, the hole blocking layer, or the electron controlling layer may each independently be in a range of about 20 Å to about 1,000 Å, for example, about 30 Å to about 300 Å. When the thicknesses of the buffer layer, the hole blocking layer, and the electron control layer are within these ranges, the electron blocking layer may have excellent electron blocking characteristics or electron control characteristics without a substantial increase in driving voltage.

[0363] A thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, for example, about 150 Å to about 500 Å. When the thickness of the electron transport layer is within the range described above, the electron transport layer may have satisfactory electron transport characteristics without a substantial increase in driving voltage.

[0364] 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.

[0365] 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 diphenyloxazole, a hydroxy diphenylthiadiazole, a hydroxy phenylpyridine, a hydroxy phenylbenzimidazole, a hydroxy phenylbenzothiazole, a bipyridine, a phenanthroline, and a cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

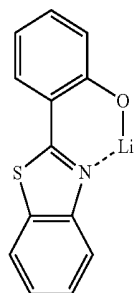
[0366] For example, the metal-containing material may include a L_1 complex. The Li complex may include, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2:



ET-D1

-continued

ET-D2



[0367] 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.

[0368] 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.

[0369] 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.

[0370] The alkali metal may be selected from Li, a Na, K, Rb, and Cs. In one embodiment, the alkali metal may be Li, a 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.

[0371] The alkaline earth metal may be selected from Mg, Ca, Sr, and Ba.

[0372] The rare earth metal may be selected from Sc, Y, Ce, Tb, Yb, and Gd.

[0373] 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.

[0374] The alkali metal compound may be selected from alkali metal oxides, such as Li_2O , Cs_2O , or K_2O , and alkali metal halides, such as LiF, NaF, CsF, KF, LiI, NaI, CsI, or KI. In one embodiment, the alkali metal compound may be selected from LiF, Li_2O , NaF, LiI, NaI, CsI, and KI, but embodiments of the present disclosure are not limited thereto.

[0375] The alkaline earth-metal compound may be selected from alkaline earth-metal oxides, such as BaO, SrO, CaO , $Ba_xSr_{1-x}O$ ($0 < x < 1$), or $Ba_xCa_{1-x}O$ ($0 < x < 1$). 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.

[0376] The rare earth metal compound may be selected from YbF_3 , ScF_3 , ScO_3 , Y_2O_3 , Ce_2O_3 , GdF_3 , and TbF_3 . In one embodiment, the rare earth metal compound may be selected from YbF_3 , ScF_3 , TbF_3 , YbI_3 , ScI_3 , and TbI_3 , but embodiments of the present disclosure are not limited thereto.

[0377] 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.

[0378] 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.

[0379] A thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, for example, about 3 Å to about 90 Å. When the thickness of the electron injection layer is within the range described above, the electron injection layer may have satisfactory electron injection characteristics without a substantial increase in driving voltage.

[0380] [Second Electrode 190]

[0381] The second electrode 190 may be disposed on the organic layer 150 having such a structure. The second electrode 190 may be a cathode that is an electron injection electrode, and in this regard, a material for forming the second electrode 190 may be a material having a low work function, and such a material may be metal, alloy, an electrically conductive compound, or a combination thereof.

[0382] The second electrode 190 may include at least one selected from lithium (Li), silver (Ag), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), magnesium-silver (Mg—Ag), ITO, and IZO, but embodiments of the present disclosure are not limited thereto. The second electrode 190 may be a transmissive electrode, a semi-transmissive electrode, or a reflective electrode.

[0383] The second electrode 190 may have a single-layered structure, or a multi-layered structure including two or more layers.

[0384] [Description of FIGS. 2 to 4]

[0385] 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, and 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.

[0386] Regarding FIGS. 2 to 4, the first electrode 110, the organic layer 150, and the second electrode 190 may be understood by referring to the description presented in connection with FIG. 1.

[0387] 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.

[0388] The first capping layer 210 and the second capping layer 220 may increase external luminescent efficiency according to the principle of constructive interference.

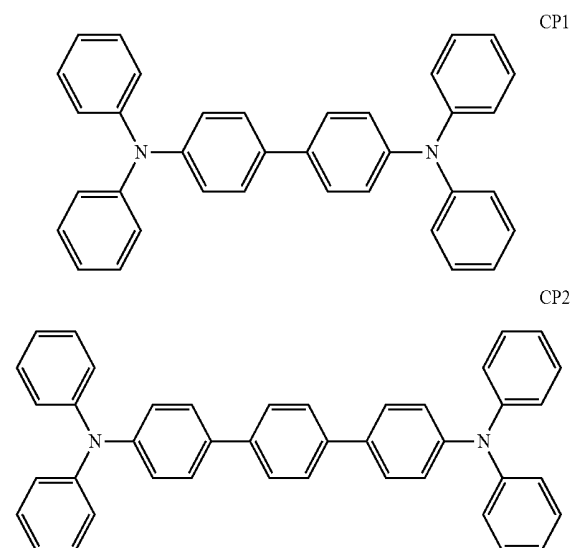
[0389] The first capping layer 210 and the second capping layer 220 may each independently be an organic capping layer including an organic material, an inorganic capping layer including an inorganic material, or a composite capping layer including an organic material and an inorganic material.

[0390] 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.

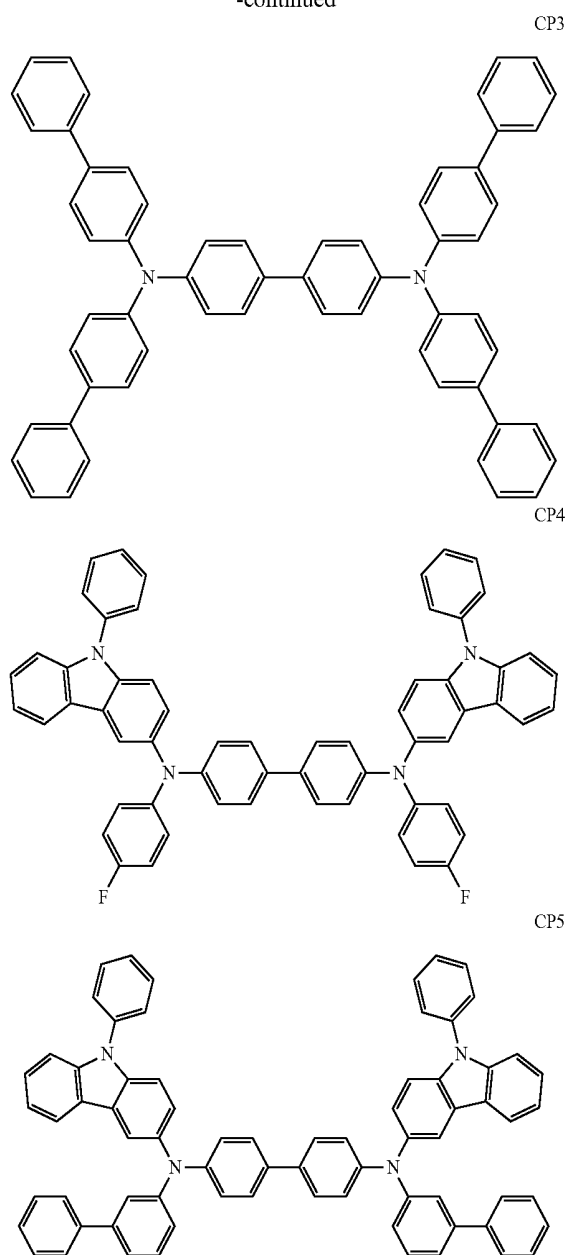
[0391] In one embodiment, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently include an amine-based compound.

[0392] 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.

[0393] 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:



-continued



[0394] Hereinbefore, the organic light-emitting device according to an embodiment has been described in connection with FIGS. 1 to 4. However, embodiments of the present disclosure are not limited thereto.

[0395] 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.

[0396] Each of the layers constituting the hole transport region, the emission layer, and each of the layers constituting the electron transport region are formed by vacuum deposition, the deposition conditions may vary according to a compound that is used to form the hole injection layer, and the structure and thermal characteristics of the hole injection layer. For example, the deposition conditions may include a deposition temperature of about 100° C. to about 500° C., a

vacuum pressure of about 10^{-8} torr to about 10^{-3} torr, and a deposition rate of about 0.01 Å/sec to about 0 Å/sec.

[0397] 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., depending on a material to be included in a layer and the structure of each layer to be formed.

[0398] [General Definition of Substituents]

[0399] The term “C₁-C₆₀ alkyl group” as used herein refers to a linear or branched saturated aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms, and non-limiting 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 iso-amyl group, and a hexyl group. The term “C₁-C₆₀ alkylene group” as used herein refers to a divalent group having the same structure as the C₁-C₆₀ alkyl group.

[0400] The term “C₂-C₆₀ alkenyl group” as used herein refers to a hydrocarbon group formed by substituting at least one carbon-carbon double bond in the middle or at the terminus of the C₂-C₆₀ alkyl group, and non-limiting examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term “C₂-C₆₀ alkenylene group” as used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkenyl group.

[0401] The term “C₂-C₆₀ alkynyl group” as used herein refers to a hydrocarbon group formed by substituting at least one carbon-carbon triple bond in the middle or at the terminus of the C₂-C₆₀ alkyl group, and non-limiting examples thereof include an ethynyl group, and a propynyl group. The term “C₂-C₆₀ alkynylene group” as used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkynyl group.

[0402] The term “C₁-C₆₀ alkoxy group” as used herein refers to a monovalent group represented by —OA₁₀₁ (wherein A₁₀₁ is the C₁-C₆₀ alkyl group), and non-limiting examples thereof include a methoxy group, an ethoxy group, and an isopropoxy group.

[0403] The term “C₃-C₁₀ cycloalkyl group” as used herein refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and non-limiting examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term “C₃-C₁₀ cycloalkylene group” as used herein refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkyl group.

[0404] The term “C₁-C₁₀ heterocycloalkyl group” as used herein refers to a monovalent saturated 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 non-limiting examples thereof include a 1,2,3,4-oxatriazolidinyl group, a tetrahydrofuranyl group, a tetrahydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkylene group” as used herein refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkyl group.

[0405] The term “C₃-C₁₀ cycloalkenyl group” as used herein refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one carbon-carbon double bond in the ring thereof and no aromaticity, and non-limiting examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term “C₃-C₁₀ cycloalkenylene group” as used herein refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkenyl group.

[0406] The term “C₁-C₁₀ 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 C₁-C₁₀ heterocycloalkenyl group include a 4,5-dihydro-1,2,3,4-oxatriazolyl group, a 2,3-dihydrofuranyl group, and a 2,3-dihydrothiophenyl group. The term

“C₁-C₁₀ heterocycloalkenylene group” as used herein refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkenyl group.

[0407] The term “C₆-C₆₀ aryl group” as used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms, and the term “C₆-C₆₀ arylene group” as used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. Non-limiting examples of the C₆-C₆₀ aryl group include a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C₆-C₆₀ aryl group and the C₆-C₆₀ arylene group each include two or more rings, the rings may be fused to each other.

[0408] The term “C₁-C₆₀ heteroaryl group” as used herein refers to a monovalent group having a heterocyclic 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. The term “C₁-C₆₀ heteroarylene group” as used herein refers to a divalent group having a heterocyclic 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. Non-limiting examples of the C₁-C₆₀ heteroaryl group include a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C₁-C₆₀ heteroaryl group and the C₁-C₆₀ heteroarylene group each include two or more rings, the rings may be fused to each other.

[0409] The term “C₆-C₆₀ aryloxy group” as used herein refers to —OA₁₀₂ (wherein A₁₀₂ is the C₆-C₆₀ aryl group), and a C₆-C₆₀ arylthio group used herein indicates —SA₁₀₃ (wherein A₁₀₃ is the C₆-C₆₀ aryl group).

[0410] 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, only carbon atoms as ring-forming atoms, and no aromaticity in its entire molecular structure. A detailed 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 the same structure as the monovalent non-aromatic condensed polycyclic group.

[0411] 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, at least one heteroatom selected from N, O, Si, P, and S, other than carbon atoms, as a ring-forming atom, and no aromaticity in its entire molecular structure. An example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. The term “divalent non-aromatic condensed heteropolycyclic group” as used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0412] The term “C₅-C₆₀ 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 C₅-C₆₀ carbocyclic group may be an aromatic carbocyclic group or a non-aromatic carbocyclic group. The C₅-C₆₀ 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 C₅-C₆₀ carbocyclic group, the C₅-C₆₀ carbocyclic group may be a trivalent group or a quadrivalent group.

[0413] The term “C₁-C₆₀ heterocyclic group” as used herein refers to a group having the same structure as the

C₅-C₆₀ 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).

[0414] At least one substituent of the substituted C₅-C₆₀ carbocyclic group, the substituted C₁-C₆₀ heterocyclic group, the substituted C₃-C₁₀ cycloalkylene group, the substituted C₁-C₁₀ heterocycloalkylene group, the substituted C₃-C₁₀ cycloalkenylene group, the substituted C₁-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₁-C₆₀ heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

[0415] deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group;

[0416] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ 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 C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁₁)(Q₁₂)(Q₁₃), —N(Q₁₁)(Q₁₂), —B(Q₁₁)(Q₁₂), —C(=O)(Q₁₁), S(=O)₂(Q₁₁), and —P(=O)(Q₁₁)(Q₁₂);

[0417] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0418] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl 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 C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₂₁)(Q₂₂)(Q₂₃), —N(Q₂₁)(Q₂₂), —B(Q₂₁)(Q₂₂), —C(=O)(Q₂₁), —S(=O)₂(Q₂₁), and —P(=O)(Q₂₁)(Q₂₂); and

[0419] $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$, $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{B}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{C}(=\text{O})(\text{Q}_{31})$, $-\text{S}(=\text{O})_2(\text{Q}_{31})$, and $-\text{P}(=\text{O})(\text{Q}_{31})(\text{Q}_{32})$, and

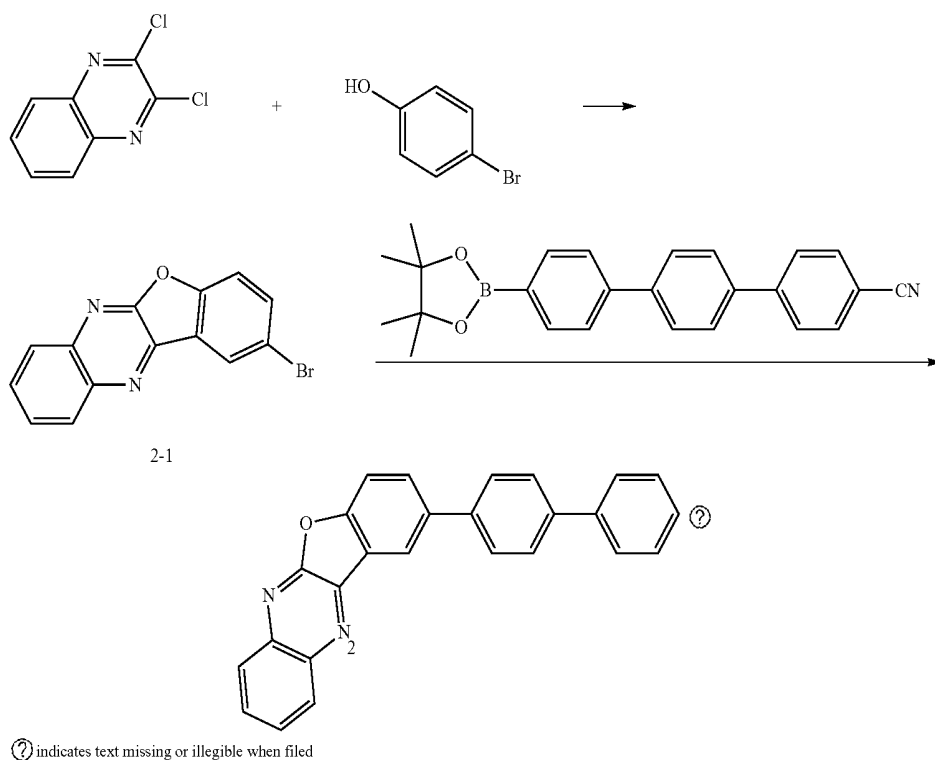
[0420] Q_{11} to Q_{13} , Q_{21} to Q_{23} , and Q_{31} to Q_{33} may each independently be selected from hydrogen, deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{60} alkyl 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}

[0425] Hereinafter, a compound according to embodiments and an organic light-emitting device according to embodiments will be described in detail with reference to Synthesis Examples and Examples. The wording “B was used instead of A” used in describing Synthesis Examples refers to that an identical molar equivalent of B was used in place of A.

SYNTHESIS EXAMPLE

[0426]

Synthesis Example 1: Synthesis of Compound 2



cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group.

[0421] The term “Ph”, as used herein, may refer to a phenyl group; the term “Me”, as used herein, may refer to a methyl group; the term “Et”, as used herein, may refer to an ethyl group; the terms “ter-Bu” or “Bu”, as used herein, may refer to a tert-butyl group; and the term “OMe” as used herein may refer to a methoxy group.

[0422] 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_6 - C_{60} aryl group as a substituent.

[0423] 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_6 - C_{60} aryl group substituted with a C_6 - C_{60} aryl group.

[0424] * and *¹ used herein, unless defined otherwise, each refer to a binding site to a neighboring atom in a corresponding formula.

Synthesis of Intermediate 2-1

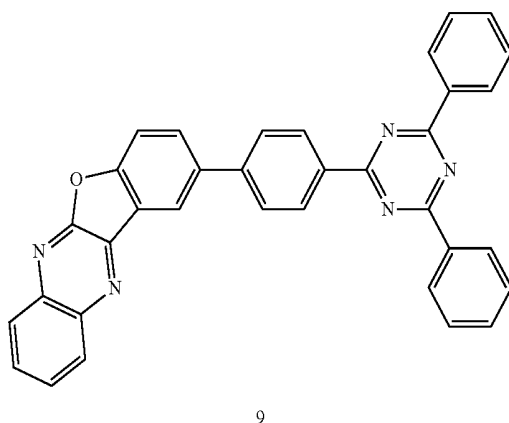
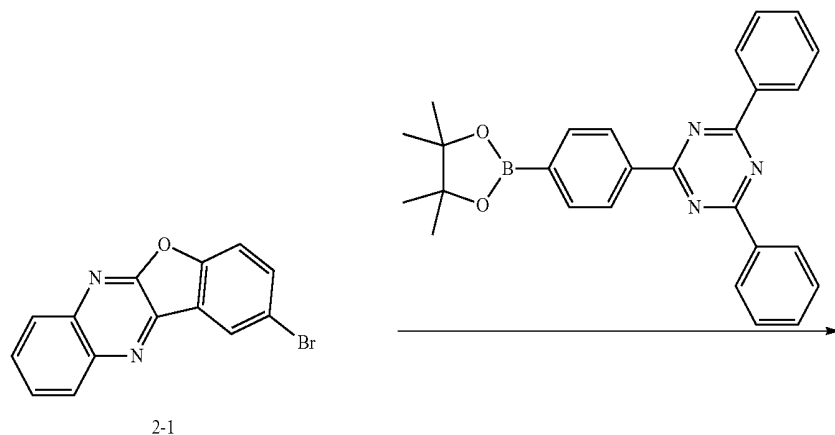
[0427] 2 g (10 mmol) of 2,3-dichloroquinoxaline, 1.73 g (10 mmol) of 4-bromophenol, and 1.33 g (10 mmol) of AlCl_3 were dissolved in 200 mL of ethyl estate (EA) and stirred at a temperature of 80°C . for 3 hours. The reaction solution was cooled to room temperature, and 1.33 g (10 mmol) of AlCl_3 was added thereto. Then, the reaction product was stirred at a temperature of 80°C . for 3 hours. After the reaction was completed, a precipitated solid was filtered under reduced pressure to obtain 2.1 g (yield: 70%) of Intermediate 2-1.

[0428] Synthesis of Compound 2

[0429] 3 g (10 mmol) of Intermediate 2-1, 3.81 g (10 mmol) of 4'--(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-[1,1':4',1''-terphenyl]-4-carbonitrile, 0.58 g (0.5 mmol) of $\text{Pd}(\text{PPh}_3)_4$, and 4.15 g (30 mmol) of K_2CO_3 were dissolved in 150 mL of a mixed solution of THF/ H_2O (2/1) and stirred at a temperature of 80°C . for 16 hours. The reaction solution was cooled to room temperature, and an organic layer was extracted therefrom three times by using 60 mL of water and 60 mL of diethylether. The extracted organic layer was dried by using magnesium sulfate, and a solvent was evaporated therefrom. Then, a residue obtained therefrom was separated and purified by silica gel column chromatography to obtain 3.3 g (yield: 70%) of Compound 2. The obtained compound was identified by LC-MS and ^1H NMR. $\text{C}_{33}\text{H}_{19}\text{N}_3\text{O}$: M+1 473.52.

Synthesis Example 2: Synthesis of Compound 9

[0430]

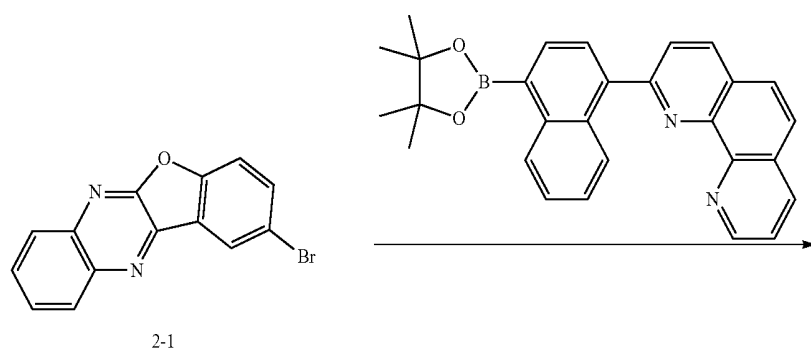


[0431] Synthesis of Compound 9

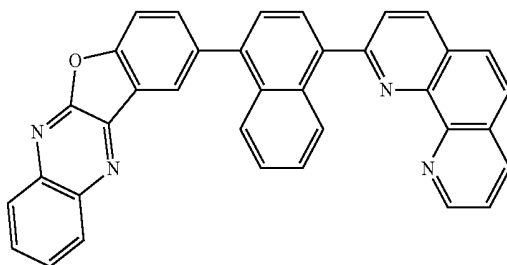
[0432] 3.7 g (yield: 70%) of Compound 9 was obtained in the same manner as in Synthesis of Compound 2, except that 2,4-diphenyl-6-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-1,3,5-triazine was used instead of 4''-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-[1,1':4',1''-terphenyl]-4-carbonitrile. The obtained compound was identified by LC-MS and ^1H NMR. $\text{C}_{35}\text{H}_{21}\text{N}_5\text{O}$: $\text{M}+1$ 527.57.

Synthesis Example 3: Synthesis of Compound 15

[0433]



-continued



15

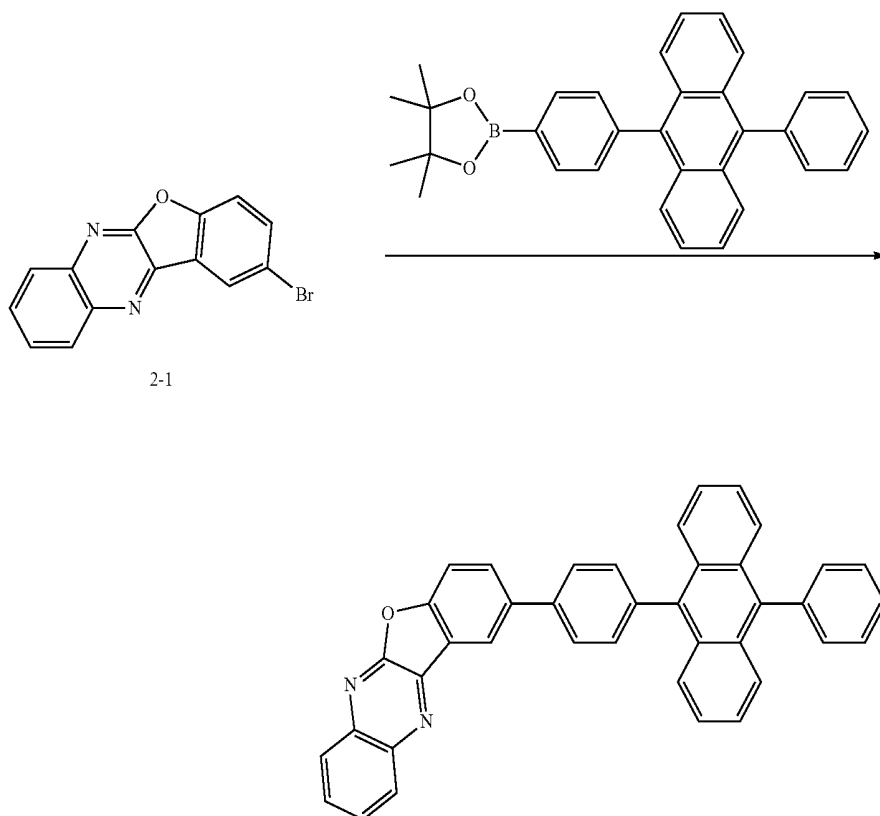
[0434] Synthesis of Compound 15

[0435] 3.15 g (yield: 60%) of Compound 15 was obtained in the same manner as in Synthesis of Compound 2, except that 2-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)naphthalen-1-yl)-1,10-phenanthroline was used instead of 4''-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-[1,1':4',1''-terphenyl]-4-carbonitrile. The obtained compound was identified by LC-MS and ^1H NMR. $\text{C}_{36}\text{H}_{20}\text{N}_4\text{O}$: $\text{M}+1$ 524.56.

Synthesis Example 4: Synthesis of Compound 22

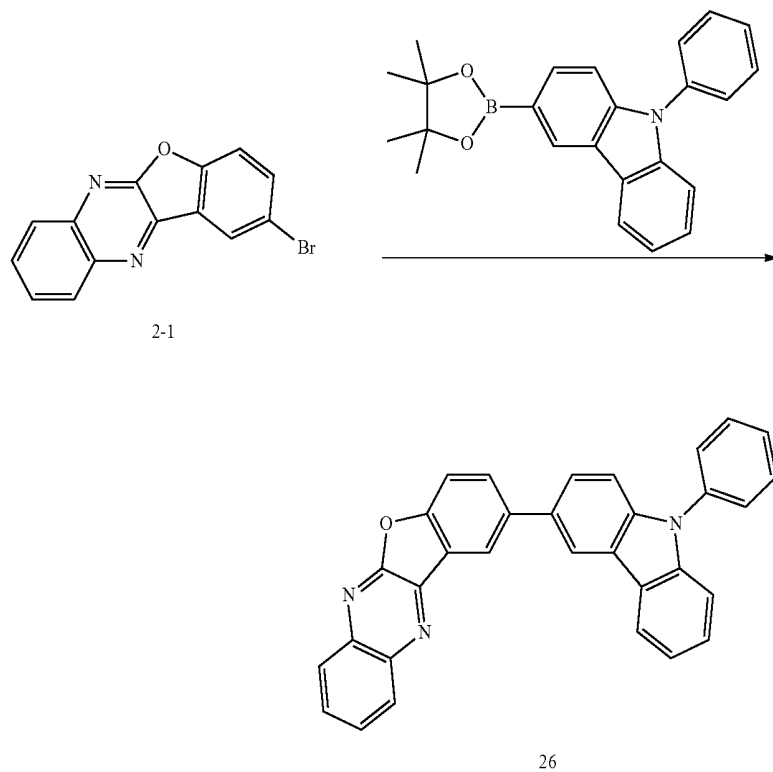
[0436]**[0437]** Synthesis of Compound 22

[0438] 4.11 g (yield: 75%) of Compound 22 was obtained in the same manner as in Synthesis of Compound 2, except that 4,4,5,5-tetramethyl-2-(4-(10-phenylanthracen-9-yl)phenyl)-1,3,2-dioxaborolane was used instead of 4''-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-[1,1':4',1''-terphenyl]-4-carbonitrile. The obtained compound was identified by LC-MS and ^1H NMR. $\text{C}_{40}\text{H}_{24}\text{N}_2\text{O}$: $\text{M}+1$ 548.63.



22

Synthesis Example 5: Synthesis of Compound 26
[0439]



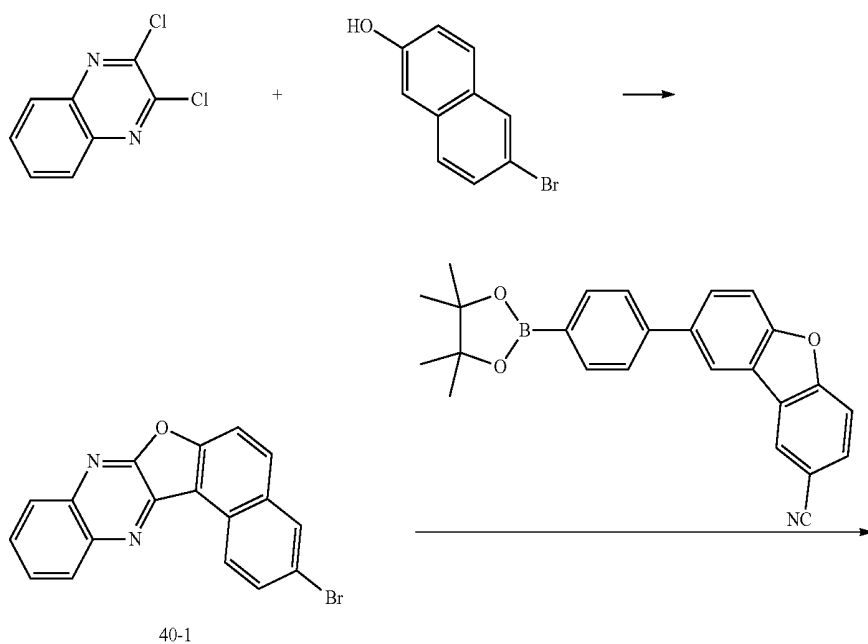
[0440] Synthesis of Compound 26

[0441] 2.77 g (yield: 60%) of Compound 26 was obtained in the same manner as in Synthesis of Compound 2, except that 9-phenyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-9H-carbazole was used instead of 4''-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-[1,1': 4',1''-terphenyl]-4-car-

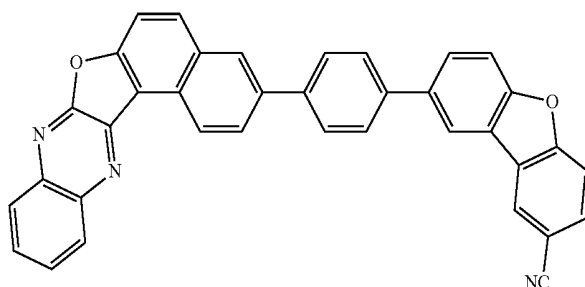
bonitrile. The obtained compound was identified by LC-MS and ^1H NMR. $\text{C}_{40}\text{H}_{24}\text{N}_2\text{O}$: M+1 461.51.

Synthesis Example 6: Synthesis of Compound 40

[0442]



-continued



40

[0443] Synthesis of Intermediate 40-1

[0444] 2.44 g (yield: 70%) of Intermediate 40-1 was obtained in the same manner as in Synthesis of Intermediate 2-1, except that 6-bromo-2-naphthol was used instead of 4-bromophenol.

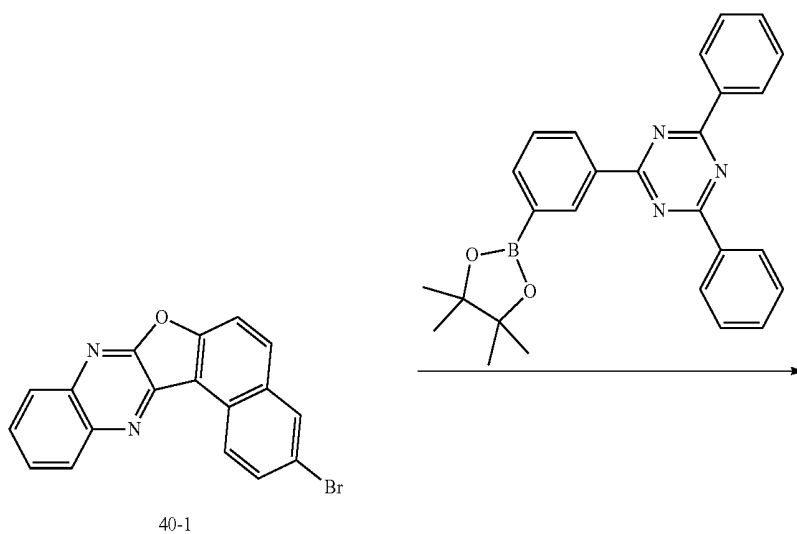
[0445] Synthesis of Compound 40

[0446] 3.23 g (yield: 60%) of Compound 40 was obtained in the same manner as in Synthesis of Compound 2, except that Intermediate 40-1 was used instead of Intermediate 2-1,

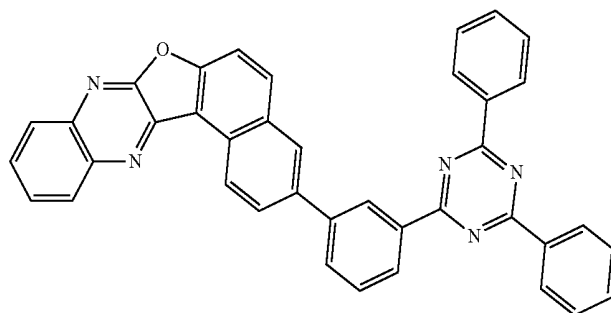
and 8-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)dibenzo[b,d]furan-2-carbonitrile was used instead of 4''-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-[1,1':4',1''-terphenyl]-4-carbonitrile. The obtained compound was identified by LC-MS and ^1H NMR. $\text{C}_{37}\text{H}_{19}\text{N}_3\text{O}_2$; $\text{M}+1$ 537.57.

Synthesis Example 7: Synthesis of Compound 41

[0447]



40-1



41

[0448] Synthesis of Compound 41

[0449] 4.04 g (yield: 70%) of Compound 41 was obtained in the same manner as in Synthesis of Compound 40, except that 2,4-diphenyl-6-(3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)-1,3,5-triazine was used instead of 8-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)dibenzo[b,d]furan-2-carbonitrile. The obtained compound was identified by LC-MS and ¹H NMR. C₃₉H₂₃N₅O: M+1 577.63.

[0450] Synthesis methods of compounds other than Compounds synthesized in Synthesis Examples 1 to 7 may also be easily recognized by those of ordinary skill in the art by referring to the synthesis mechanisms and source materials described above.

[0452] N-([1,1'-biphenyl]-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluoren-2-amine (Compound 301) and F4-TCNQ were vacuum-deposited on the ITO substrate at a weight ratio of 98:2 to form a hole injection layer having a thickness of 100 Å, Compound 301 was vacuum-deposited on the hole injection layer to form a first hole transport layer having a thickness of 1,200 Å, and N,N-di([1,1'-biphenyl]-4-yl)-4'-(9H-carbazol-9-yl)-[1,1'-biphenyl]-4-amine (Compound HA) was vacuum-deposited on the first hole transport layer to form a second hole transport layer having a thickness of 100 Å. 9,10-di-naphthalene-2-yl-anthracene (ADN), which is a known blue fluorescent host, and N,N,N',N'-tetraphenyl-pyrene-1,6-diamine (TPD), which is a blue fluorescent dopant, were

Compound	¹ H NMR (CDCl ₃ , 500 MHz)	HR-EIMS	
		found	calc.
2	7.65-7.67 (2H, m), 8.11-8.15 (5H, m), 8.19-8.23 (1H, m), 8.33-8.35 (2H, m), 8.36-8.53 (6H, m), 8.82-8.90 (2H, m), 8.93-8.96 (1H, m)	473.52	473.54
9	7.77-7.88 (6H, m), 8.22-8.24 (1H, m), 8.32-8.35 (1H, m), 8.40-8.49 (6H, m), 8.52-8.55 (2H, m), 8.82-8.86 (2H, m), 8.86-8.97 (3H, m)	527.57	527.59
15	8.31-8.35 (1H, m), 8.49-8.54 (2H, m), 8.63-8.67 (1H, m), 8.72-8.75 (1H, m), 8.77-8.86 (4H, m), 8.83-8.86 (1H, m), 8.91-9.00 (3H, m), 9.06-9.18 (5H, m), 9.34-9.43 (2H, m)	524.56	524.58
22	7.66-7.82 (3H, m), 7.93-7.99 (2H, m), 8.01-8.06 (2H, m), 8.13-8.18 (2H, m), 8.19-8.23 (1H, m), 8.64-8.73 (6H, m), 8.76-8.79 (2H, m), 8.89-8.93 (1H, m), 9.03-9.15 (3H, m), 9.34-9.38 (1H, m), 9.39-9.42 (1H, m)	548.63	548.65
26	7.53-7.86 (1H, m), 7.63-7.83 (5H, m), 7.93-7.97 (2H, m), 8.10-8.25 (4H, m), 8.36-8.41 (1H, m), 8.42-8.51 (2H, m)	461.51	461.52
40	8.61-8.74 (4H, m), 7.92-7.96 (1H, m), 8.07-8.11 (1H, m), 8.16-8.20 (1H, m), 8.32-8.41 (4H, m), 8.48-8.52 (1H, m), 8.57-8.62 (3H, m), 8.72-8.79 (2H, m), 8.81-8.88 (2H, m), 8.90-8.93 (1H, m), 8.96-9.01 (1H, m), 9.05-9.09 (1H, m), 9.31-9.34 (1H, m)	537.57	537.58
41	7.80-7.93 (6H, m), 8.00-8.05 (1H, m), 8.34-8.41 (5H, m), 8.67-8.71 (1H, m), 8.85-8.92 (2H, m), 9.00-9.20 (6H, m), 9.34-9.38 (1H, m), 9.41-9.46 (1H, m)	577.63	577.65

Example

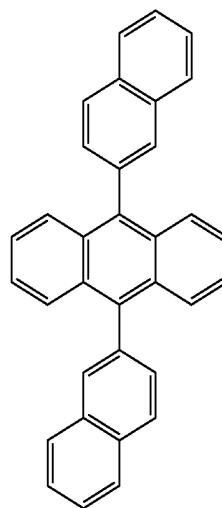
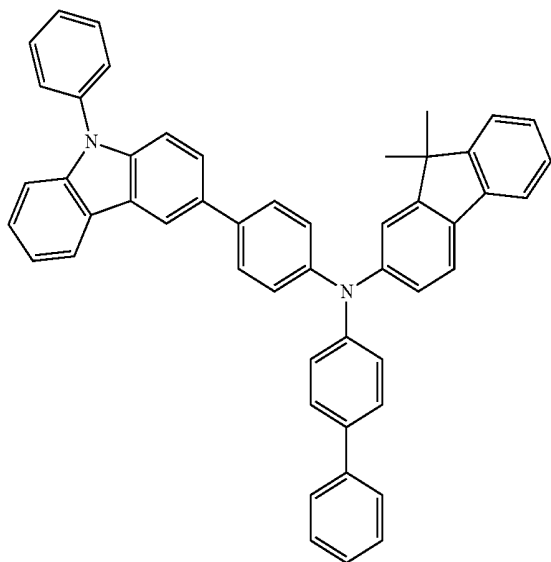
Example 1

[0451] As an anode, an ITO substrate, on which ITO/Ag/ITO were deposited to thicknesses of 70 Å/1,000 Å/70 Å, was cut to a size of 50 mm×50 mm×0.5 mm, sonicated with isopropyl alcohol and pure water each for 5 minutes, and cleaned by exposure to ultraviolet rays and ozone for 30 minutes. Then, the ITO substrate was provided to a vacuum deposition apparatus.

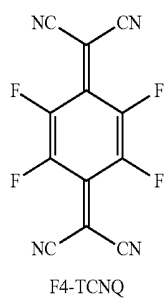
co-deposited on the second hole transport layer at a weight ratio of 98:2 to form an emission layer having a thickness of 300 Å. Compound 2 and LiQ were co-deposited on the emission layer at a ratio of 5:5 to form an electron transport layer having a thickness of 300 Å. LiF, which is an alkali metal halide, was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and then, MgAg was vacuum-deposited on the electron injection layer at a weight ratio of 90:10 to form a cathode having a thickness of 120 Å, thereby completing the manufacture of an organic light-emitting device.

-continued

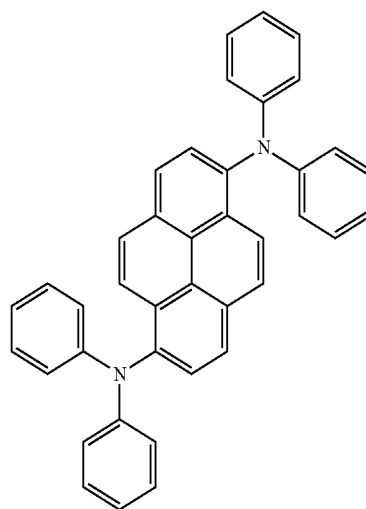
301



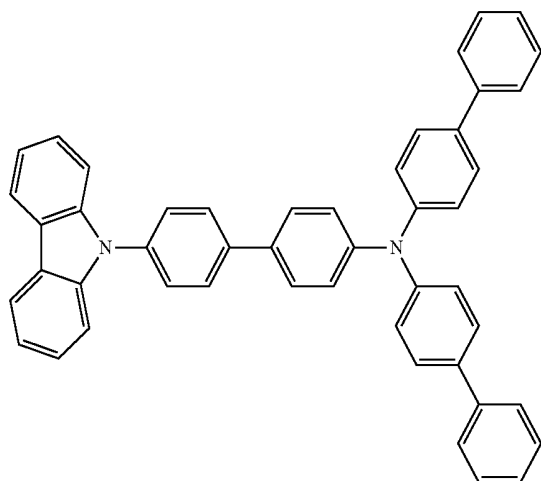
ADN



F4-TCNQ



TPD



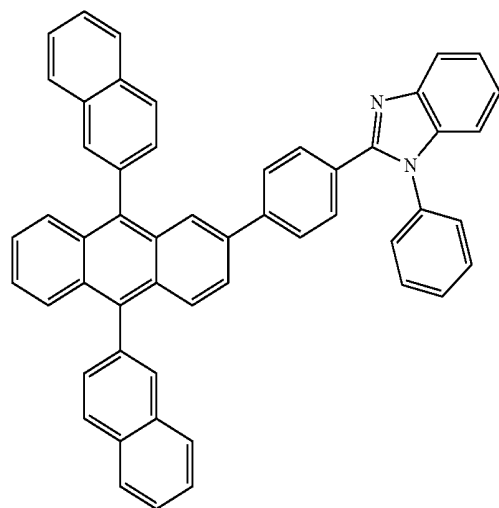
HA

Examples 2 to 7

[0453] Organic light-emitting devices were manufactured in the same manner as in Example 1, except that Compounds shown in Table 1 were each used instead of Compound 2 in forming an electron transport layer.

Comparative Example 1

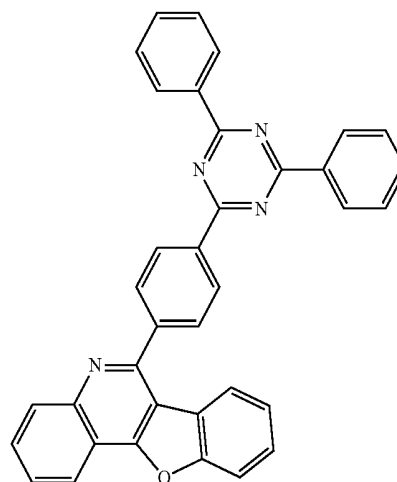
[0454] An organic light-emitting device was manufactured in the same manner as in Example 1, except that 2-(4-(9,10-di(naphthalen-2-yl)anthracen-2-yl)phenyl)-1-phenyl-1 H-benzo[d]imidazole (Compound A), which is a known electron transport compound, was used instead of Compound 2 in forming an electron transport layer.



Comparative Example 2

[0455] An organic light-emitting device was manufactured in the same manner as in Example 1, except that Compound 305 was used instead of Compound 2 in forming an electron transport layer.

A



305

[0456] The device performance (driving voltage, luminance, efficiency, and color coordinates) at a current density of 10 mA/cm² and the lifespan (T₉₇) at a current density of 1.0 mA/cm² in the organic light-emitting devices were measured, and results thereof are shown in Table 1. The lifespan (T₉₇) indicates an amount of time that lapsed when luminance was 97% of initial luminance (100%).

TABLE 1

	Electron transport material	Driving voltage (V)	Efficiency (cd/A)	Color coordinates CIE(x, y)	Lifespan (T ₉₇) (@1.0 mA/cm ²)
Example 1	Compound 2	3.80	5.54	0.140, 0.055	145
Example 2	Compound 9	3.78	5.70	0.141, 0.056	118
Example 3	Compound 15	3.82	5.88	0.141, 0.055	142
Example 4	Compound 22	3.87	5.46	0.140, 0.057	138
Example 5	Compound 26	4.0	5.25	0.142, 0.058	158
Example 6	Compound 40	3.79	5.54	0.141, 0.054	129
Example 7	Compound 41	3.84	5.49	0.141, 0.055	135
Comparative Example 1	Compound A	4.8	4.62	0.141, 0.053	77
Comparative Example 2	Compound 305	4.2	4.87	0.142, 0.055	95

[0457] Referring to Table 1, it is confirmed that the organic light-emitting devices of Examples 1 to 7 have a low driving voltage and high efficiency, as compared with those of the organic light-emitting devices of Comparative Examples 1 and 2. In particular, it is confirmed that the lifespans (T₉₇) of the organic light-emitting devices are significantly improved.

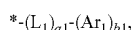
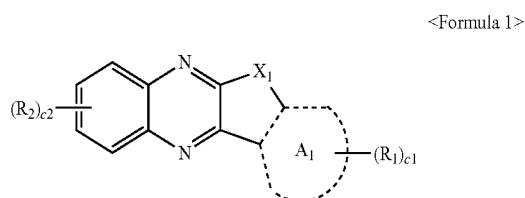
[0458] According to one or more embodiments, an organic light-emitting device including the condensed cyclic compound may have a low driving voltage, high efficiency, and a long lifespan.

[0459] 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.

[0460] 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 spirit and scope as defined by the following claims.

What is claimed is:

1. A condensed cyclic compound represented by Formula 1:



<Formula 2>

wherein, in Formulae 1 and 2,

A₁ is selected from a benzene group, a naphthalene group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a naphthyridine group, a quinoxaline group, a quinazoline group, and a cinnoline group,

X₁ is O or S,

L₁ is selected from a substituted or unsubstituted C₅-C₆₀ carbocyclic group, a substituted or unsubstituted C₁-C₆₀ heterocyclic group, *-P(=O)(Q₁)-*, *-P(=O)₂*, *-P(=S)(Q₁)-*, *-P(=S)₂*, *-S(=O)(Q₁)-*, and *-S(=O)₂*,

a₁ is an integer from 0 to 5, wherein, when a₁ is zero, -(L₁)_{a1} is a single bond, and when a₁ is two or more, two or more L₁(s) are identical to or different from each other,

Ar₁ is selected from a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, -Si(Q₁)(Q₂)(Q₃), -B(Q₁)(Q₂), -C(=O)(Q₁), -N(Q₁)(Q₂), -P(=O)(Q₁)(Q₂), -P(=O)₂(Q₁), -P(=S)(Q₁)(Q₂), -P(=S)₂(Q₁), -S(=O)(Q₁)(Q₂), and -S(=O)₂(Q₁)(Q₂),

b₁ is an integer from 1 to 10, wherein, when b₁ is two or more, two or more Ar₁(s) are identical to or different from each other,

R₁ and R₂ are each independently selected from a group represented by Formula 2, 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 C₁-C₆₀ alkyl group, a substituted or unsubstituted C₂-C₆₀ alkenyl group, a substituted or unsubstituted C₂-C₆₀ alkynyl group, a substituted or unsubstituted C₁-C₆₀ alkoxy group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, -Si(Q₁)(Q₂)(Q₃), -B(Q₁)(Q₂), -C(=O)(Q₁), -N(Q₁)(Q₂), -P(=O)(Q₁)(Q₂), -P(=O)₂(Q₁), -P(=S)(Q₁)(Q₂), -P(=S)₂(Q₁), -S(=O)(Q₁)(Q₂), and -S(=O)₂(Q₁)(Q₂),

at least one of R₁(s) in the number of c₁ and R₂(s) in the number of c₂ is a group represented by Formula 2,

c₁ is an integer from 1 to 6, wherein, when c₁ is two or more, two or more R₁(s) are identical to or different from each other,

c₂ is an integer from 1 to 4, wherein, when c₂ is two or more, two or more R₂(s) are identical to or different from each other,

at least one substituent of the substituted C₅-C₆₀ carbocyclic group, the substituted C₁-C₆₀ heterocyclic group, the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic 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 C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group;

a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ 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 C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, -Si(Q₁₁)(Q₁₂)(Q₁₃), -N(Q₁₁)(Q₁₂), -B(Q₁₁)(Q₁₂), -C(=O)(Q₁₁), -S(=O)₂(Q₁₁), and -P(=O)(Q₁₁)(Q₁₂);

a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl 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 C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₂₁)(Q₂₂)(Q₂₃), —N(Q₂₁)(Q₂₂), —B(Q₂₁)(Q₂₂), —C(=O)(Q₂₁), —S(=O)₂(Q₂₁), and —P(=O)(Q₂₁)(Q₂₂); and —Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), —B(Q₃₁)(Q₃₂), —C(=O)(Q₃₁), —S(=O)₂(Q₃₁), and —P(=O)(Q₃₁)(Q₃₂).

Q₁ to Q₃, Q₁₁ to Q₁₃, Q₂₁ to Q₂₃, and Q₃₁ to Q₃₃ 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 C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, and

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

2. The condensed cyclic compound of claim 1, wherein L₁ is selected from:

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene 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 pentaphenylene group, a hexacene group, a pyrrole group, an imidazole group, a pyrazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an iso-indole group, an indole 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 carbazole group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzoxazole group, a benzimidazole group, a furan group, a benzofuran group, a thiophene group, a benzothiophene group, a thiazole group, an isothiazole group, a benzothiazole group, an isoxazole group, an oxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a benzoxazole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, and a dibenzocarbazole group;

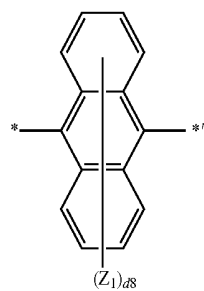
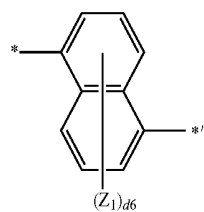
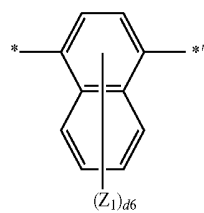
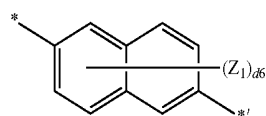
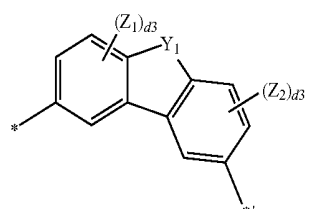
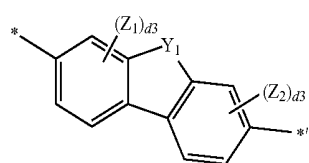
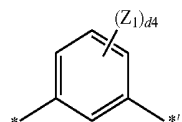
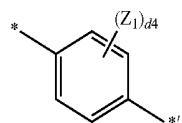
a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphenylene group, a hexacene group, a pyrrole group, an imidazole group, a pyrazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an iso-indole group, an indole 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 quinoxaline group, a cinnoline group, a carbazole group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzoxazole group, a benzimidazole group, a furan group, a benzofuran group, a thiophene group, a benzothiophene group, a thiazole group, an isothiazole group, a benzothiazole group, an isoxazole group, an oxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a benzoxazole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, and a dibenzocarbazole group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino 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 C_6 - O_{20} aryl group, a C_1 - C_{20} heteroaryl group, and —Si(Q_{31})(Q_{32})(Q_{33}); and

$$\begin{aligned} &^*\text{---P(=O)(Q}_1\text{)}\text{---}^*, \text{ }^*\text{---P(=O)}_2\text{---}^*, \text{ }^*\text{---P(=S)(Q}_1\text{)}\text{---}^*, \\ &^*\text{---P(=S)}_2\text{---}^*, \text{ }^*\text{---S(=O)(Q}_1\text{)}\text{---}^*, \text{ and } \text{S(=O)}_2\text{---}^*, \end{aligned}$$

Q₁ and Q₃₁ to Q₃₃ are each independently selected from a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a C₆-C₂₀ aryl group, a C₁-C₂₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, and

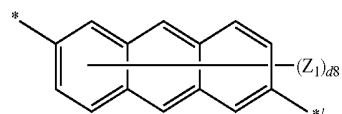
* and *' each indicate a binding site to a neighboring atom.

3. The condensed cyclic compound of claim 1, wherein L_1 is selected from groups represented by Formulae 3-1 to 3-48, $^*P(=O)(Q_1)-^{*t}$, $^*P(=O)_2-^{*t}$, $^*P(=S)(Q_1)-^{*t}$, $^*P(=S)_2-^{*t}$, $^*S(=O)(Q_1)-^{*t}$, and $^*S(=O)_2-^{*t}$.



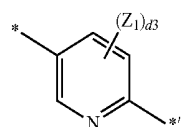
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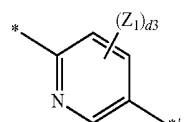
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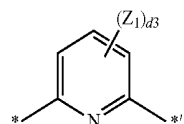
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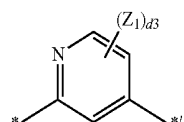
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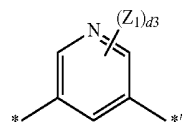
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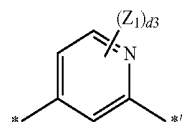
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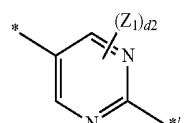
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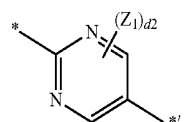


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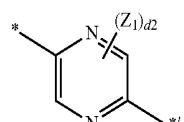
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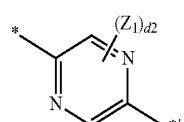
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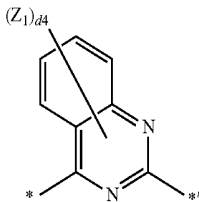
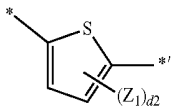
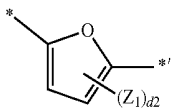
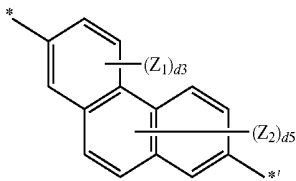
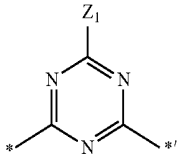
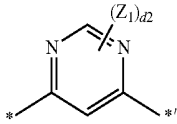
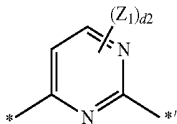
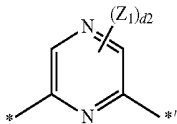
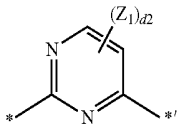


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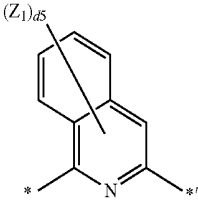
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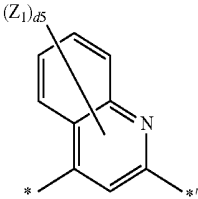


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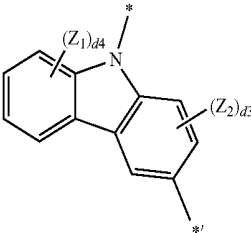
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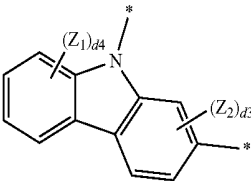
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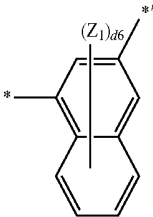
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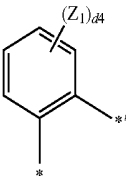
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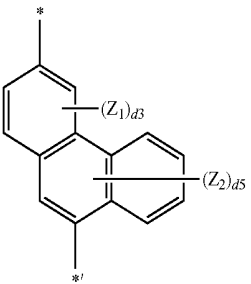
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3-31

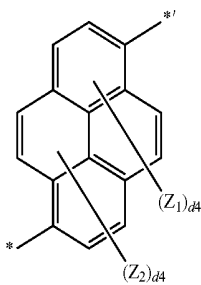
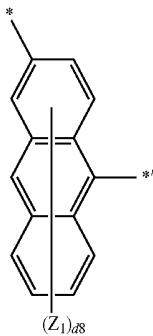
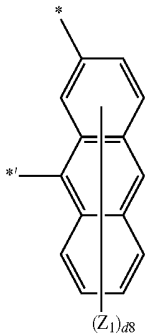
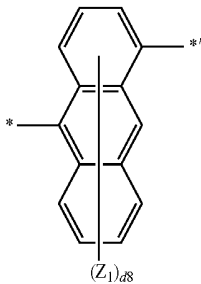
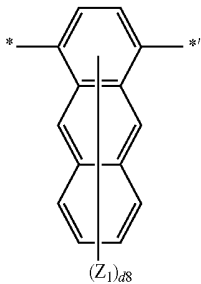
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3-33

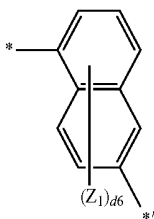
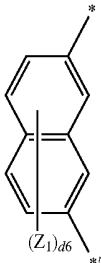
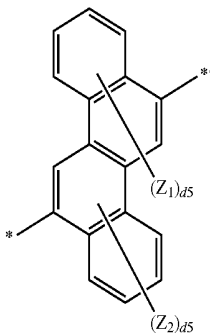
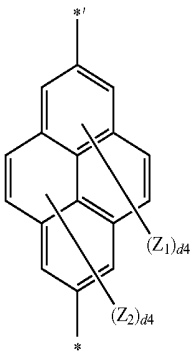
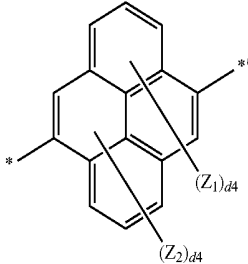
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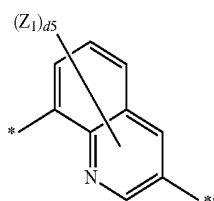
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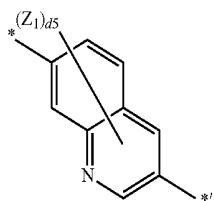
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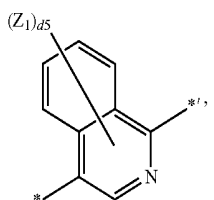
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3-46



3-47



3-48

wherein, in Formulae 3-1 to 3-48,

Y_1 is O, S, $C(Z_3)(Z_4)$, $N(Z_5)$, or $Si(Z_6)(Z_7)$,

Z_1 to Z_7 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 cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a triazinyl group, a dibenzofuran group, a dibenzothiophenyl group, and $-Si(Q_{31})(Q_{32})(Q_{33})$.

d_2 is an integer from 0 to 2, wherein, when d_2 is two or more, two or more $Z_1(s)$ are identical to or different from each other,

d_3 is an integer from 0 to 3, wherein, when d_3 is two or more, two or more $Z_1(s)$ are identical to or different from each other, and two or more $Z_2(s)$ are identical to or different from each other,

d_4 is an integer from 0 to 4, wherein, when d_4 is two or more, two or more $Z_1(s)$ are identical to or different from each other, and two or more $Z_2(s)$ are identical to or different from each other,

d_5 is an integer from 0 to 5, wherein, when d_5 is two or more, two or more $Z_1(s)$ are identical to or different from each other, and two or more $Z_2(s)$ are identical to or different from each other,

d_6 is an integer from 0 to 6, wherein, when d_6 is two or more, two or more $Z_1(s)$ are identical to or different from each other,

d_8 is an integer from 0 to 8, wherein, when d_8 is two or more, two or more $Z_1(s)$ are identical to or different from each other,

Q_1 and Q_{31} to Q_{33} are each independently selected from a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a triazinyl group, a dibenzofuran group, and a dibenzothiophenyl group, and

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

4. The condensed cyclic compound of claim 1, wherein Ar_1 is selected from:

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene 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 pentaphenylene group, a hexacene group, a pyrrole group, an imidazole group, a pyrazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an iso-indole group, an indole 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 carbazole group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzoxazole group, a benzimidazole group, a furan group, a benzofuran group, a thiophene group, a benzothiophene group, a thiazole group, an isothiazole group, a benzothiazole group, an isoxazole group, an oxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a benzoxazole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, and a dibenzocarbazole group;

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-fluorene 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 pentaphenylene group, a hexacene group, a pyrrole group, an imidazole group, a pyrazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an iso-indole group, an indole group, an indazole group, a purine group, a

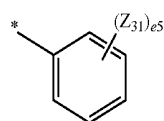
quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, a naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a carbazole group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzoxazole group, a benzimidazole group, a furan group, a benzofuran group, a thiophene group, a benzothiophene group, a thiazole group, an isothiazole group, a benzothiazole group, an isoxazole group, an oxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a benzoxazole group, a dibenzofuran group, a dibenzothiophene group, a benzocarbazole group, and a dibenzocarbazole group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino 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 C_6 - C_{20} aryl group, a C_1 - C_{20} heteroaryl group, —Si(Q_{31})(Q_{32})(Q_{33}), and P(=O)(Q_{31})(Q_{32}); and

—Si(Q_1)(Q_2)(Q_3), —P(=O)(Q_1)(Q_2), —P(=O)₂(Q_1), —P(=S)(Q_1)(Q_2), —P(=S)₂(Q_1), —S(=O)(Q_1)(Q_2), and —S(=O)₂(Q_1), and

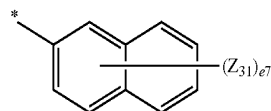
Q_1 to Q_3 and Q_{31} to Q_{33} are each independently selected from a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a C_6 - C_{20} aryl group, a C_1 - C_{20} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

5. The condensed cyclic compound of claim 1, wherein

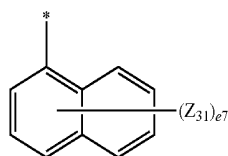
Ar_1 is selected from groups represented by Formulae 5-1 to 5-36, —Si(Q_1)(Q_2)(Q_3), —P(=O)(Q_1)(Q_2), —P(=O)₂(Q_1), —P(=S)(Q_1)(Q_2), —P(=S)₂(Q_1), —S(=O)(Q_1)(Q_2), and —S(=O)₂(Q_1):



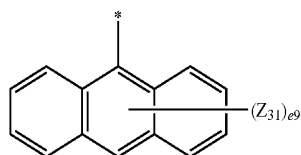
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5-2



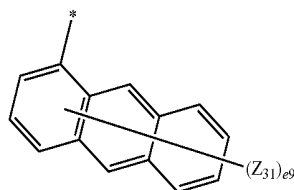
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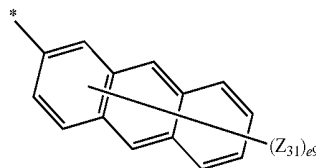
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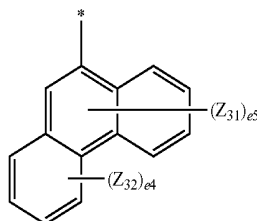
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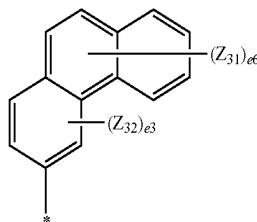
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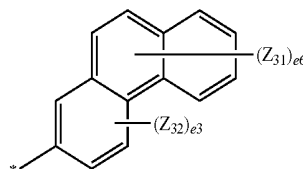
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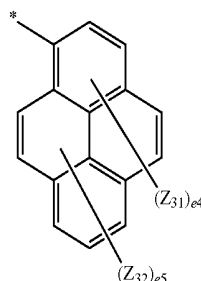
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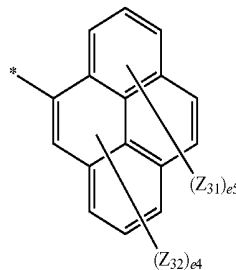
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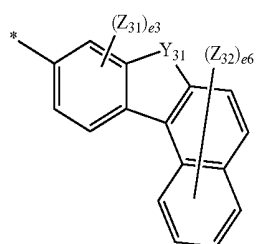
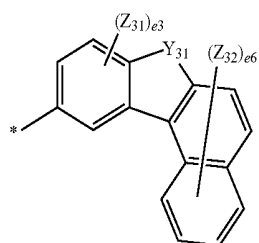
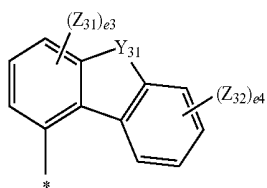
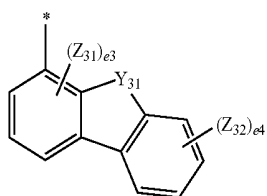
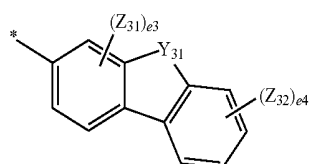
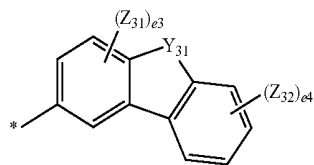
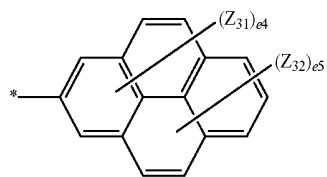
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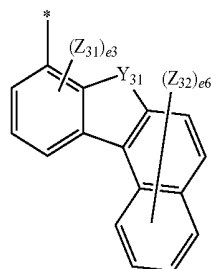


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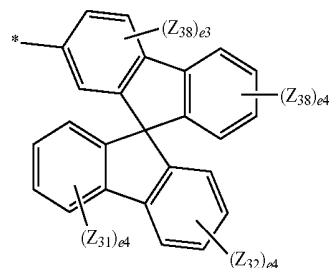
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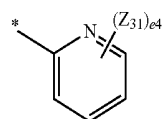
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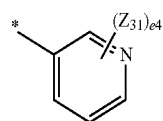
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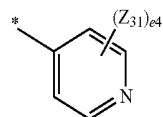
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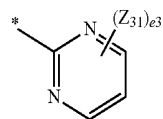
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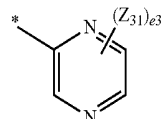


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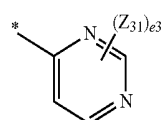
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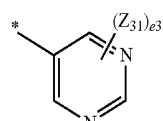
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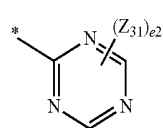
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5-26

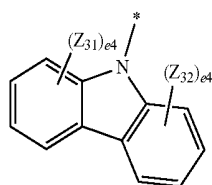


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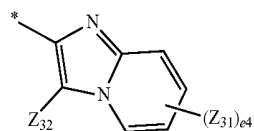


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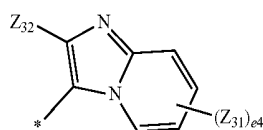
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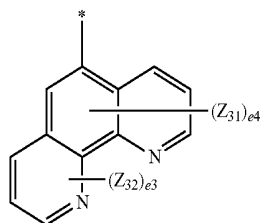
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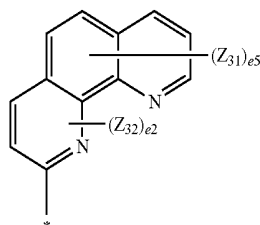
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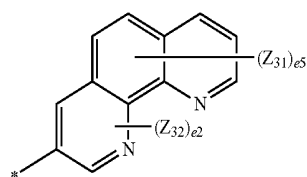
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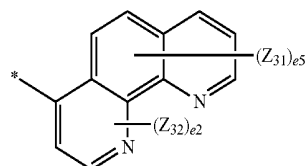
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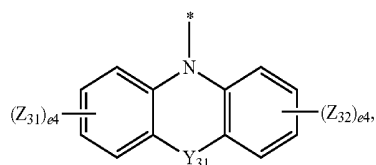
5-33



5-34



5-35



5-36

wherein, in Formulae 5-1 to 5-36,
 Y_{31} is O, S, C(Z_{33})(Z_{34}), N(Z_{35}), or Si(Z_{36})(Z_{37}),
 Z_{31} to Z_{39} 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 cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a spiro-fluorene-benzofluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenaziny group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, —Si(Q_{31})(Q_{32})(Q_{33}), and P(=O)(Q_{31})(Q_{32}),

Q_1 to Q_3 and Q_{31} to Q_{33} are each independently selected from a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenaziny group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group,

e_2 is an integer from 0 to 2, wherein, when e_2 is two or more, two or more Z_{31} (s) are identical to or different from each other, and two or more Z_{32} (s) are identical to or different from each other,

e_3 is an integer from 0 to 3, wherein, when e_3 is two or more, two or more Z_{31} (s) are identical to or different from each other, two or more Z_{32} (s) are identical to or different from each other, and two or more Z_{38} (s) are identical to or different from each other,

e_4 is an integer from 0 to 4, wherein, when e_4 is two or more, two or more Z_{31} (s) are identical to or different from each other, two or more Z_{32} (s) are identical to or different from each other, and two or more Z_{39} (s) are identical to or different from each other,

e_5 is an integer from 0 to 5, wherein, when e_5 is two or more, two or more Z_{31} (s) are identical to or different from each other, and two or more Z_{32} (s) are identical to or different from each other,

e_6 is an integer from 0 to 6, wherein, when e_6 is two or more, two or more Z_{31} (s) are identical to or different from each other, and two or more Z_{32} (s) are identical to or different from each other,

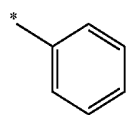
e_7 is an integer from 0 to 7, wherein, when e_7 is two or more, two or more Z_{31} (s) are identical to or different from each other,

e_9 is an integer from 0 to 9, wherein, when e_9 is two or more, two or more Z_{31} (s) are identical to or different from each other, and

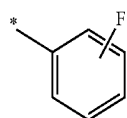
* indicates a binding site to a neighboring atom.

6. The condensed cyclic compound of claim 1, wherein Ar_1 is selected from groups represented by Formulae 6-1 to 6-93, $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$, and $-\text{P}(=\text{O})(\text{Q}_1)(\text{Q}_2)$:

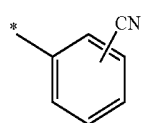
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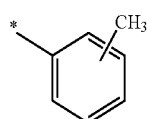
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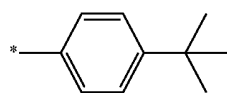
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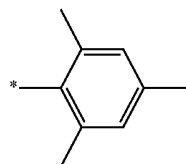
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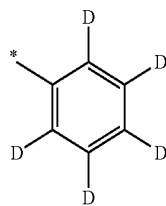
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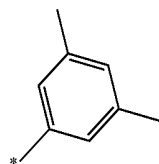
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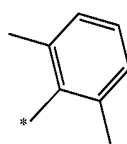
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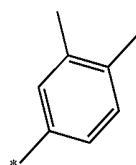
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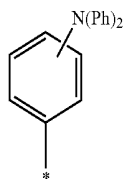
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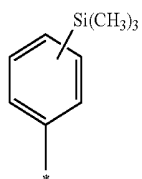
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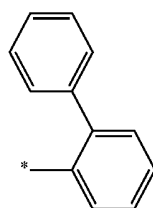
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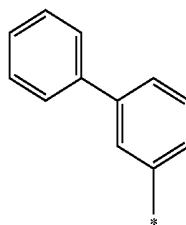
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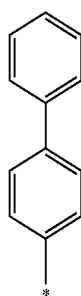
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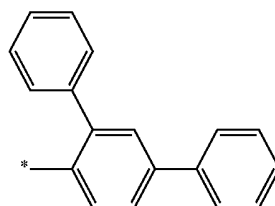
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6-14

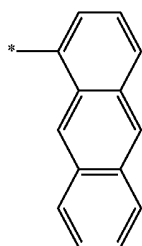
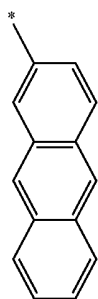
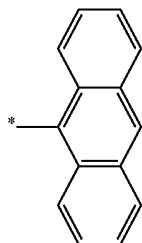
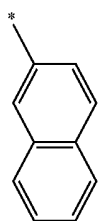
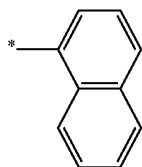
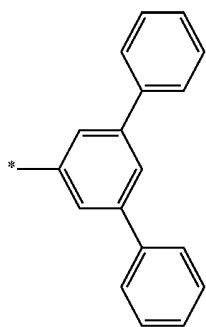


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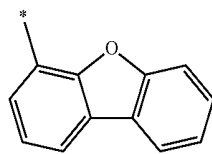
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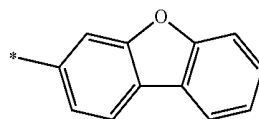
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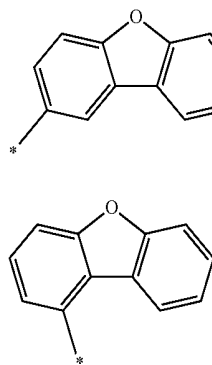
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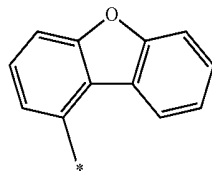
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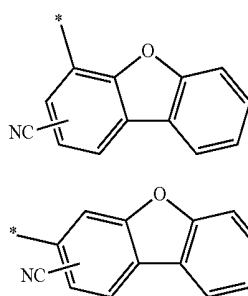
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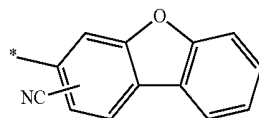


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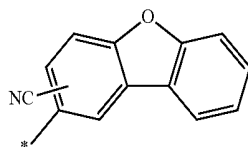
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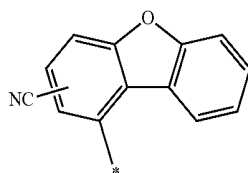
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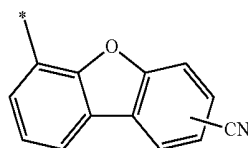


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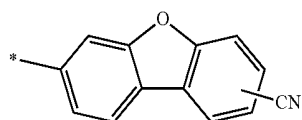


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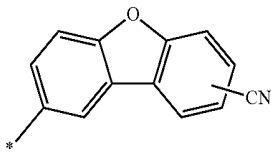


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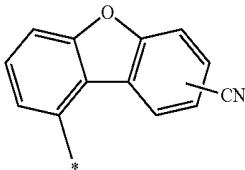


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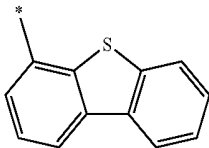
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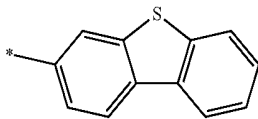
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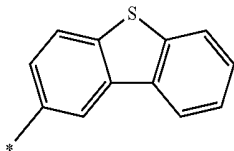
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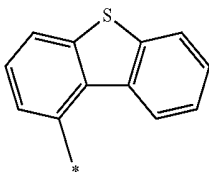
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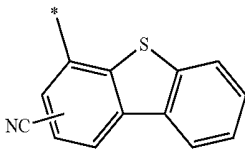
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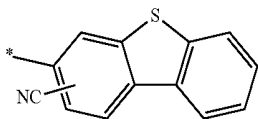
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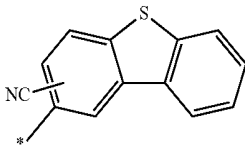
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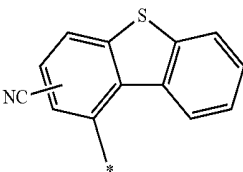


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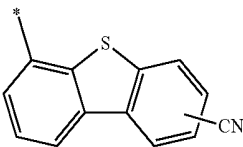


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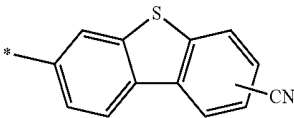
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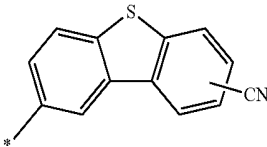
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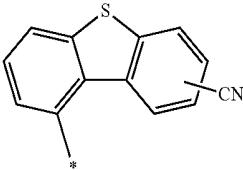
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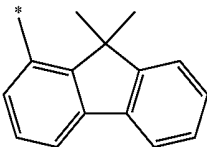
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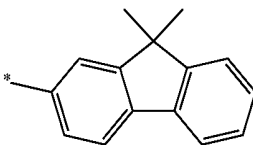
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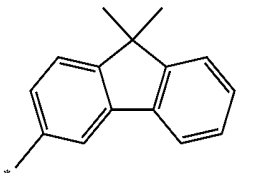
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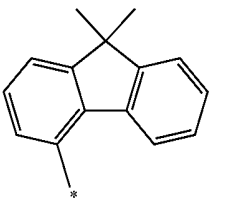
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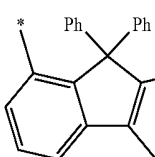
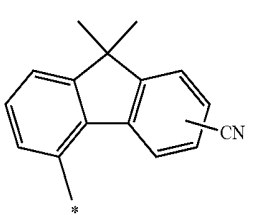
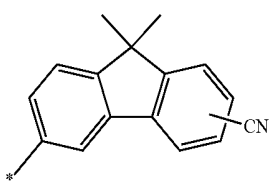
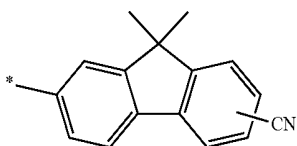
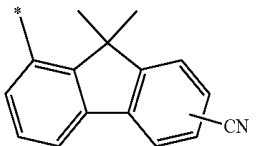
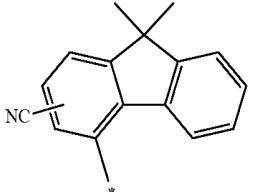
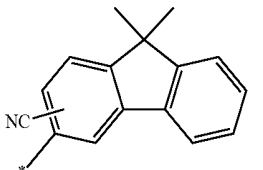
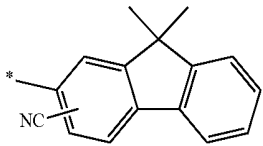
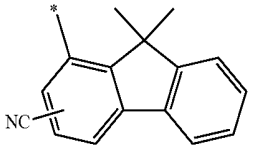


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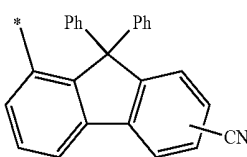
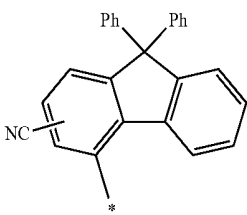
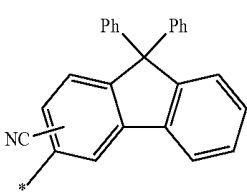
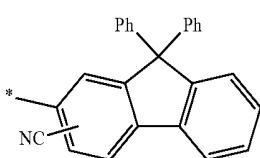
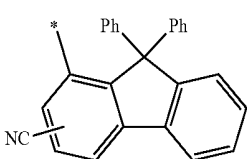
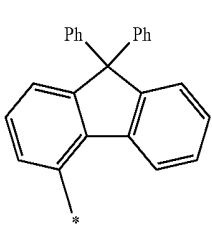
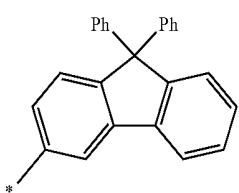
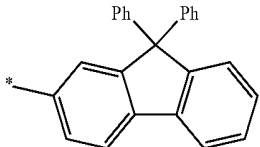


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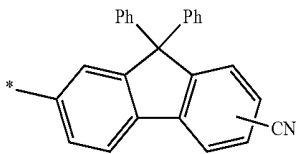
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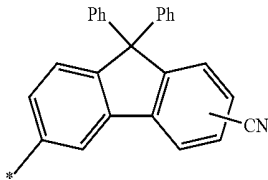
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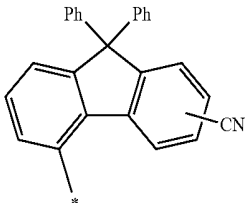
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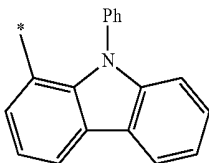
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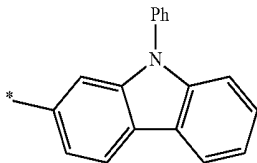
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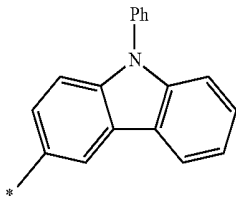
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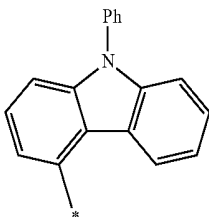
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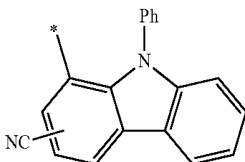
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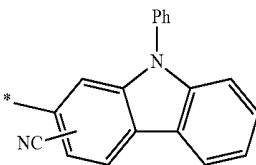


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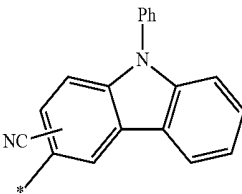


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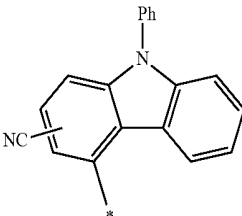
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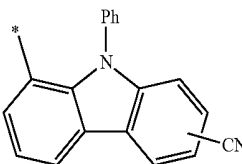
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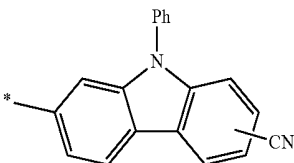
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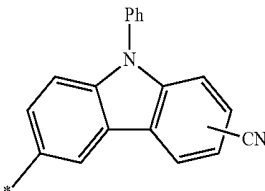
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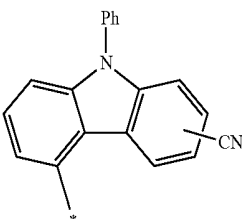
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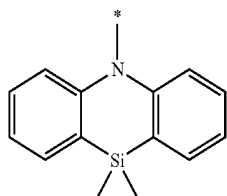
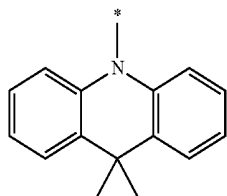
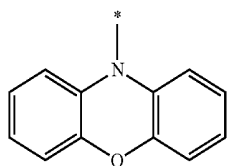
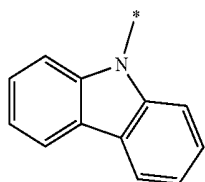
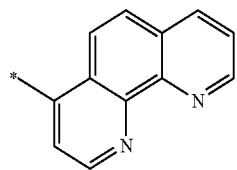
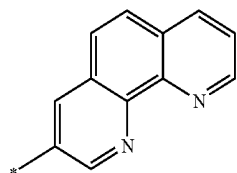
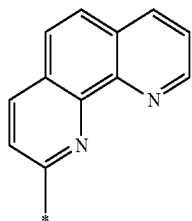
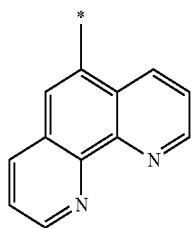


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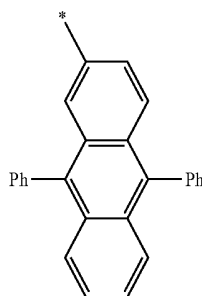
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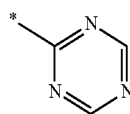
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6-91



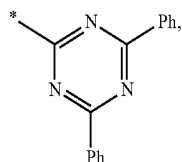
6-84

6-92



6-85

6-93



6-86

wherein, in Formulae 6-1 to 6-93,

Ph indicates a phenyl group,

Q₁ to Q₃ each indicate a phenyl group, and

* indicates a binding site to a neighboring atom.

7. The condensed cyclic compound of claim 1, wherein

R₁ and R₂ are each independently selected from a group represented by Formula 2, 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a phenanthrolinyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and a dibenzocarbazolyl group.

8. The condensed cyclic compound of claim 1, wherein

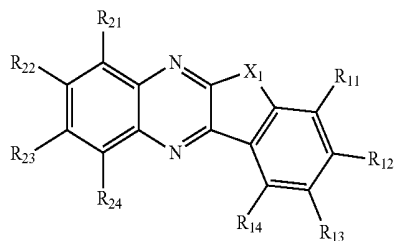
at least one of R₁(s) in the number of c1 is a group represented by Formula 2;

at least one of R₂(S) in the number of c2 is a group represented by Formula 2; or

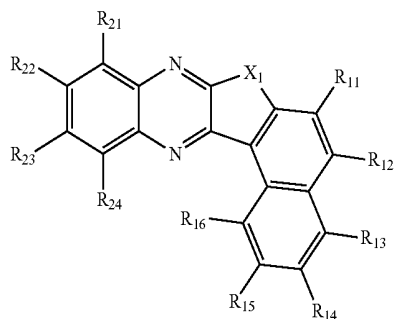
at least one of R₁(s) in the number of c1 and at least one of R₂(S) in the number of c2 are each a group represented by Formula 2.

9. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound represented by Formula 1 is represented by one of Formulae 1-1 to 1-4:

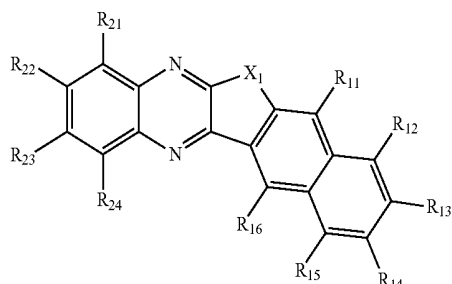
<Formula 1-1>



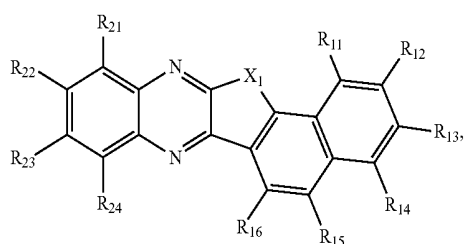
<Formula 1-2>



<Formula 1-3>



<Formula 1-4>



wherein, in Formulae 1-1 to 1-4, X₁ is the same as described in claim 1, R₁₁ to R₁₆ are defined the same as R₁ of Formula 1, R₂₁ to R₂₄ are defined the same as R₂ of Formula 1, at least one of R₁₁ to R₁₄ and R₂₁ to R₂₄ in Formula 1-1 is a group represented by Formula 2, and at least one of R₁₁ to R₁₆ and R₂₁ to R₂₄ in Formulae 1-2 to 1-4 is a group represented by Formula 2.

10. The condensed cyclic compound of claim 9, wherein at least one of R₁₁ to R₁₄ in Formula 1-1 is a group represented by Formula 2; or at least one of R₁₁ to R₁₆ in Formulae 1-2 to 1-4 is a group represented by Formula 2.

11. The condensed cyclic compound of claim 9, wherein

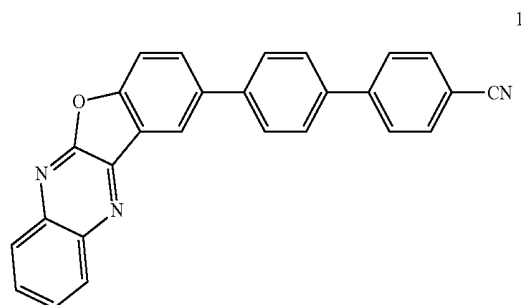
i) R₁₃ in Formula 1-1 is a group represented by Formula 2,

ii) R₁₁ and R₁₃ in Formula 1-1 are each a group represented by Formula 2,

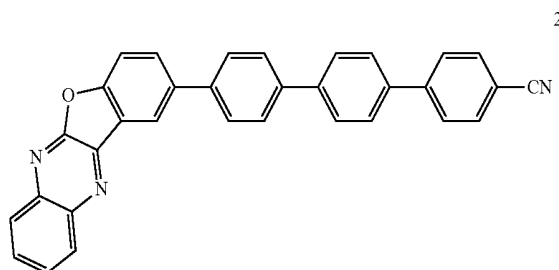
iii) R₁₄ in Formulae 1-2 to 1-4 is a group represented by Formula 2, or

iv) R₁₁ and R₁₄ in Formulae 1-2 to 1-4 are each a group represented by Formula 2.

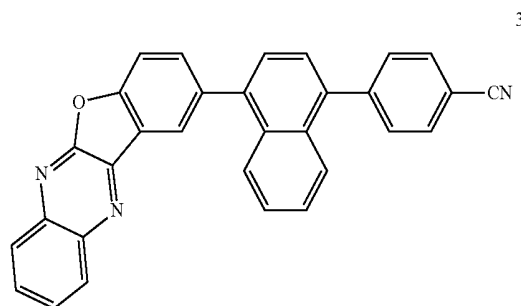
12. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound is selected from Compounds 1 to 66:



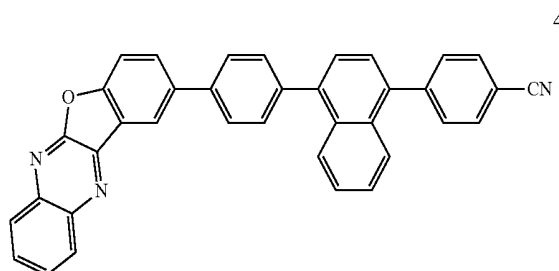
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2



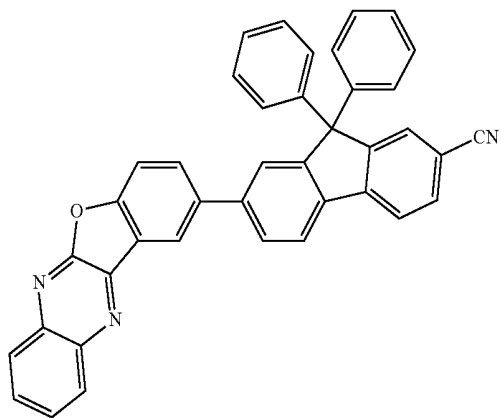
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4

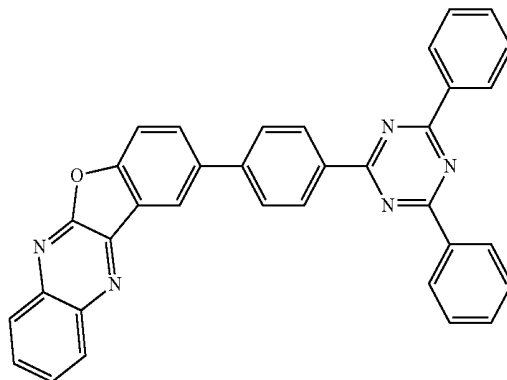
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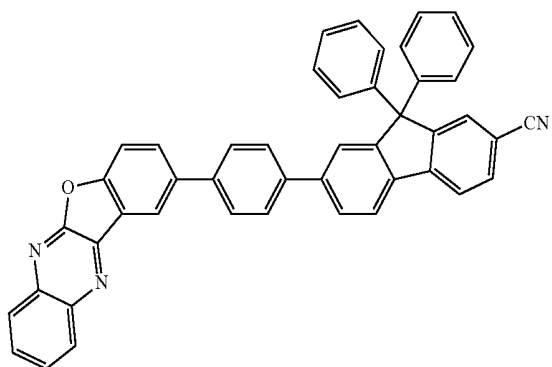


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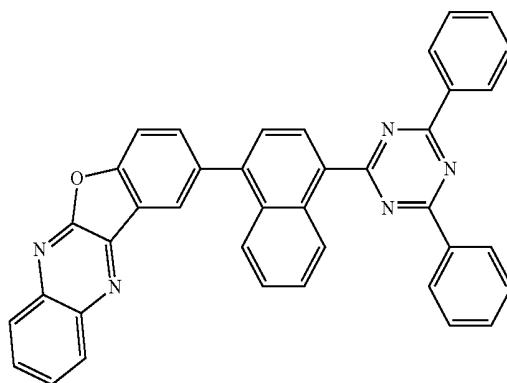
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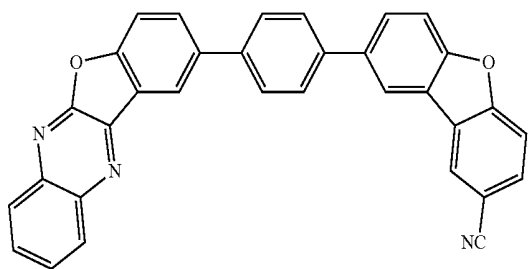
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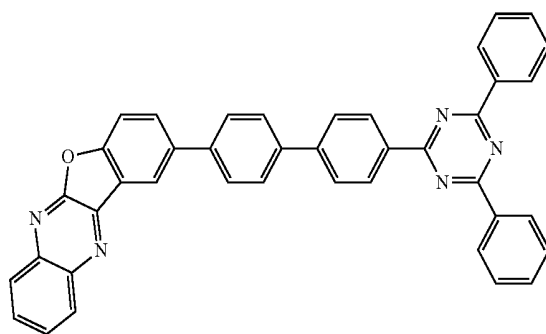
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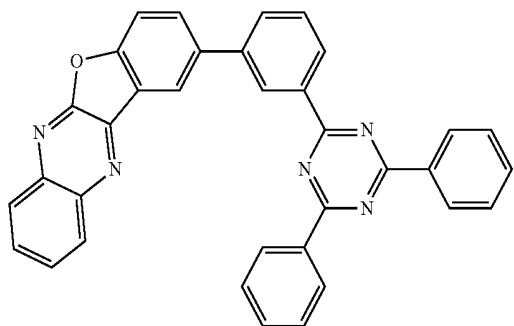
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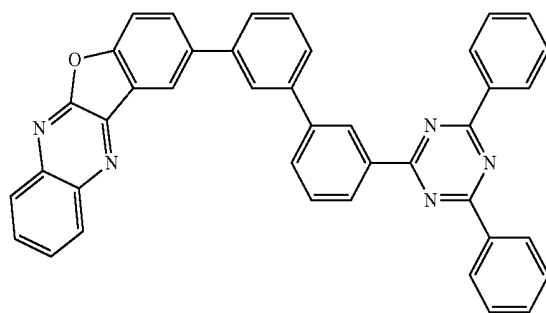
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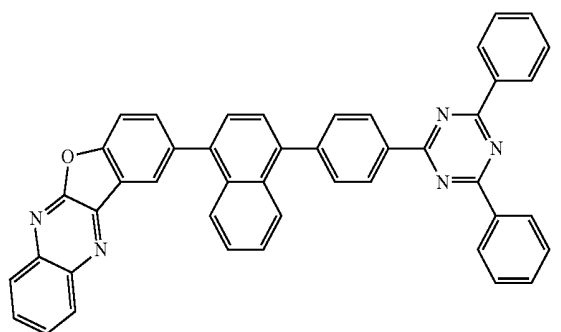
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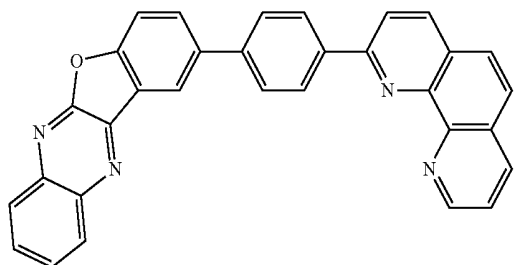
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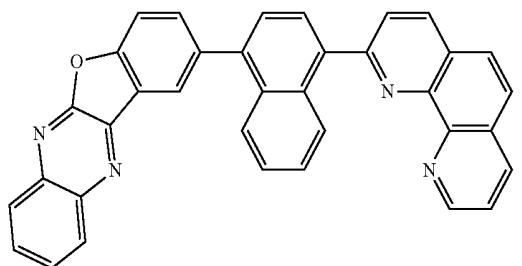
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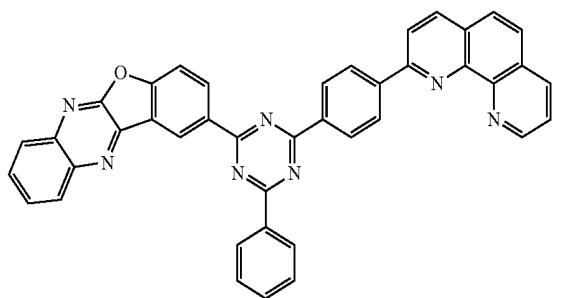
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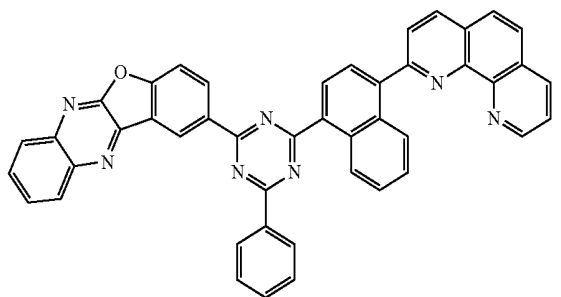
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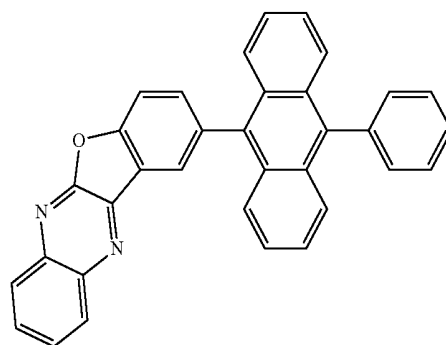


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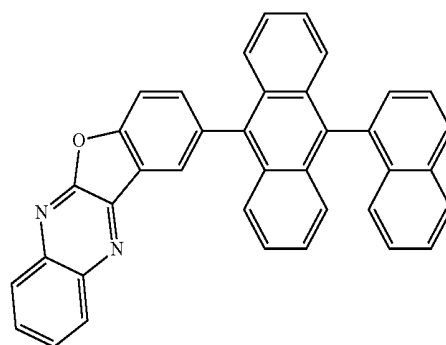


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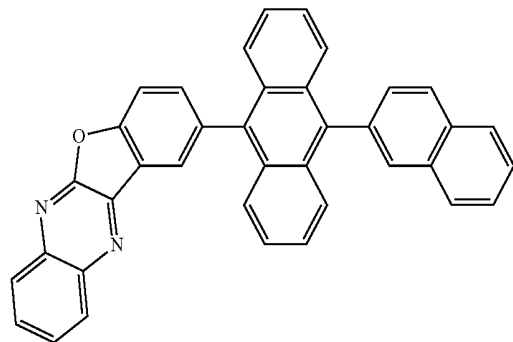
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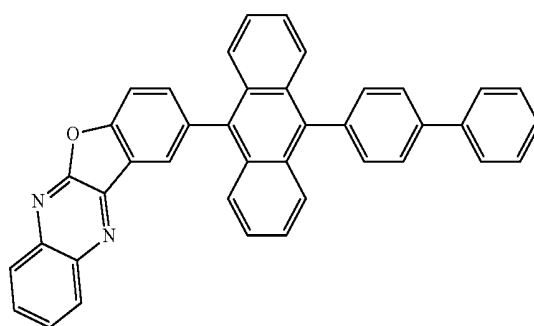
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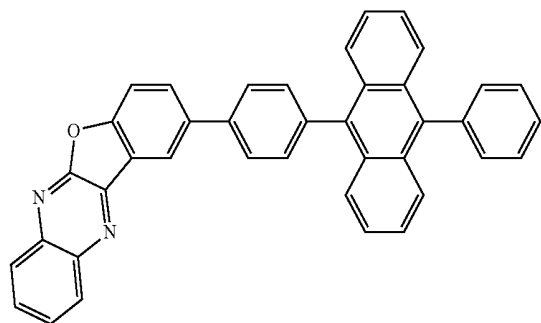
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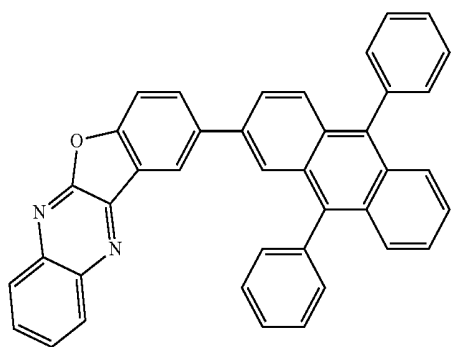
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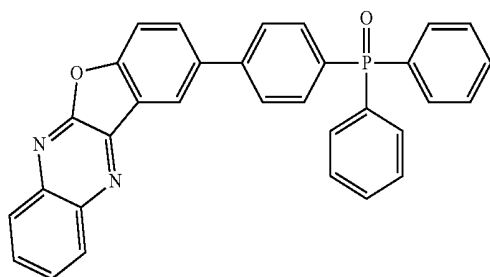
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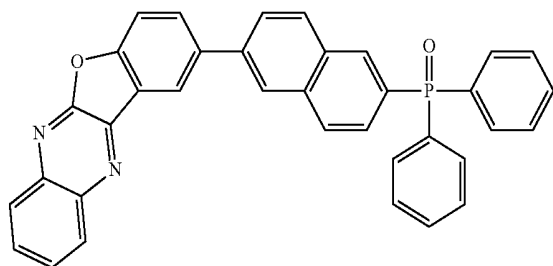
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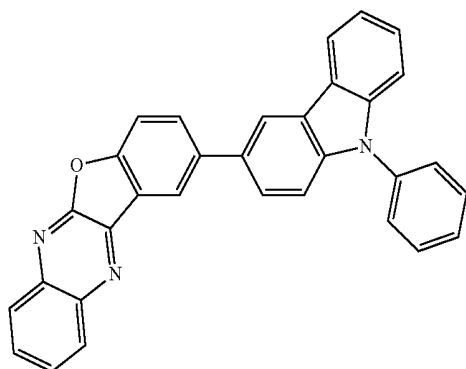
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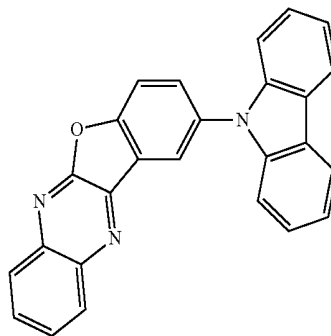


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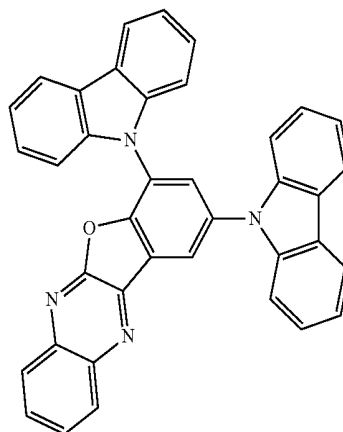


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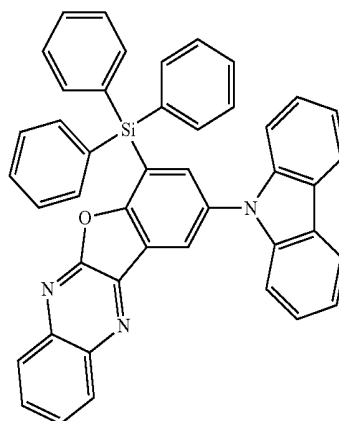
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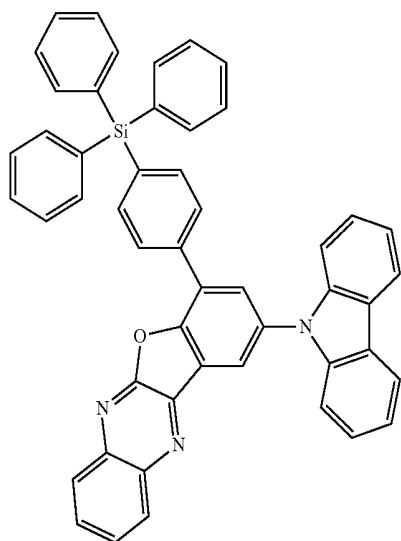
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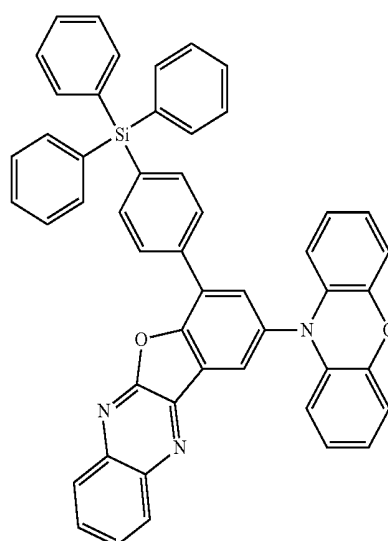


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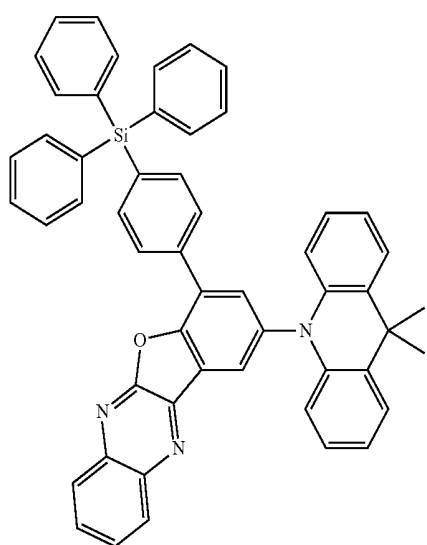


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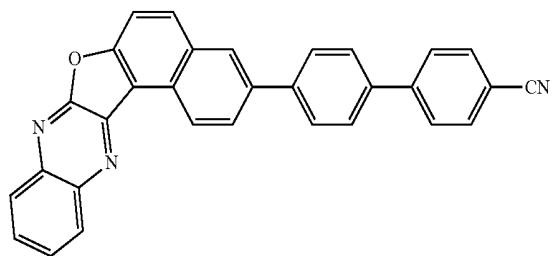
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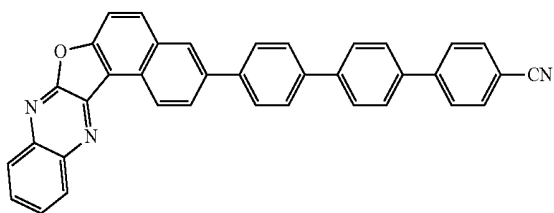
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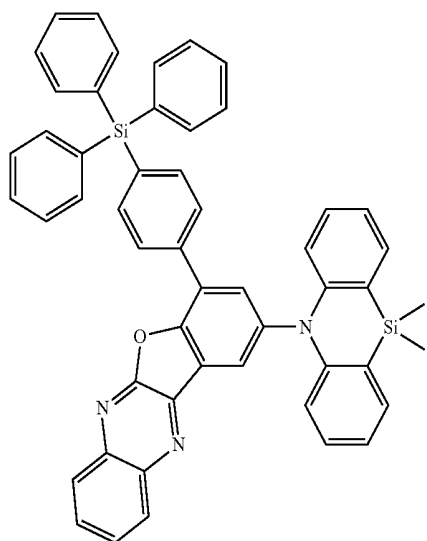
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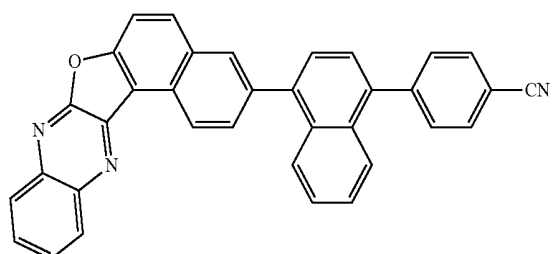
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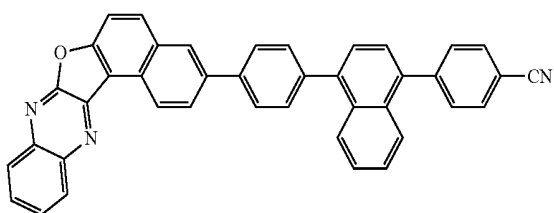
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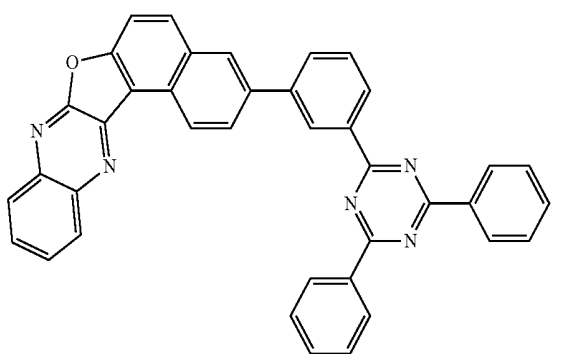
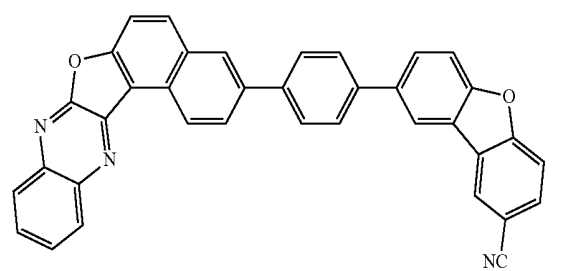
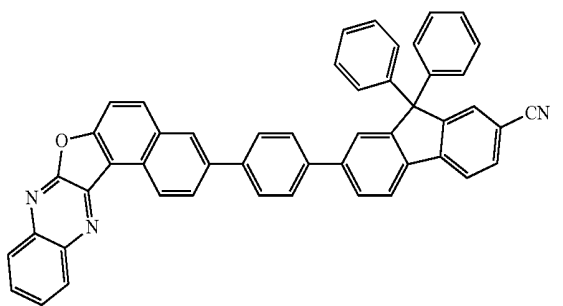
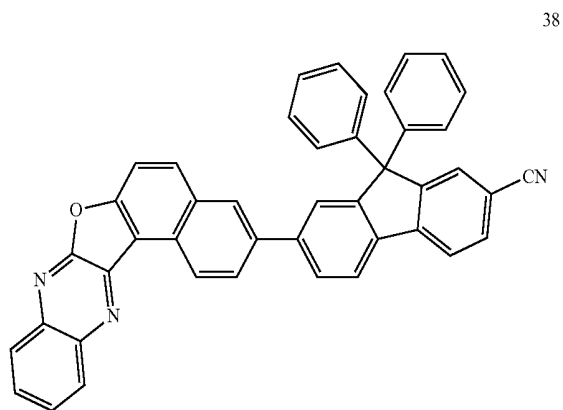


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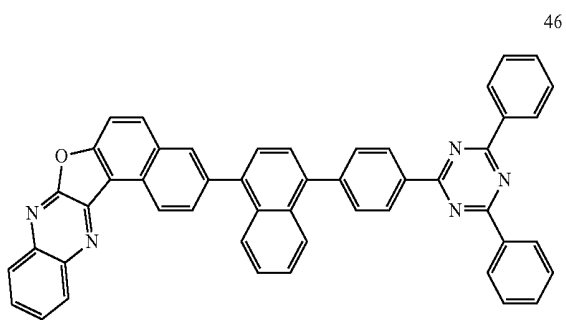
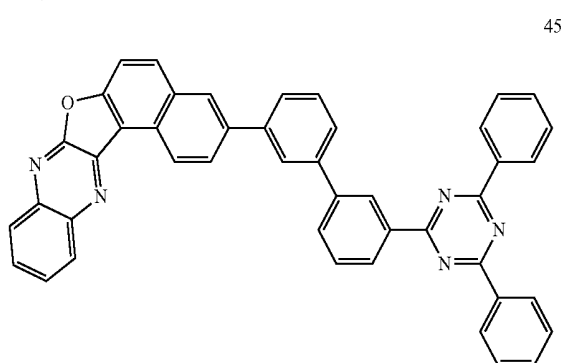
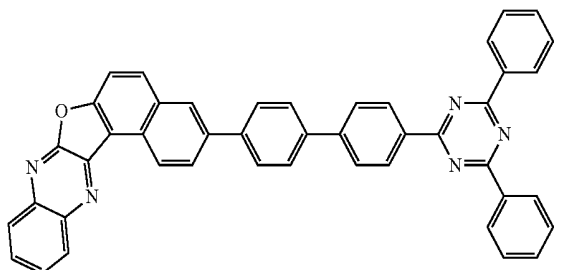
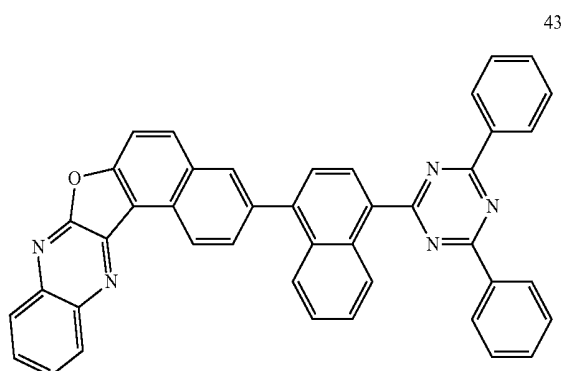
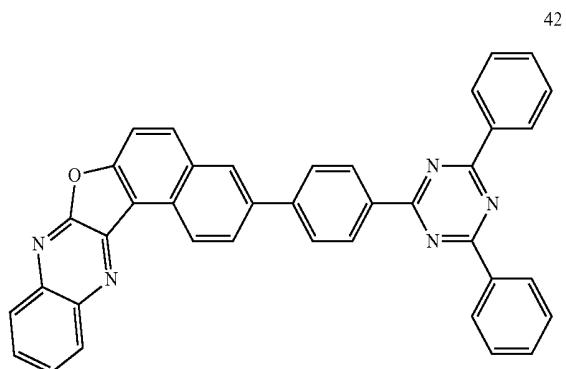


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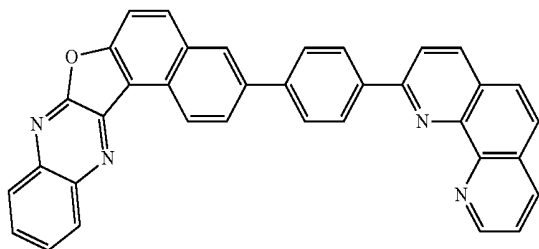


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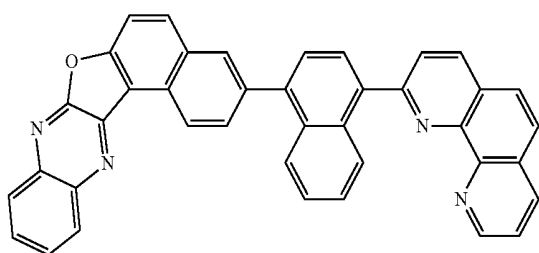


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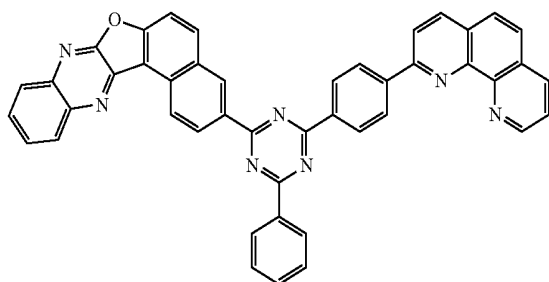
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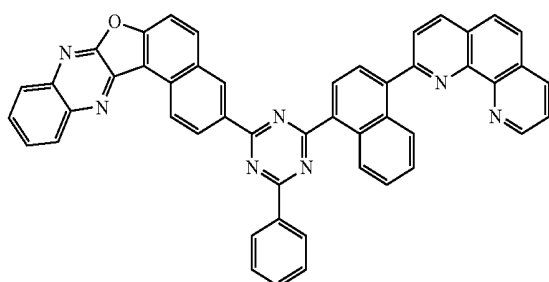
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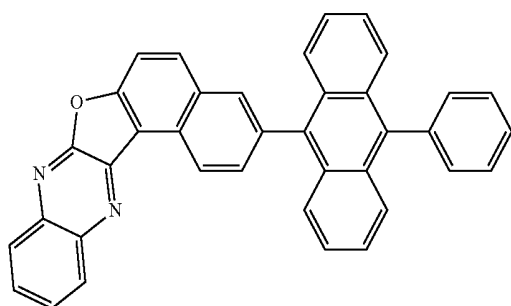
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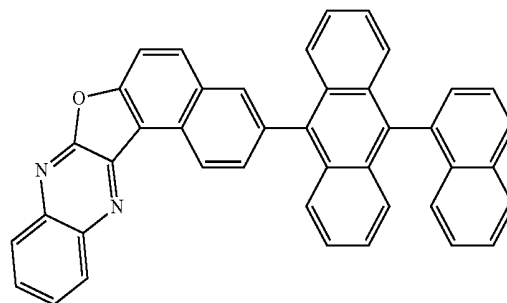


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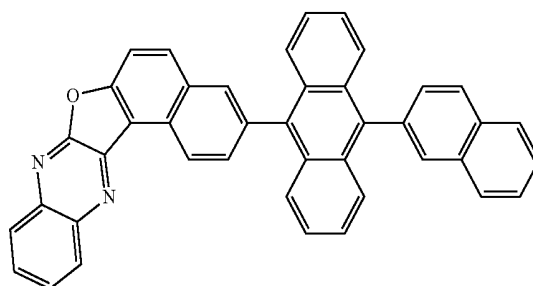


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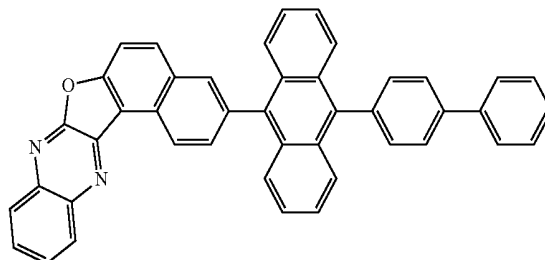
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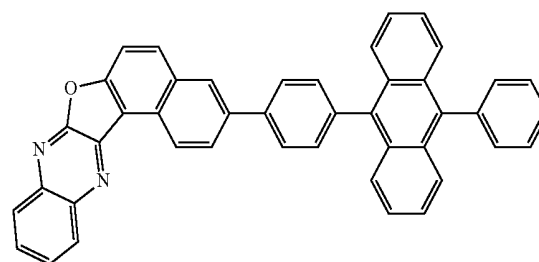
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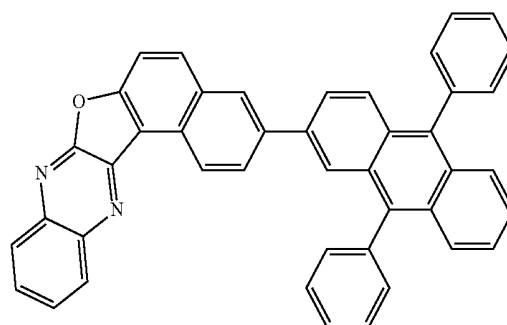
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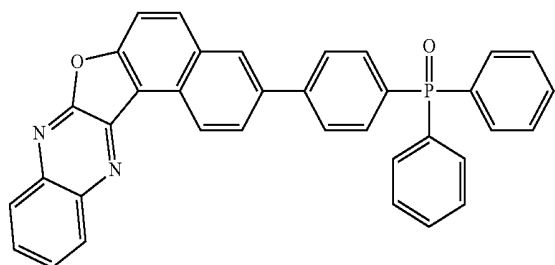


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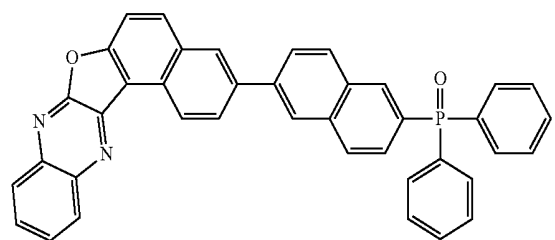


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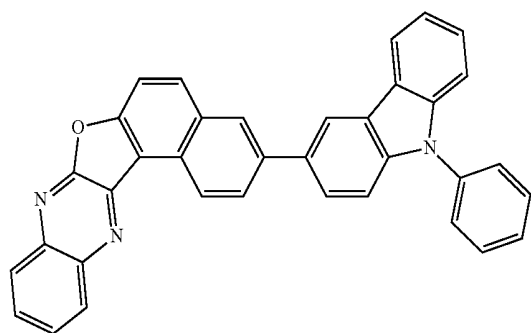
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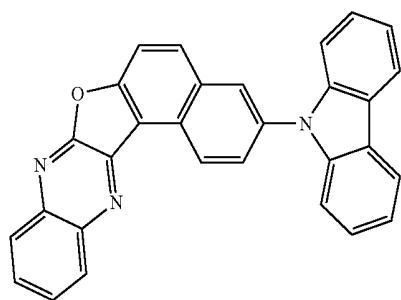
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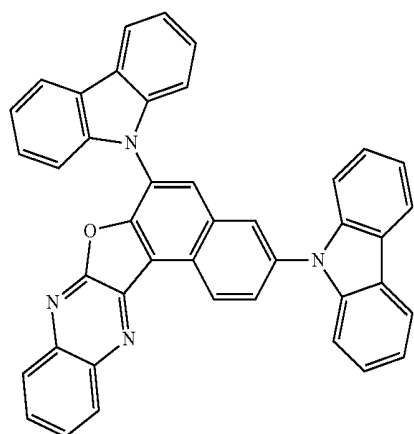
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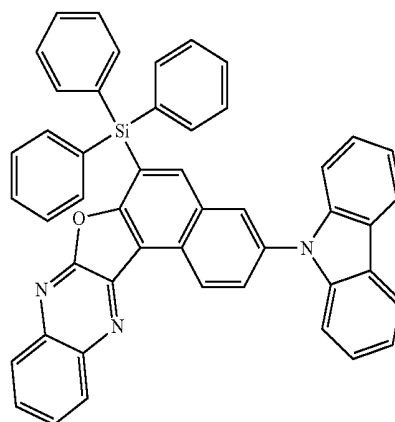


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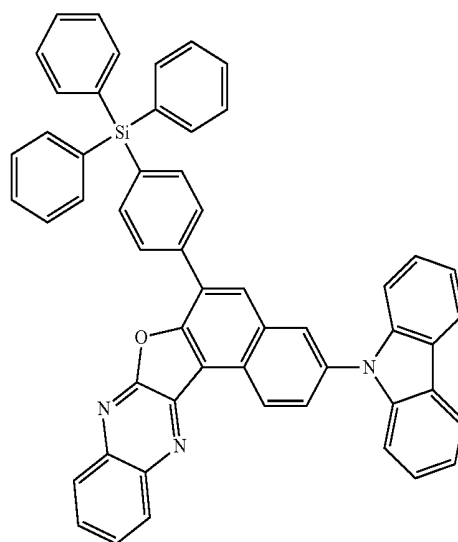


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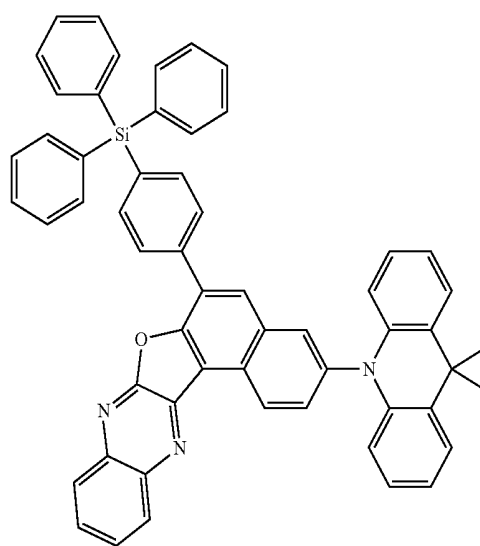
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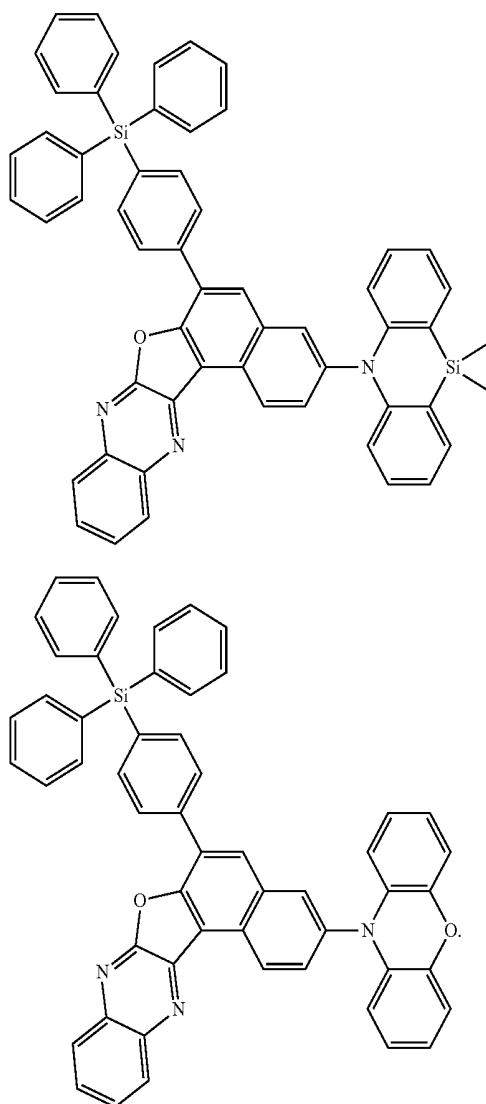
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13. An organic light-emitting device comprising:
a first electrode;
a second electrode facing the first electrode; and
an organic layer between the first electrode and the second electrode,

wherein the organic layer comprises an emission layer and at least one of the condensed cyclic compound of claim 1.

14. The organic light-emitting device of claim 13, wherein 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 an electron transport region between the emission layer and the second electrode, the hole transport region comprises a hole injection layer, a hole transport layer, an emission auxiliary layer, an electron blocking layer, or any combination thereof, and the electron transport region comprises an emission auxiliary layer, a hole blocking layer, an electron transport layer, an electron injection layer, or any combination thereof.

15. The organic light-emitting device of claim 14, wherein the electron transport region comprises the condensed cyclic compound.

16. The organic light-emitting device of claim 14, wherein the electron transport region comprises the electron transport layer and the electron injection layer, and at least one of the electron transport layer and the electron injection layer comprises the condensed cyclic compound.

17. The organic light-emitting device of claim 14, wherein the electron transport region comprises the electron transport layer, and the electron transport layer comprises the condensed cyclic compound.

18. The organic light-emitting device of claim 14, wherein the electron transport region further comprises a metal-containing material, and the metal-containing material comprises a Li complex.

19. The organic light-emitting device of claim 13, wherein the emission layer comprises the condensed cyclic compound.

20. The organic light-emitting device of claim 19, wherein the emission layer further comprises a dopant, an amount of the condensed cyclic compound in the emission layer is greater than an amount of the dopant, and the dopant is a phosphorescent dopant or a fluorescent dopant.

* * * * *

专利名称(译)	缩合环状化合物和包括其的有机发光器件		
公开(公告)号	US20190131540A1	公开(公告)日	2019-05-02
申请号	US16/049572	申请日	2018-07-30
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
[标]发明人	SIM MUNKI PARK JUNHA LEE HYOYOUNG KIM YOUNGKOOK HWANG SEOKHWAN		
发明人	SIM, MUNKI PARK, JUNHA LEE, HYOYOUNG KIM, YOUNGKOOK HWANG, SEOKHWAN		
IPC分类号	H01L51/00 C07D491/048		
CPC分类号	H01L51/0071 C07D491/048 H01L51/0067 H01L51/0072 H01L51/0073 H01L51/5016 H01L51/5056 H01L51/5072 H01L51/5096 H01L51/5088 H01L51/5092 H01L51/0052 H01L51/5076		
优先权	1020170142566 2017-10-30 KR		
外部链接	Espacenet USPTO		

摘要(译)

本发明提供由下式表示的稠合环状化合物和包含该化合物的有机发光装置。有机发光装置包括第一电极;面对第一电极的第二电极, 以及第一电极和第二电极之间的有机层, 其中有机层包括发光层和至少一种上述稠合环状化合物。

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