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

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(57) **ABSTRACT**

Provided is a flat display apparatus including a host and a dopant that each have a set or predetermined formula. The organic light-emitting device includes: a first electrode, a second electrode facing the first electrode, and an organic layer between the first electrode and the second electrode and including an emission layer, where the organic layer includes a compound represented by Formula 1 and a compound represented by Formula 2.

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Oct. 16, 2017 (KR) 10-2017-0134245

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FIG. 1

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FIG. 2

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FIG. 3

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FIG. 4

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ORGANIC LIGHT-EMITTING DEVICE AND FLAT DISPLAY APPARATUS INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2017-0134245, filed on Oct. 16, 2017, in the Korean Intellectual Property Office, the entire content of which is incorporated herein by reference.

BACKGROUND

1. Field

[0002] One or more embodiments relate to an organic light-emitting device and a flat display apparatus including the same.

2. Description of the Related Art

[0003] Organic light-emitting devices are self-emission devices that have wide viewing angles, high contrast ratios, and short response times, and excellent characteristics in terms of luminance, driving voltage, and response speed, compared to other 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 trans-

port 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 emission layer. Carriers, such as holes and electrons, recombine in the emission layer to produce excitons. These excitons transit (or relax) from an excited state to a ground state, thereby generating light.

SUMMARY

[0005] Aspects of embodiments of the present disclosure provide an organic light-emitting device with high efficiency and long lifespan and a flat display apparatus including the same.

[0006] Additional aspects of embodiments of the present disclosure 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.

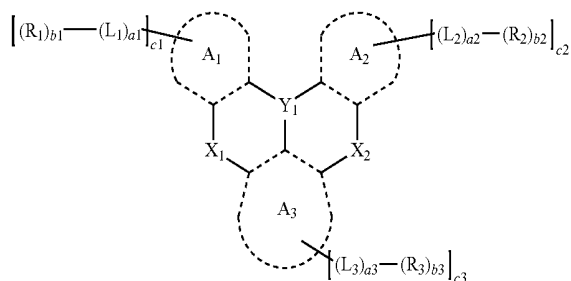
[0007] An aspect of an embodiment provides an organic light-emitting device including:

[0008] a first electrode,

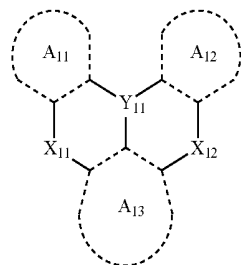
[0009] a second electrode facing the first electrode, and

[0010] an organic layer between the first electrode and the second electrode and including an emission layer,

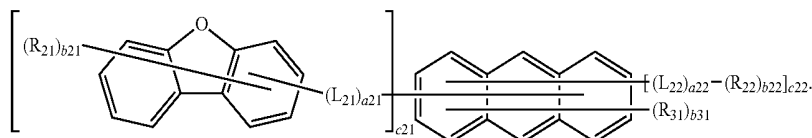
[0011] wherein the organic layer includes a compound represented by Formula 1 and a compound represented by Formula 2:



Formula 1



Formula 1A



Formula 2

[0012] In Formula 1, rings A_1 , A_2 , and A_3 may each independently be a C_5 - C_{60} carbocyclic group, a C_2 - C_{60} heterocyclic group, or a group represented by Formula 1A,

[0013] in Formula 1A, rings A_{11} , A_{12} , and A_{13} may each independently be a C_5 - C_{60} carbocyclic group or a C_2 - C_{60} heterocyclic group,

[0014] in Formula 1, Y_1 may be B, P, P=O, P=S, Al, Ga, As, Si(R_{41}), or Ge(R_{41}), X_1 may be O, S, or N(R_{42}), and X_2 may be O, S, or N(R_{43}),

[0015] in Formula 1A, Y_{11} may be B, P, P=O, P=S, Al, Ga, As, Si(R_{51}), or Ge(R_{51}), X_{11} may be O, S, or N(R_{52}), and X_{12} may be O, S, or N(R_{53}),

[0016] in Formulae 1 and 2, L_1 to L_3 , L_{21} , and L_{22} may each independently be a substituted or unsubstituted C_5 - C_{60} carbocyclic group or a substituted or unsubstituted C_2 - C_{60} heterocyclic group,

[0017] in Formulae 1 and 2, a_1 to a_3 and a_{21} may each independently be an integer of 0 to 5, and when a_1 is 0, $*(L_1)_{a_1}-*$ may be a single bond, when a_2 is 0, $*(L_2)_{a_2}-*$ may be a single bond, when a_3 is 0, $*(L_3)_{a_3}-*$ may be a single bond, and when a_{21} is 0, $*(L_{21})_{a_{21}}-*$ may be a single bond,

[0018] in Formula 2, a_{22} may be an integer of 1 to 5,

[0019] in Formulae 1 and 2, R_1 to R_3 , R_{21} , R_{22} , R_{31} , R_{41} to R_{43} , and R_{51} to R_{53} 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_{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_{30} cycloalkyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{30} cycloalkenyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_2 - C_{60} heteroaryl group, a substituted or unsubstituted C_1 - C_{60} hetero aryloxy group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_1)(Q_2)(Q_3), —B(Q_1)(Q_2), —C(=O)(Q_1), —P(=O)(Q_1)(Q_2), —P(=S)(Q_1)(Q_2), —S(=O)(Q_1)(Q_2), and —S(=O)₂(Q_1)(Q_2),

[0020] at least two groups selected from R_1 to R_3 , R_{21} , R_{22} , R_{31} , R_{41} to R_{43} , and R_{51} to R_{53} may optionally be linked to form a substituted or unsubstituted C_5 - C_{60} carbocyclic group or a substituted or unsubstituted C_2 - C_{60} heterocyclic group,

[0021] in Formulae 1 and 2, b_1 to b_3 , b_{21} , b_{22} , and b_{31} may each independently be an integer of 0 to 7,

[0022] in Formula 1, c_1 to c_3 may each independently be an integer of 0 to 10,

[0023] in Formula 2, c_{21} may be an integer of 1 to 10 and c_{22} may be an integer of 0 to 9,

[0024] at least one substituent selected from the substituted C_5 - C_{60} carbocyclic group, the substituted C_2 - 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_{30} cycloalkyl group, the substituted C_2 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{30} cycloalkenyl

group, the substituted C_2 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, the substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_2 - C_{60} heteroaryl group, the substituted C_1 - C_{60} hetero aryloxy group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

[0025] 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;

[0026] 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_{30} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{30} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_{11})(Q_{12})(Q_{13}), —B(Q_{11})(Q_{12}), —C(=O)(Q_{11}), —S(=O)₂(Q_{11}), and —P(=O)(Q_{11})(Q_{12});

[0027] a C_3 - C_{30} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{30} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0028] a C_3 - C_{30} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{30} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_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_{30} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{30} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_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}), —B(Q_{21})(Q_{22}), —C(=O)(Q_{21}), —S(=O)₂(Q_{21}), and —P(=O)(Q_{21})(Q_{22}); and

[0029] —Si(Q_{31})(Q_{32})(Q_{33}), —B(Q_{31})(Q_{32}), —C(=O)(Q_{31}), —S(=O)₂(Q_{31}), and —P(=O)(Q_{31})(Q_{32}),

[0030] Q_1 to Q_3 , Q_{11} to Q_{13} , Q_{21} to Q_{23} , Q_{31} to Q_{33} , Q_{41} , Q_{42} , Q_{51} , Q_{52} , Q_{61} , and Q_{71} 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_{30} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{30} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic con-

densified polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, and

[0031] * and *' each independently indicate a binding site to a neighboring atom.

[0032] Another aspect of an embodiment provides a flat display apparatus including a thin film transistor and the organic light-emitting device, wherein the thin film transistor may include a source electrode, a drain electrode, and an active layer, and the first electrode of the organic light-emitting device may be electrically coupled or connected with at least one of the source electrode and the drain electrode of the thin film transistor.

embodiments. As used herein, the term “and/or” includes any and all combinations of one or more of the associated listed items. Expressions such as “at least one of,” when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

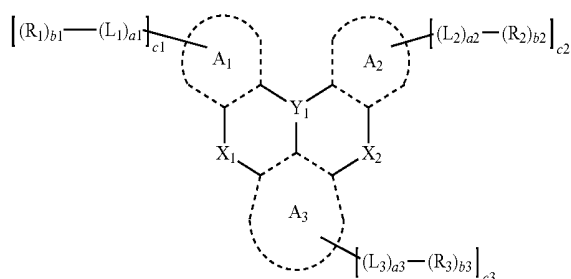
[0036] An organic light-emitting device according to an embodiment may include:

[0037] a first electrode;

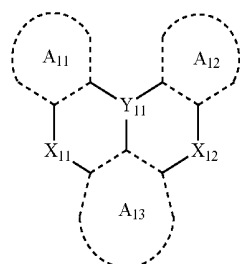
[0038] a second electrode facing the first electrode; and

[0039] an organic layer between the first electrode and the second electrode and including an emission layer,

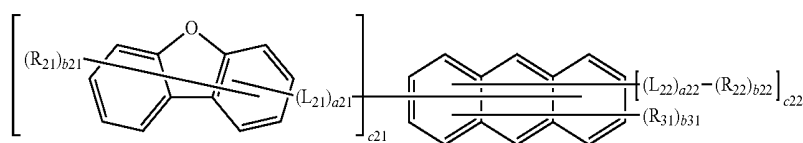
[0040] wherein the organic layer may include a compound represented by Formula 1 and a compound represented by Formula 2:



Formula 1



Formula 1A



Formula 2

BRIEF DESCRIPTION OF THE DRAWINGS

[0033] These and/or other aspects of embodiments will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

[0034] FIGS. 1-4 are each a schematic view of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

[0035] Reference will now be made in more detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of

[0041] In Formula 1, rings A₁, A₂, and A₃ may each independently be a C₅-C₆₀ carbocyclic group, a C₂-C₆₀ heterocyclic group, or a group represented by Formula 1A,

[0042] in Formula 1A, rings A₁₁, A₁₂, and A₁₃ may each independently be a C₅-C₆₀ carbocyclic group or a C₂-C₆₀ heterocyclic group.

[0043] In one embodiment, rings A₁, A₂, A₃, A₁₁, A₁₂, and A₁₃ may each independently be selected from a benzene group, a naphthalene group, an anthracene group, a phenanthrene group, a triphenylene group, a pyrene group, a chrysene group, a cyclopentadiene group, a 1,2,3,4-tetrahydronaphthalene group, a thiophene group, a furan group, a pyrrole group, an indole group, an indene group, a benzosilole group, a benzothiophene group, a benzofuran group, a carbazole group, a fluorene group, a dibenzosilole group, a dibenzothiophene group, a dibenzofuran group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline

group, a quinoxaline group, a quinazoline group, a phenanthroline group, a pyrazole group, an imidazole group, a triazole group, an oxazole group, an iso-oxazole group, a thiazole group, an isothiazole group, an oxadiazole group, a thiadiazole group, a benzopyrazole group, a benzimidazole group, a benzoxazole group, a benzothiazole group, a benzooxadiazole group, a benzothiadiazole group, a 5,6,7,8-tetrahydroisoquinoline group, a 5,6,7,8-tetrahydroquinoline group, and a group represented by Formula 1A, wherein rings A_{11} , A_{12} , and A_{13} may not be a group represented by Formula 1A. However, embodiments of the present disclosure are not limited thereto.

[0044] In one embodiment, rings A_1 , A_2 , and A_3 may each independently be a benzene group or a group represented by Formula 1A, but embodiments of the present disclosure are not limited thereto.

[0045] In Formula 1A, rings A_{11} , A_{12} , and A_{13} may each independently be a benzene group, but embodiments of the present disclosure are not limited thereto.

[0046] In Formula 1A, Y_{11} may be B, P, P=O, P=S, Al, Ga, As, Si(R_{51}), or Ge(R_{51}), X_{11} may be O, S, or N(R_{52}), and X_{12} may be O, S, or N(R_{53}).

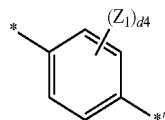
[0047] In Formulae 1 and 2, L_1 to L_3 , L_{21} , and L_{22} may each independently be selected from a substituted or unsubstituted C_5 - C_{60} carbocyclic group or a substituted or unsubstituted C_2 - C_{60} heterocyclic group.

[0048] In one embodiment, L_1 to L_3 , L_{21} , and L_{22} may each independently be selected from a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenyl group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, and a dibenzocarbazolylene group; and

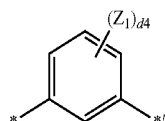
[0049] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene

group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isooxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzooxazolylene group, an isobenzooxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, and a dibenzocarbazolylene 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 hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_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 pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isooxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzooxazolyl group, an isobenzooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, and an imidazopyridinyl group, but embodiments of the present disclosure are not limited thereto.

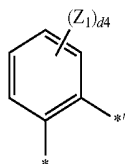
[0050] In one embodiment, L_1 to L_3 , L_{21} , and L_{22} may each independently be selected from Formulae 3-1 to 3-22, but embodiments of the present disclosure are not limited thereto:



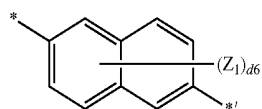
3-1



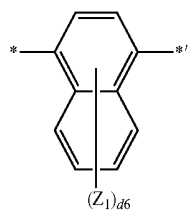
3-2



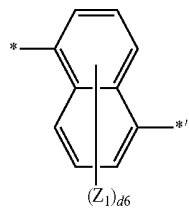
3-3



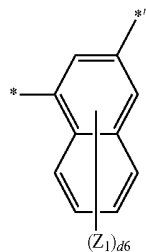
3-4



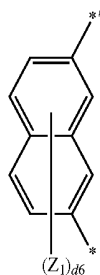
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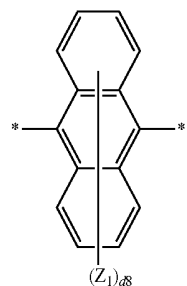
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3-7

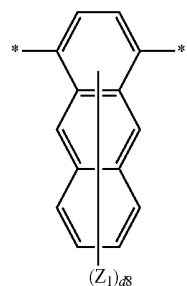


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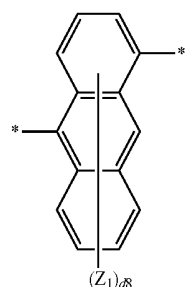


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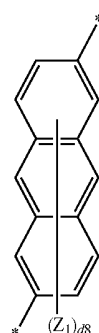
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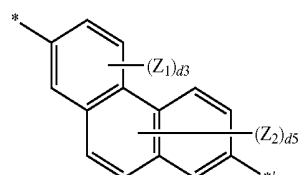
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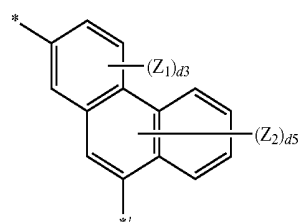
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3-12

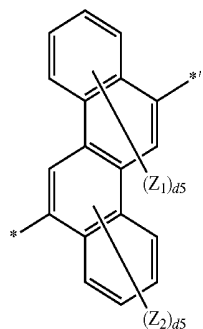
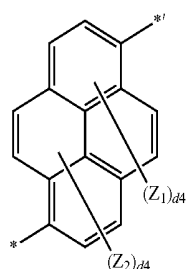
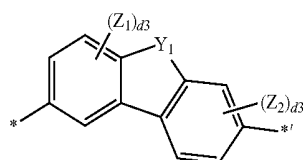
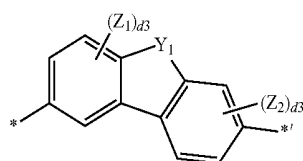
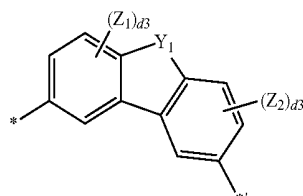
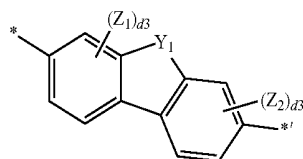
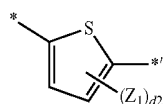
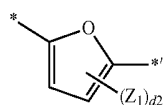


3-13



3-14

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**[0051]** In Formulae 3-1 to 3-22,**[0052]** Y₁ may be O, S, C(Z₃)(Z₄), N(Z₅), or Si(Z₆)(Z₇),**[0053]** Z₁ to Z₇ 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 cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, 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 pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnoliny group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranly group, a dibenzothiophenyl group, a dibenzosilolyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranly group, an azadibenzothiophenyl group, an azadibenzosilolyl group, —Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), —B(Q₃₁)(Q₃₂), —C(=O)(Q₃₁), —S(=O)₂(Q₃₁), and —P(=O)(Q₃₁)(Q₃₂).

[0054] Q₃₁ to Q₃₃ may each independently be selected from:**[0055]** a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a quinoliny group, an isoquinoliny group, a quinoxalinyl group, and a quinazolinyl group; and**[0056]** a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a quinoliny group, an isoquinoliny group, a quinoxalinyl group, and a quinazolinyl group, each substituted with at least one selected from a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, and a phenyl group,**[0057]** d₂ may be an integer of 0 to 2, d₃ may be an integer of 0 to 3, d₄ may be an integer of 0 to 4, d₅ may be an integer of 0 to 5, d₆ may be an integer of 0 to 6, and d₈ may be an integer of 0 to 8, and**[0058]** * and *' each indicate a binding site to a neighboring atom.**[0059]** In Formulae 1 and 2, a₁ to a₃ and a₂₁ may each independently be an integer of 0 to 5, and when a₁ is 0, *-(L₁)_{a1}-* may be a single bond, when a₂ is 0, *-(L₂)_{a2}-* may be a single bond, when a₃ is 0, *-(L₃)_{a3}-* may be a

single bond, and when a21 is 0, $^{*-}(L_{21})_{a21}-^{*-}$ may be a single bond, and

[0060] In Formula 2, a22 may be an integer of 1 to 5.

[0061] In one embodiment, a1 to a3 and a21 may each independently be 0 or 1, and a22 may be 1 or 2, but embodiments of the present disclosure are not limited thereto.

[0062] In Formulae 1 and 2, R_1 to R_3 , R_{21} , R_{22} , R_{31} , R_{41} to R_{43} , and R_{51} to R_{53} 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_{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_{30} cycloalkyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{30} cycloalkenyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_2 - C_{60} heteroaryl group, a substituted or unsubstituted C_1 - C_{60} hetero aryloxy group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_1)(Q_2)(Q_3)$, $-B(Q_1)(Q_2)$, $-C(=O)(Q_1)$, $-P(=O)(Q_1)(Q_2)$, $-P(=S)(Q_1)(Q_2)$, $-S(=O)(Q_1)(Q_2)$, and $-S(=O)_2(Q_1)(Q_2)$, and

[0063] at least two groups selected from R_1 to R_3 , R_{21} , R_{22} , R_{31} , R_{41} to R_{43} , and R_{51} to R_{53} may be optionally linked to form a substituted or unsubstituted C_5 - C_{60} carbocyclic group or a substituted or unsubstituted C_2 - C_{60} heterocyclic group.

[0064] Here, Q_1 to Q_3 may be the same as described above.

[0065] In one embodiment, R_1 to R_3 , R_{21} , R_{22} , R_{31} , R_{41} to R_{43} , and R_{51} to R_{53} may each independently be selected from:

[0066] 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_2 - C_{20} alkenyl group, a C_2 - C_{20} alkynyl group, and a C_1 - C_{20} alkoxy group;

[0067] a C_1 - C_{20} alkyl group, a C_2 - C_{20} alkenyl group, a C_2 - C_{20} alkynyl group, and a C_1 - C_{20} alkoxy group, each substituted with at least one selected from deuterium, $-F$, $-Cl$, $-Br$, $-I$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl 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 $-P(=O)(Q_{31})(Q_{32})$;

[0068] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenan-

threnyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoiyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinylnyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[0069] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoiyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinylnyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and $-B(Q_1)(Q_2)$, $-P(Q_1)(Q_2)$, and $-C(=O)(Q_1)$, each substituted with at least one selected from deuterium, $-F$, $-Cl$, $-Br$, $-I$, $-CD_3$, $-CD_2H$, $-CDH_2$, $-CF_3$, $-CF_2H$, $-CFH_2$, 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_2 - C_{20} alkenyl group, a C_2 - C_{20} alkynyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinylnyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an

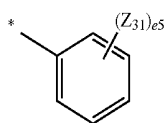
isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$, $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{B}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{C}(=\text{O})(\text{Q}_{31})$, $-\text{S}(=\text{O})_2(\text{Q}_{31})$, and $-\text{P}(=\text{O})(\text{Q}_{31})(\text{Q}_{32})$, but embodiments of the present disclosure are not limited thereto.

[0070] Here, Q_1 to Q_3 and Q_{31} to Q_{33} may be the same as described above.

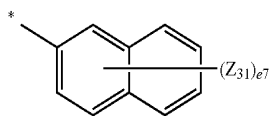
[0071] In one embodiment, R_1 to R_3 , R_{21} , R_{22} , R_{31} , R_{41} to R_{43} , and R_{51} to R_{53} may each independently be selected from:

[0072] 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_{20} alkyl group, a C_2 - C_{20} alkenyl group, a C_2 - C_{20} alkynyl group, and a C_1 - C_{20} alkoxy group; and

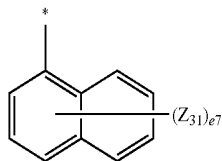
[0073] groups represented by Formulae 5-1 to 5-46, but embodiments of the present disclosure are not limited thereto:



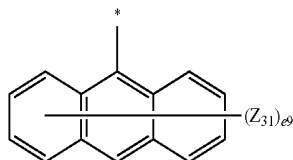
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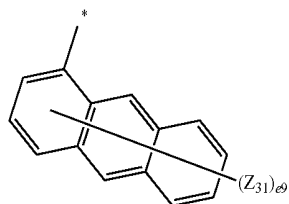
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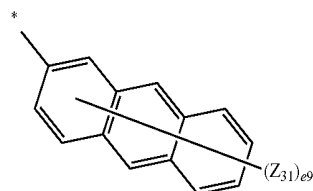
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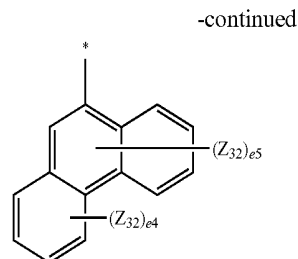
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5-5

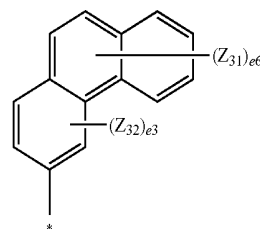


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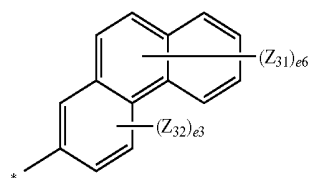


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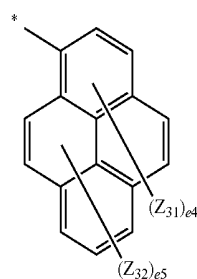
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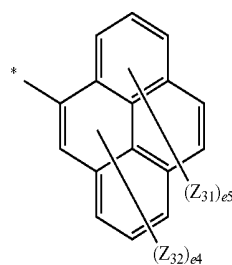
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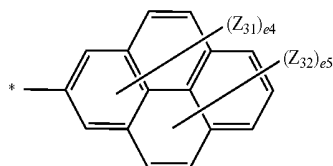
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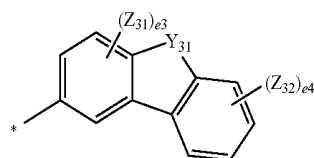
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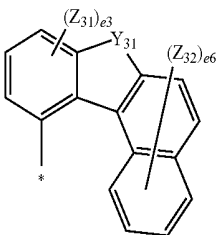
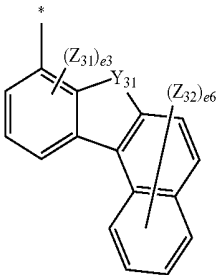
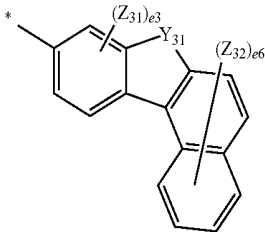
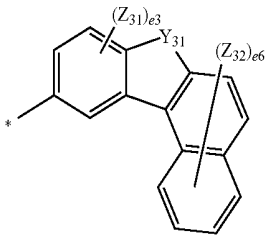
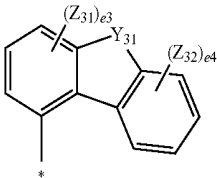
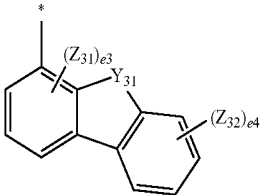
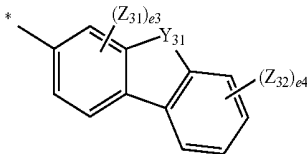


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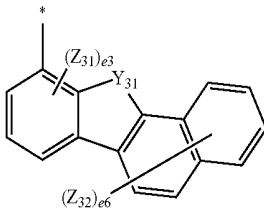
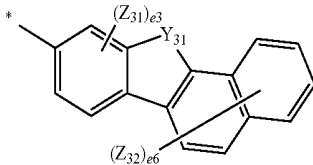
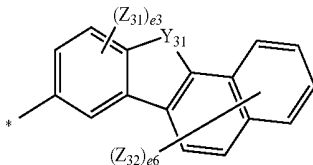
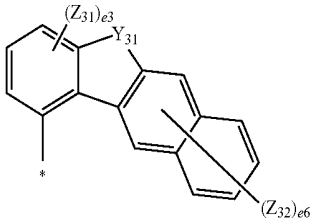
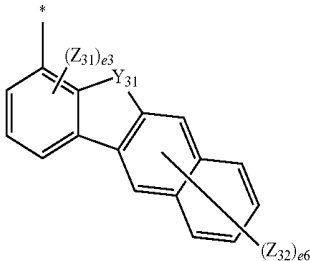
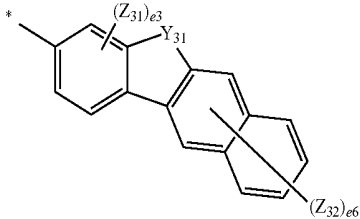
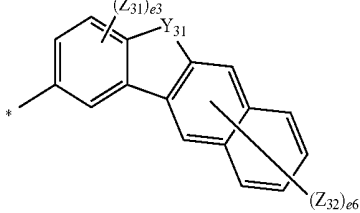


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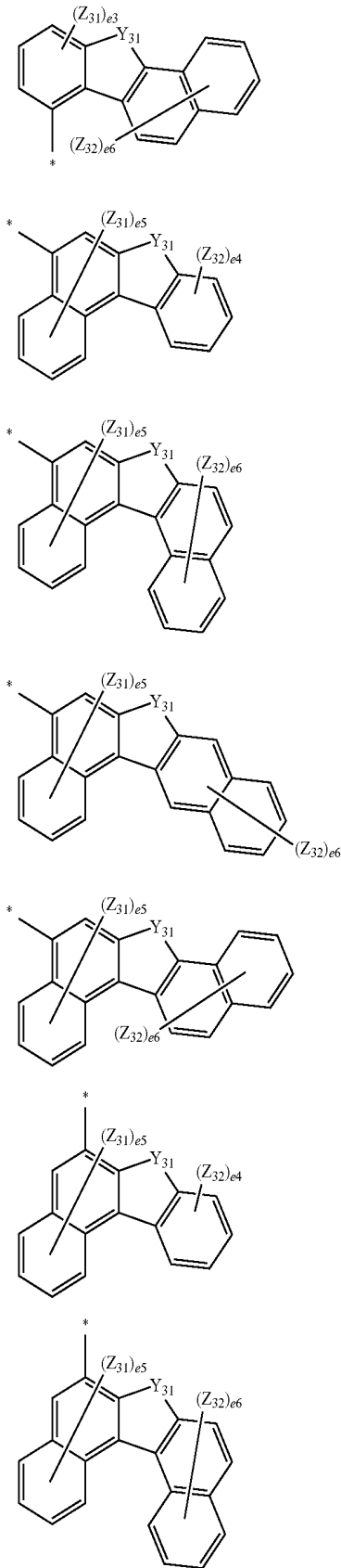
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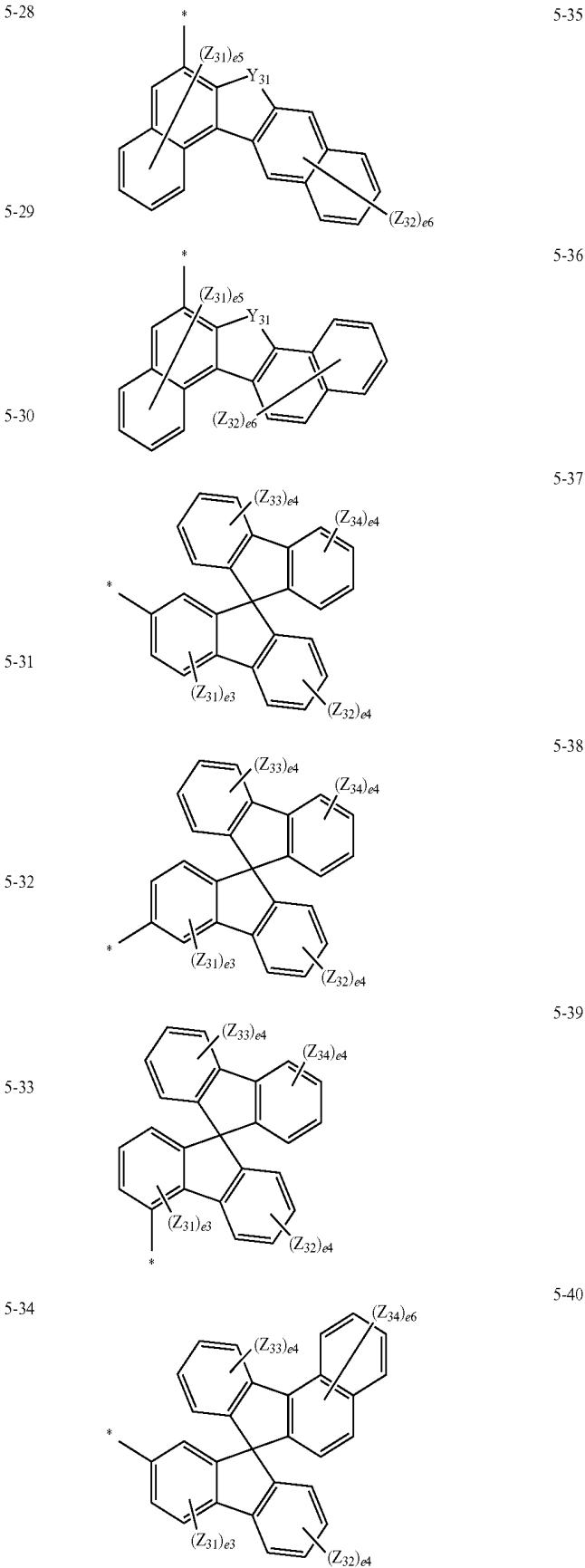
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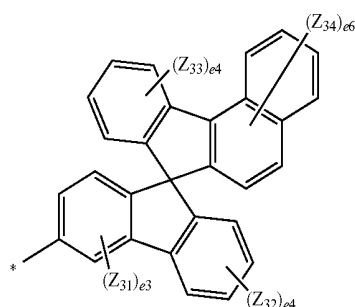
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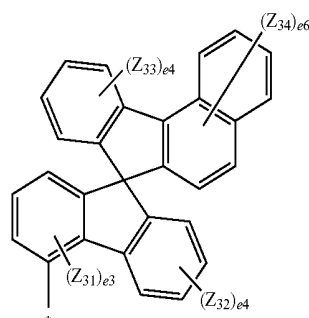
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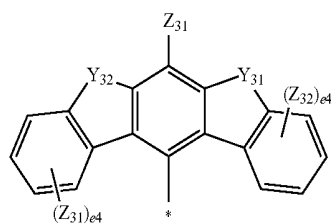
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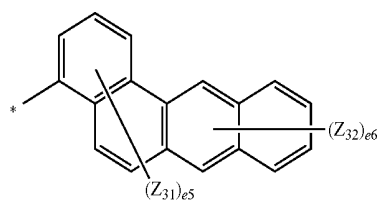
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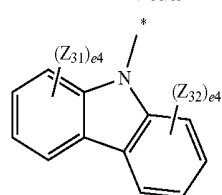
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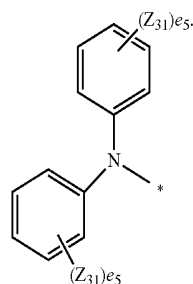
5-43



5-44



5-45



5-46

[0074] In Formulae 5-1 to 5-46,

[0075] Y_{31} and Y_{32} may each independently be O, S, C(Z_{35})(Z_{36}), N(Z_{37}), or Si(Z_{38})(Z_{39}),

[0076] 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 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 spirobifluorenyl 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 pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an indolyl group, an isoindolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a 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, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a dibenzosilolyl group, a carbazolyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, a benzonaphthyridinyl group, an azafluorenyl group, an azaspiro-bifluorenyl group, an azacarbazolyl group, an azadibenzofuranyl group, an azadibenzothiophenyl group, an azadibenzosilolyl group, and —Si(Q_{31})(Q_{32})(Q_{33}).

[0077] Q_1 to Q_3 and Q_{31} to Q_{33} may each independently be selected from:

[0078] a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, and a quinazolinyl group; and

[0079] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, and a quinazolinyl group, each substituted with at least one selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, and a phenyl group,

[0080] e_3 may be an integer of 0 to 3, e_4 may be an integer of 0 to 4, e_5 may be an integer of 0 to 5, e_6 may be an integer of 0 to 6, e_7 may be an integer of 0 to 7, and e_9 may be an integer of 0 to 9, and

[0081] * indicates a binding site to a neighboring atom.

[0082] In Formulae 1 and 2, b_1 to b_3 , b_{21} , b_{22} , and b_{31} may each independently be an integer of 0 to 7. In Formula 1, c_1 to c_3 may each independently be an integer of 0 to 10. In Formula 2, c_{21} may be an integer of 1 to 10, and c_{22} may be an integer of 0 to 9.

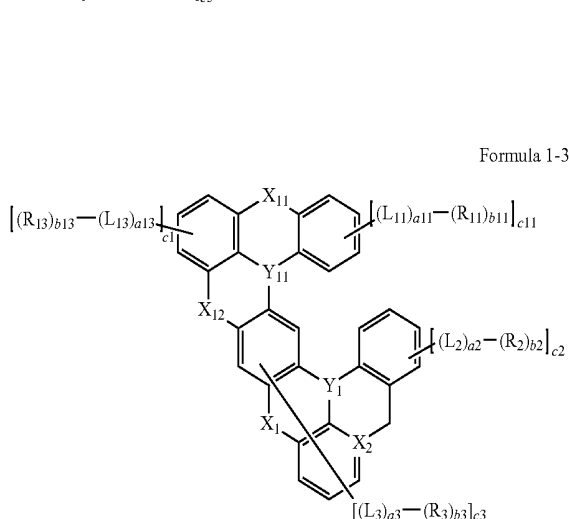
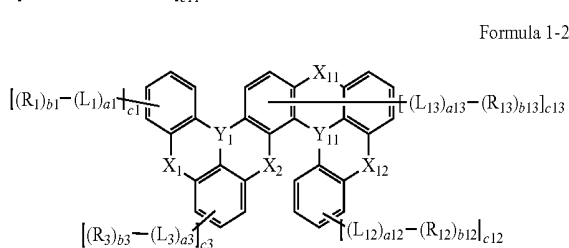
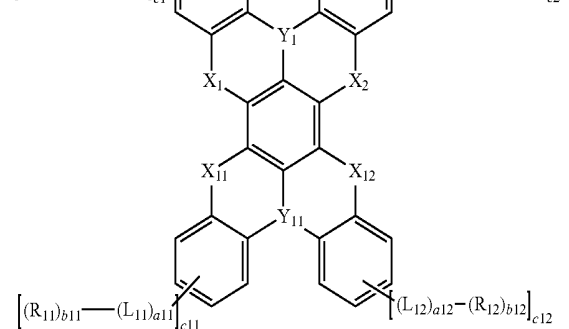
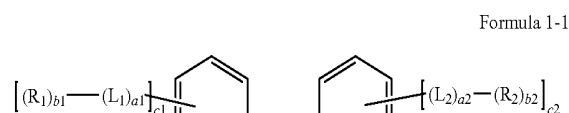
[0083] In one embodiment, b1 to b3, b21, b22, and b31 may each independently be 0, 1, or 2, but embodiments of the present disclosure are not limited thereto.

[0084] In one embodiment, the sum of c1 to c3 may be 0, 1, or 2, but embodiments of the present disclosure are not limited thereto.

[0085] In one embodiment, c21 and c22 may each independently be 1, 2, or 3, but embodiments of the present disclosure are not limited thereto.

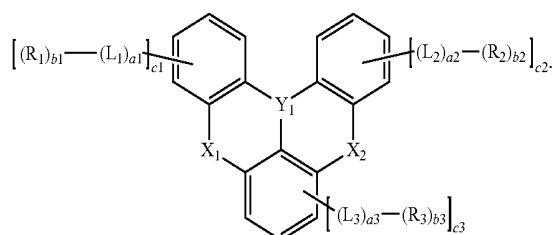
[0086] In one embodiment, c21 and c22 may each independently be 1 or 2, but embodiments of the present disclosure are not limited thereto.

[0087] In one embodiment, the 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:



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Formula 1-4

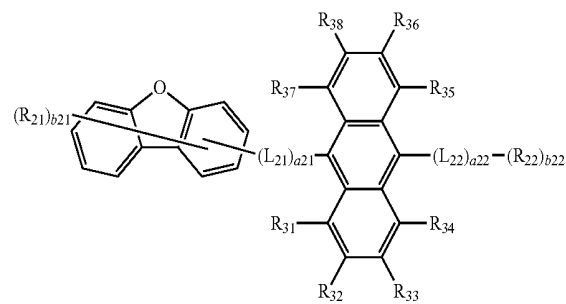


[0088] In Formulae 1-1 to 1-4, Y₁, X₁, X₂, Y₁₁, X₁₁, X₁₂, L₁ to L₃, a1 to a3, R₁ to R₃, b1 to b3, and c1 to c3 may respectively be the same as those of Formula 1, L₁₁ to L₁₃ may each independently be the same as described in connection with L₁ to L₃, all to a13 may each independently be the same as described in connection with a1 to a3, R₁₁ to R₁₃ may each independently be the same as described in connection with R₁ to R₃, b11 to b13 may each independently be the same as described in connection with b1 to b3, and c11 to c13 may each independently be the same as described in connection with c1 to c3.

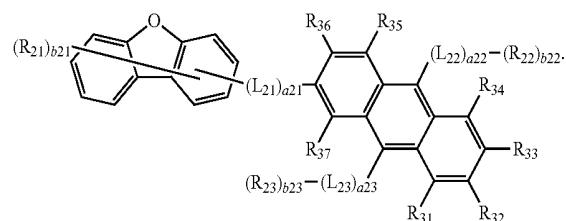
[0089] In one embodiment, in Formulae 1-1 to 1-4, Y₁ may be B, P=O, or P=S, X₁ may be O, S, or N(R₄₂), X₂ may be O, S, or N(R₄₃), Y₁₁ may be B, and X₁₁ and X₁₂ may be O, but embodiments of the present disclosure are not limited thereto.

[0090] In one embodiment, the compound represented by Formula 2 may be represented by Formula 2-1 or Formula 2-2, but embodiments of the present disclosure are not limited thereto:

Formula 2-1

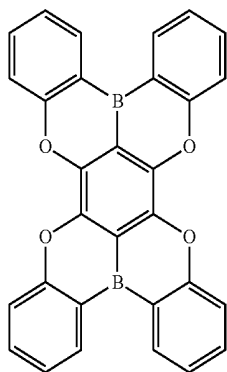


Formula 2-2



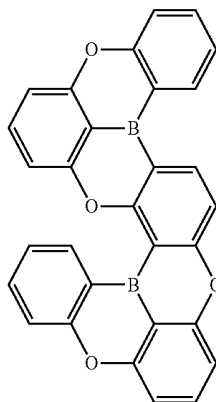
[0091] In Formulae 2-1 and 2-2, L₂₁, L₂₂, a21, a22, R₂₁, R₂₂, b21, b22, and R₃₁ may respectively be the same as those of Formula 2, L₂₃, a23, R₂₃, and b23 may each independently be the same as described in connection with L₂₂, a22, R₂₂, and b22, respectively, and R₃₂ to R₃₇ may each independently be the same as described in connection with R₃₁.

[0092] In one embodiment, the compound represented by Formula 1 may be selected from Compounds 1-1 to 1-53, and the compound represented by Formula 2 may be selected from Compounds 2-1 to 2-87, but embodiments of the present disclosure are not limited thereto:



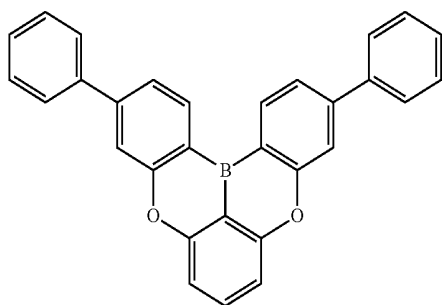
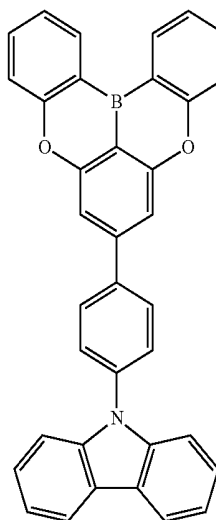
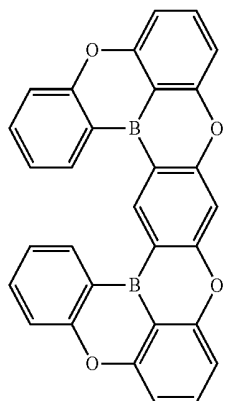
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1-2



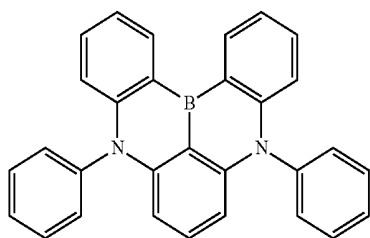
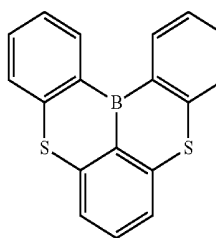
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1-4



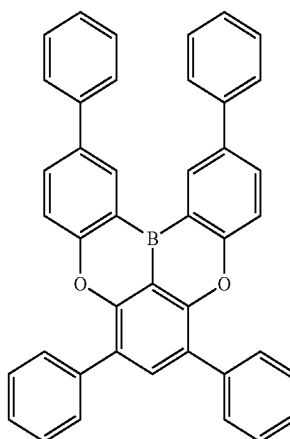
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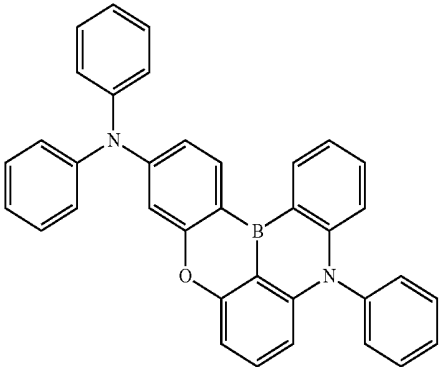


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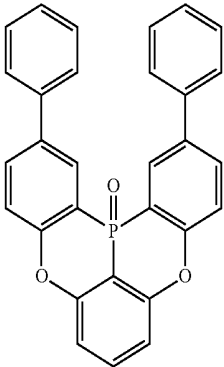


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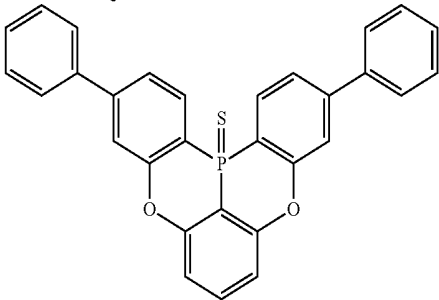
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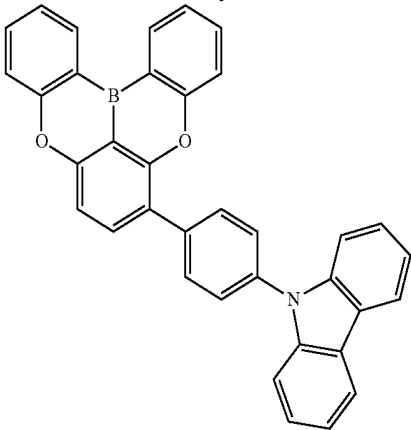
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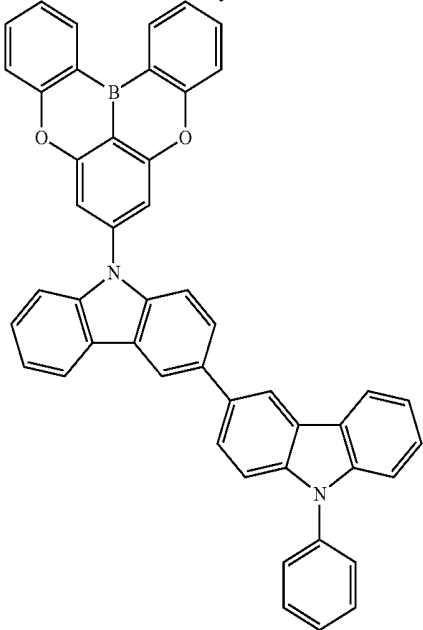
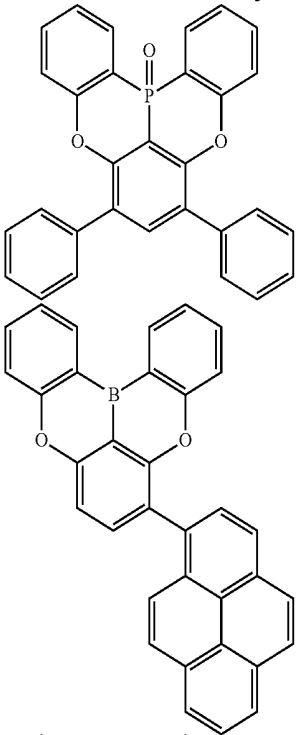
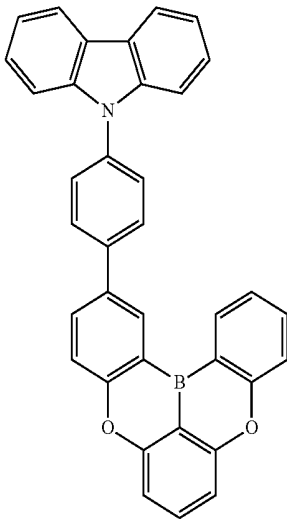
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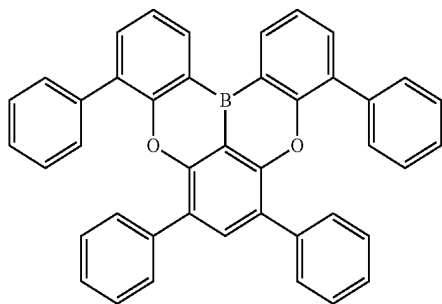
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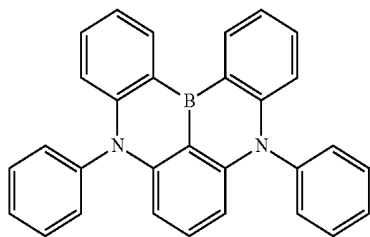
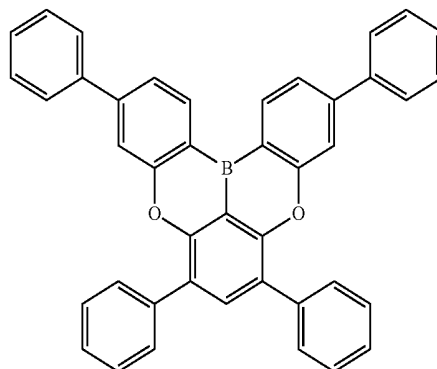


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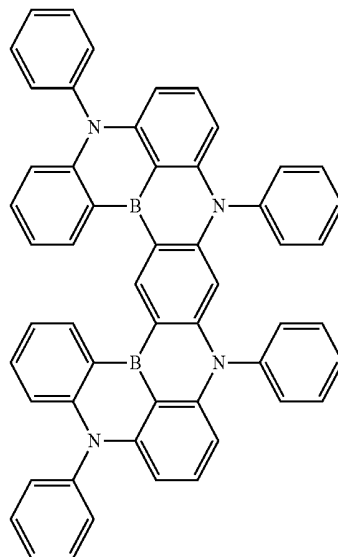


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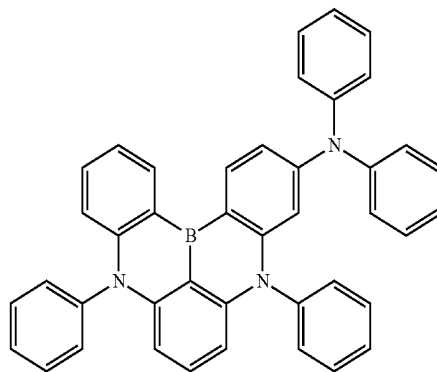
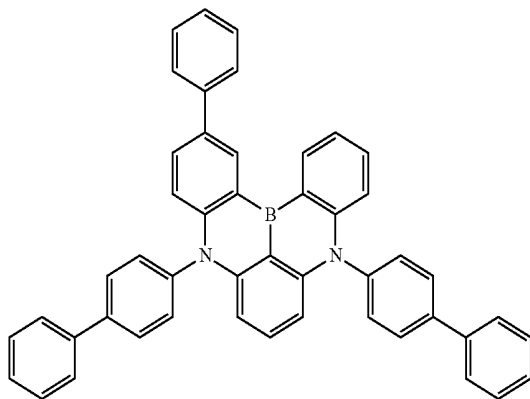
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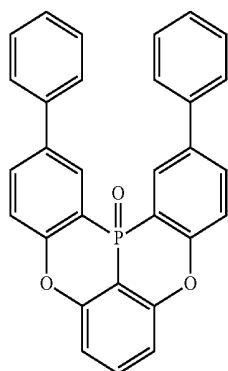
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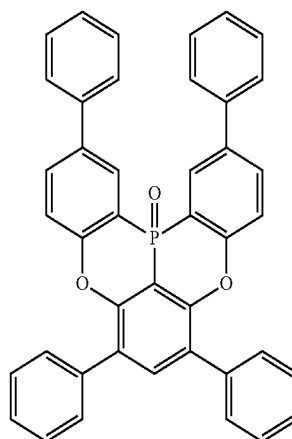


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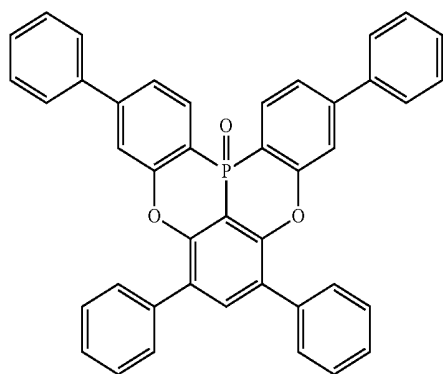
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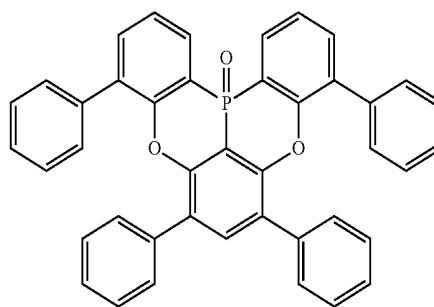
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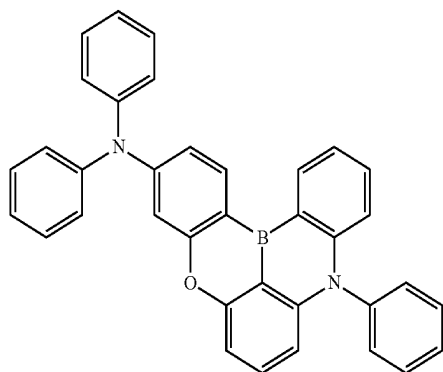
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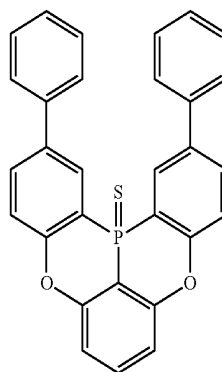
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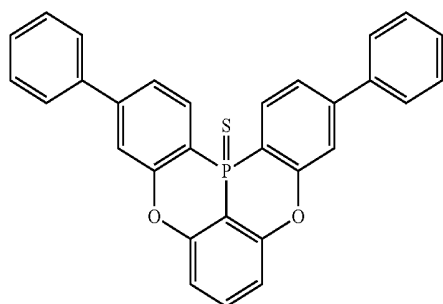
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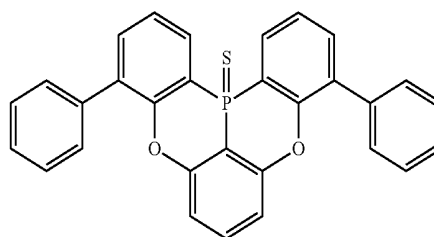
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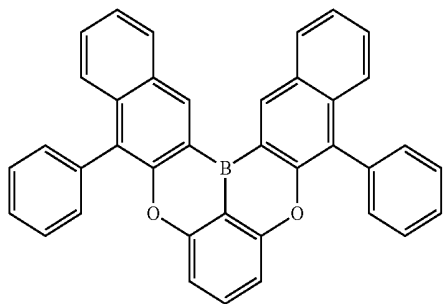


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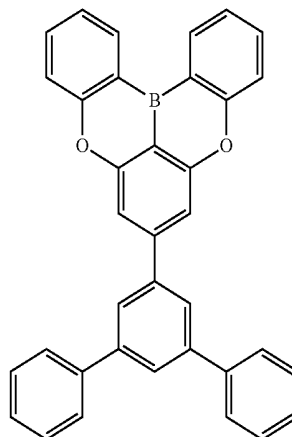


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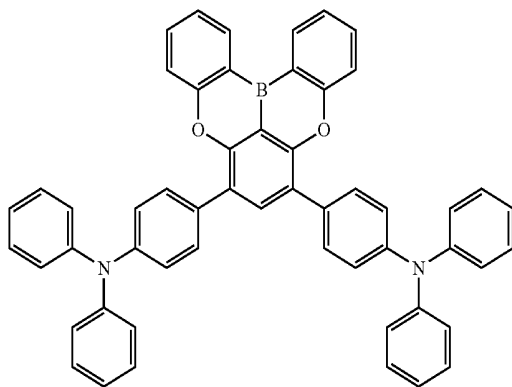
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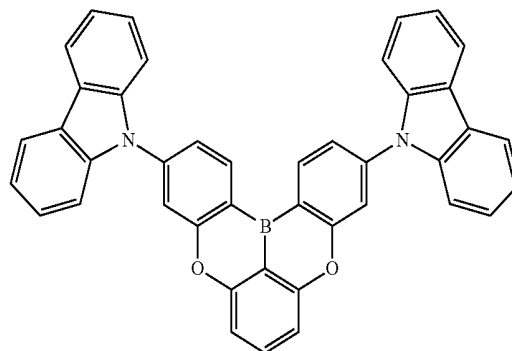
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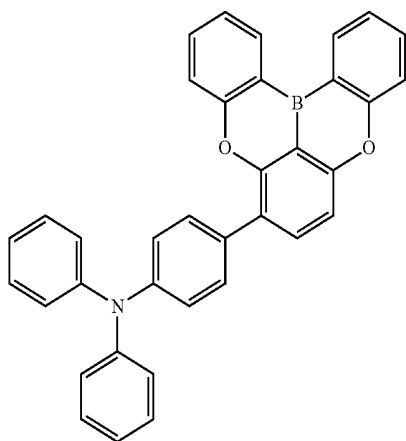
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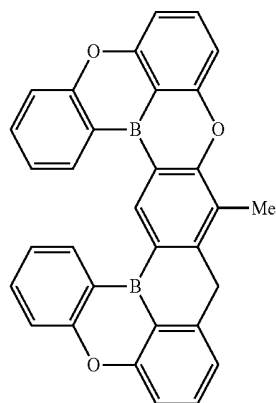
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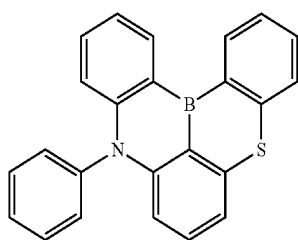
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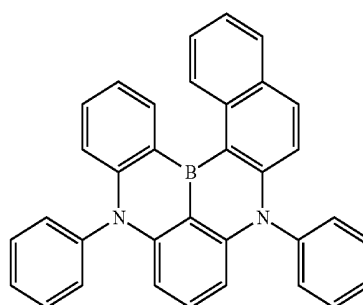
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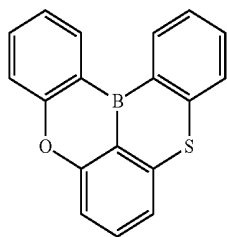


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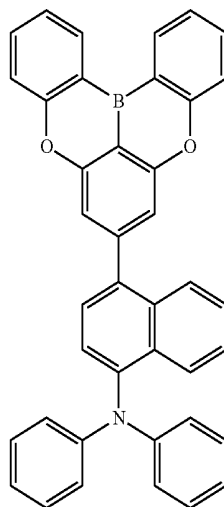


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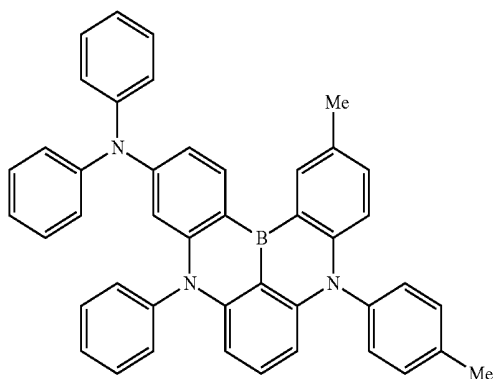


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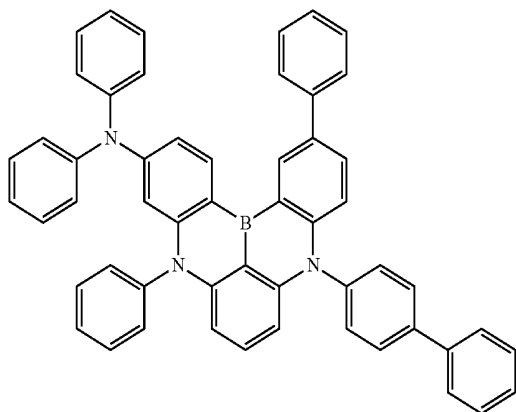
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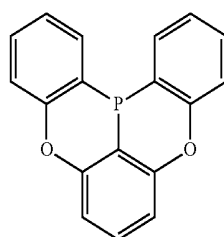
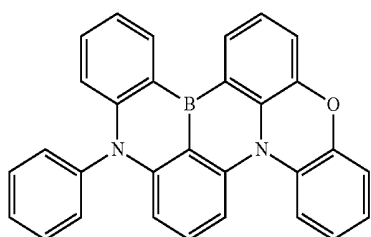
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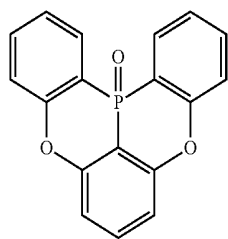


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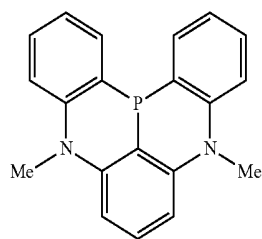
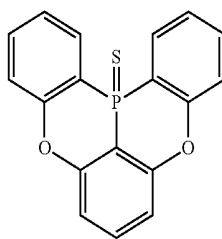


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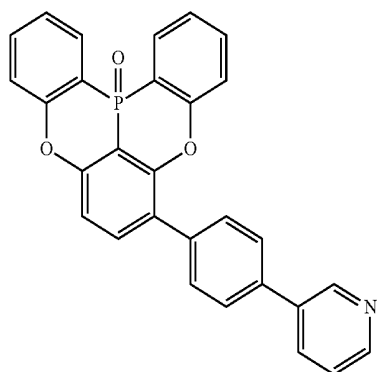
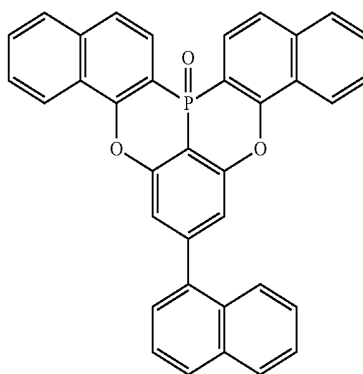
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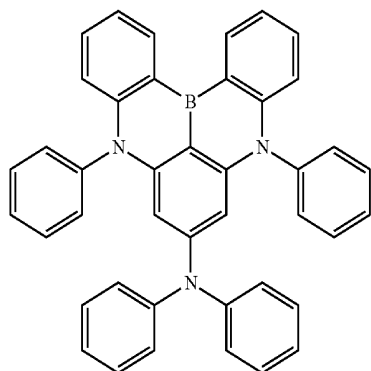
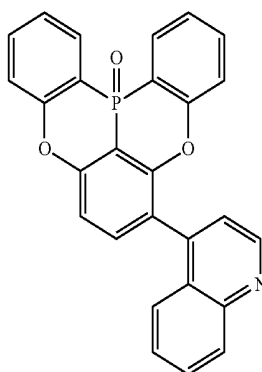
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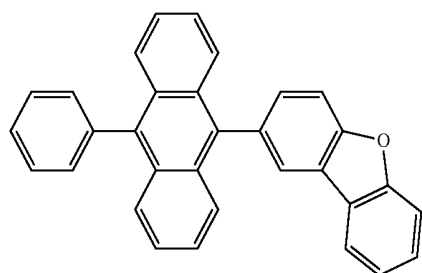


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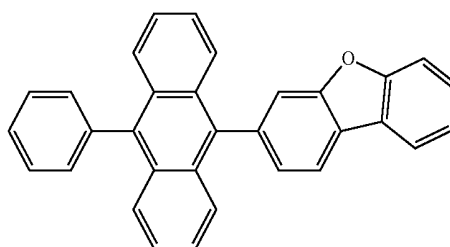


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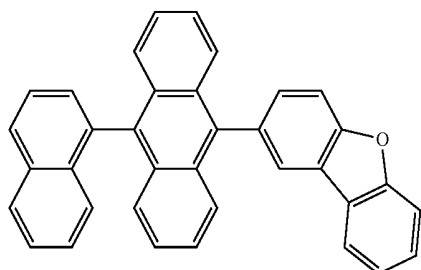
2-1

2-2

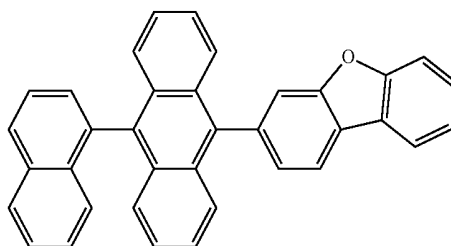


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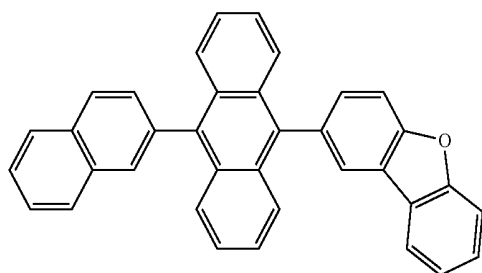
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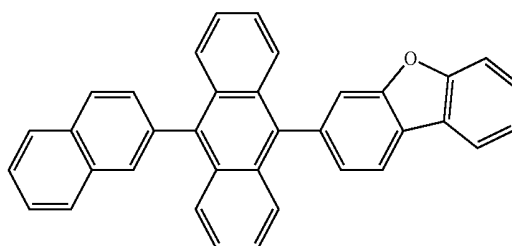
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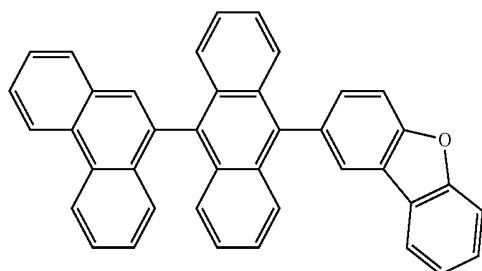
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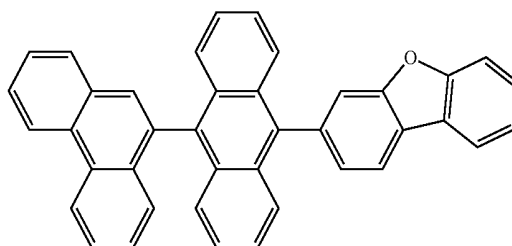
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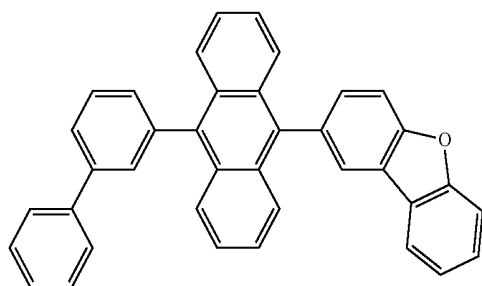
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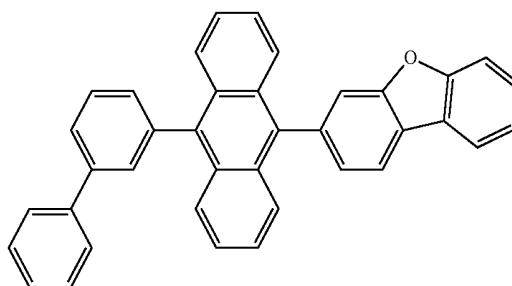
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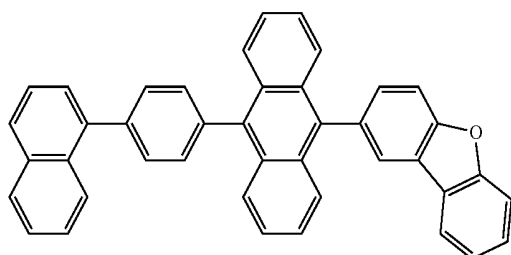
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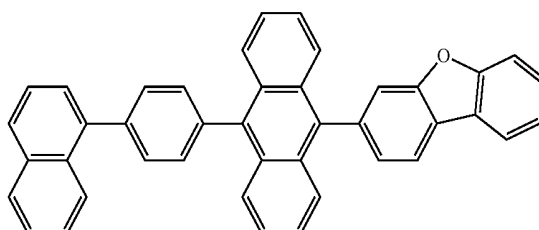
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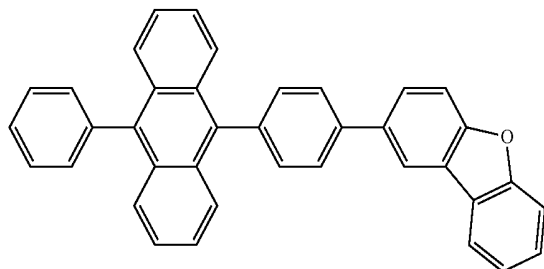


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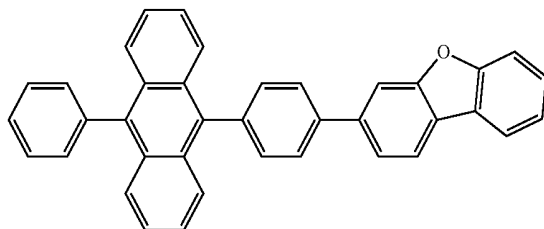


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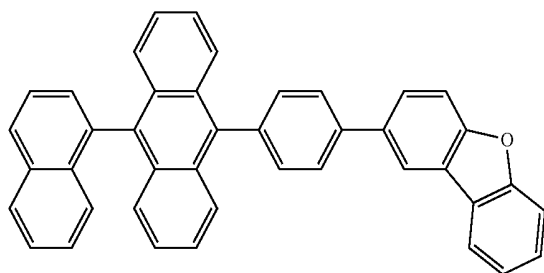
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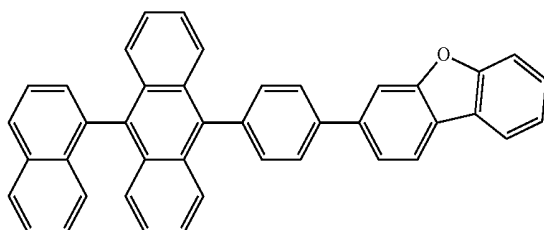
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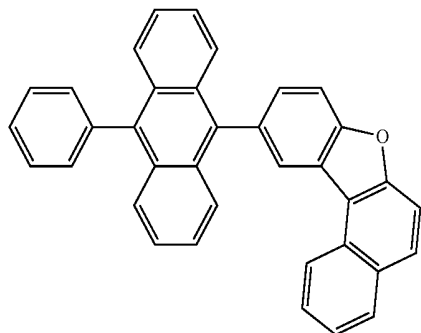
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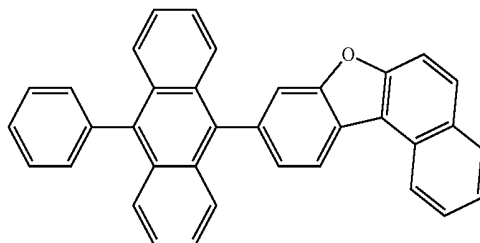
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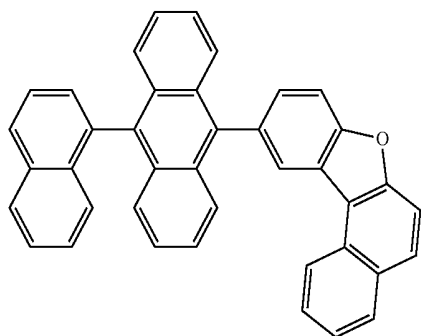
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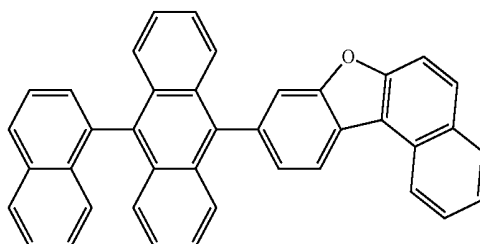
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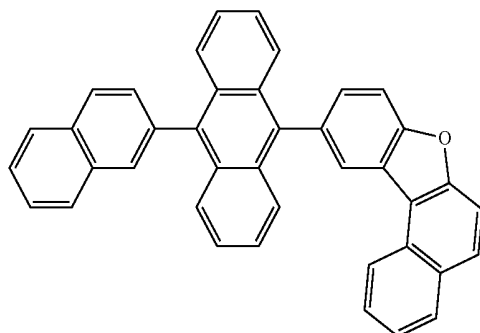
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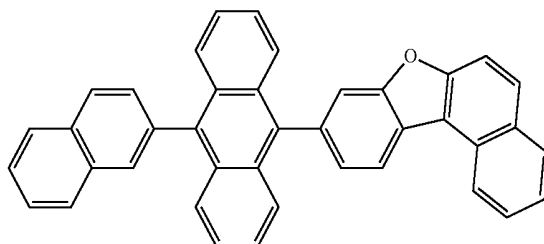
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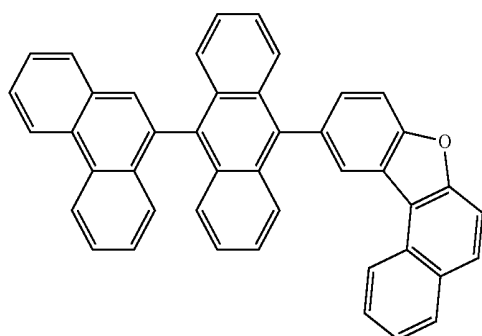
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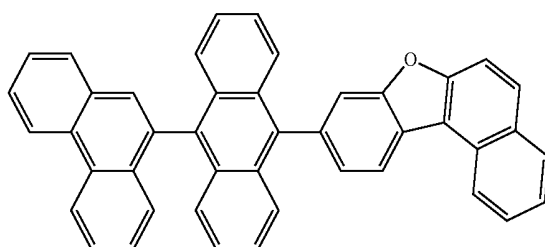
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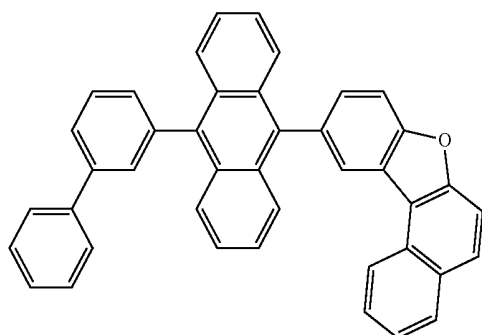
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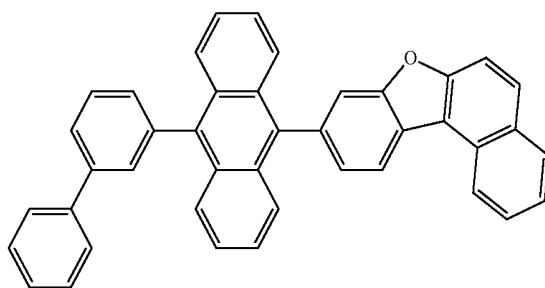
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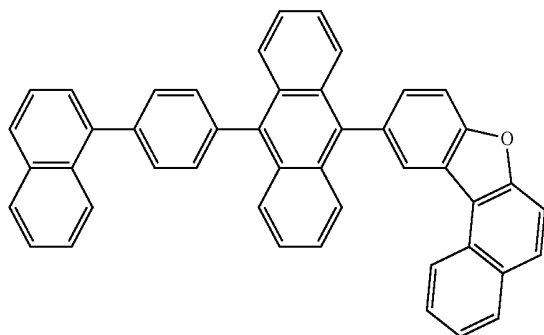
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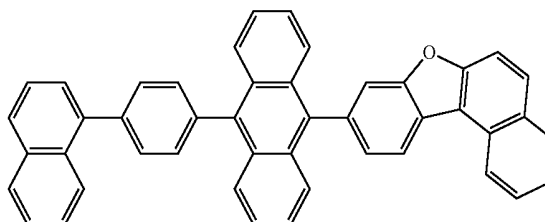
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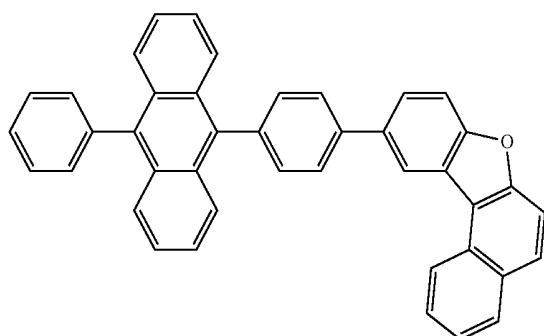
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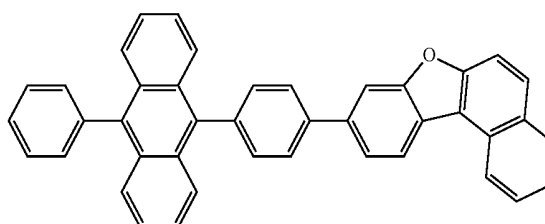
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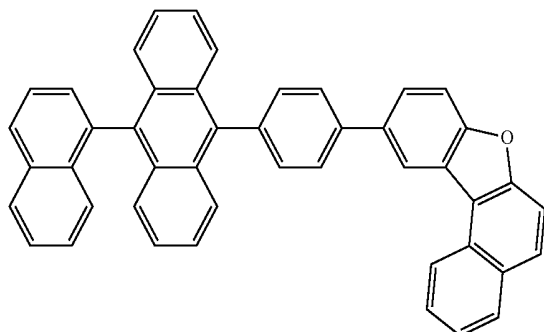


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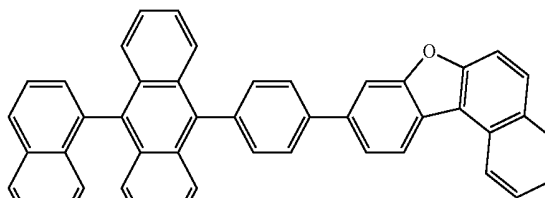


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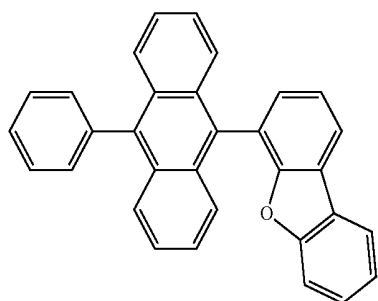
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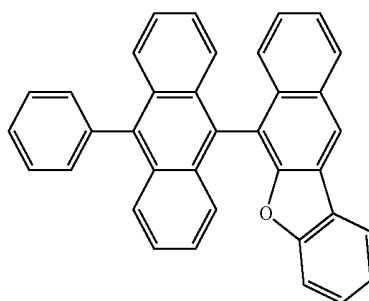
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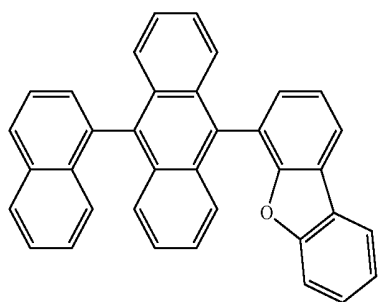
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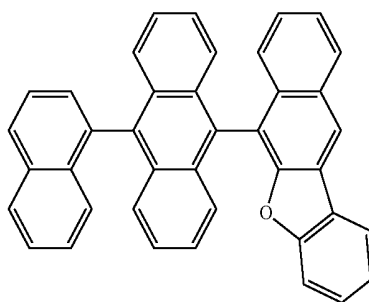
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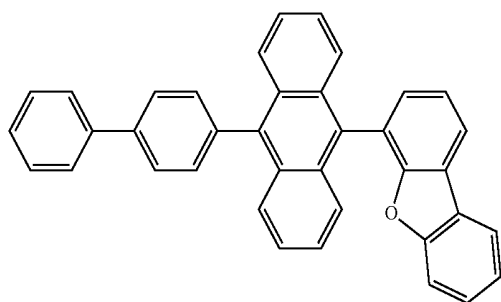
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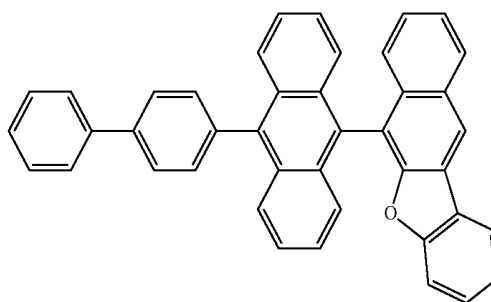
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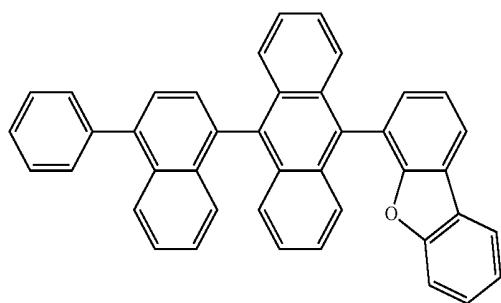
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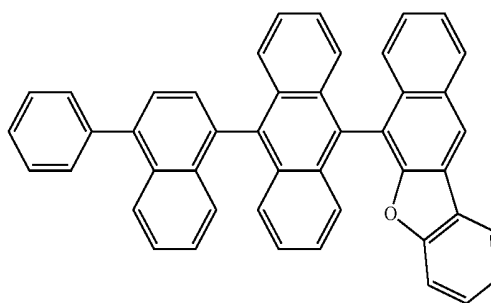
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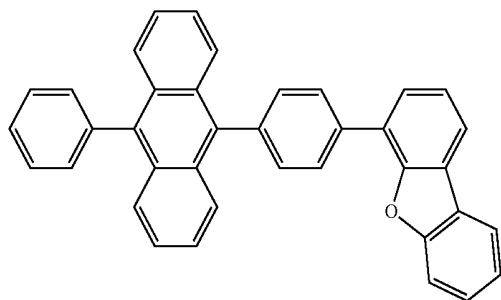


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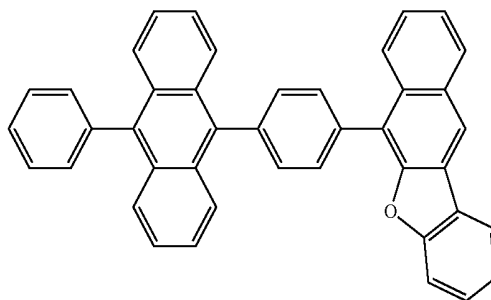


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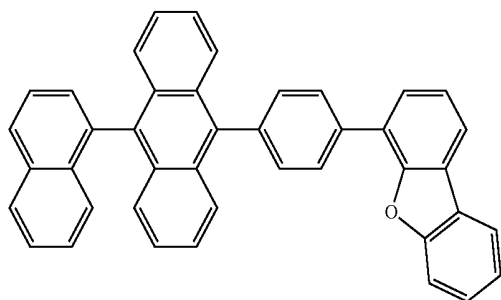
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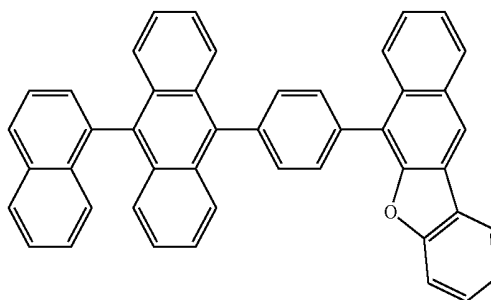
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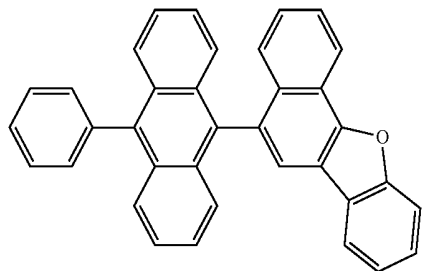
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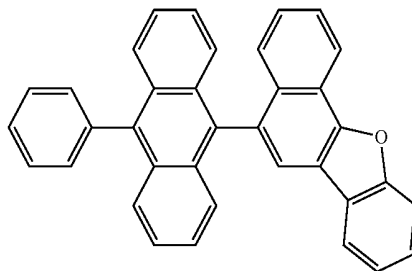
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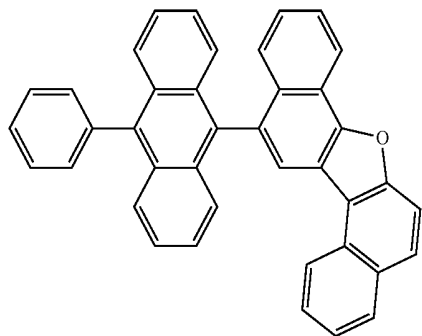
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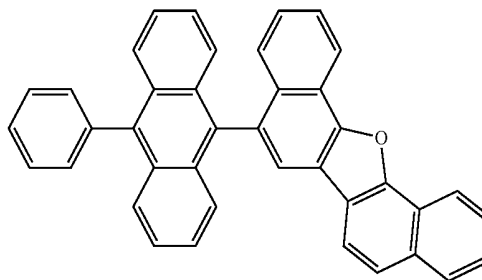
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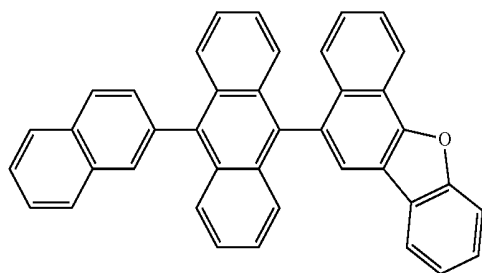
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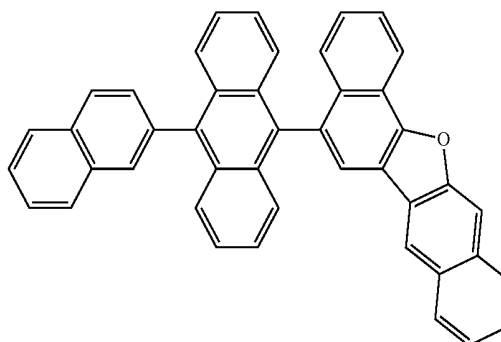
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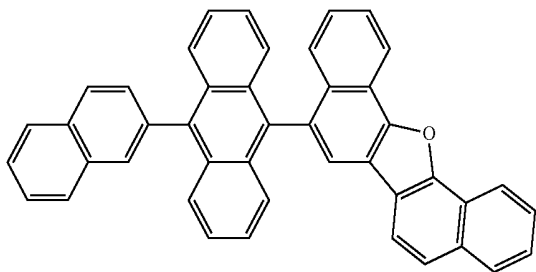


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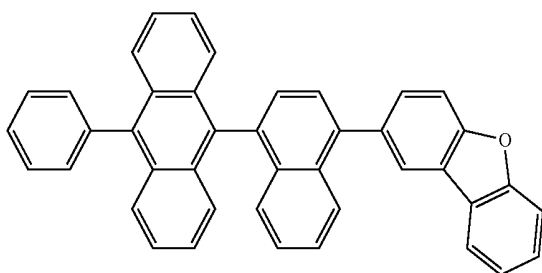


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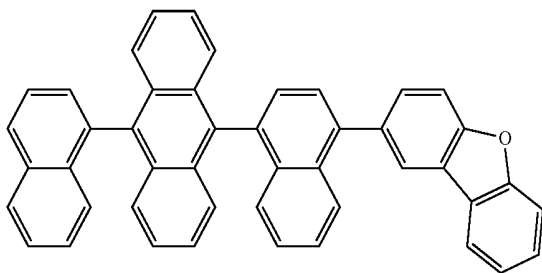
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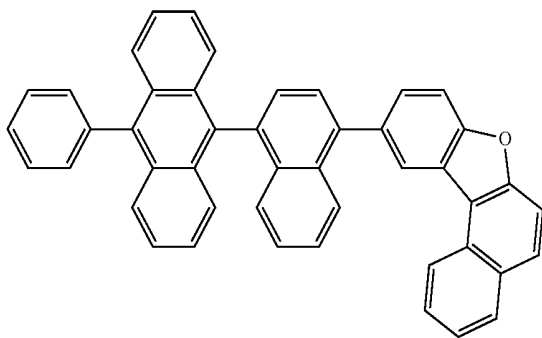
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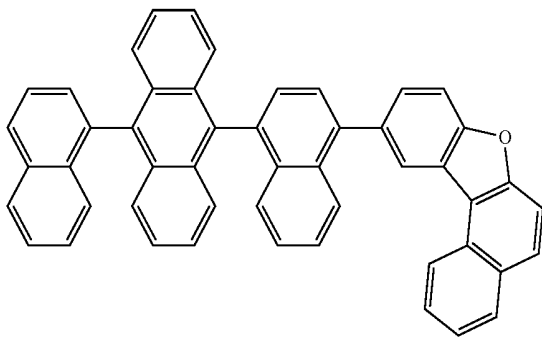
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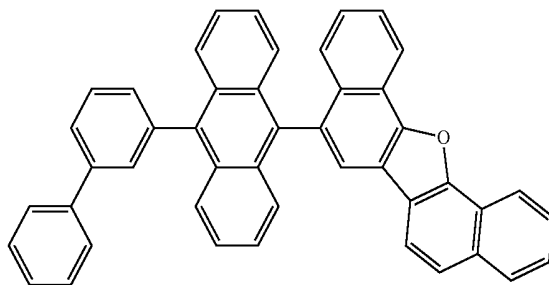
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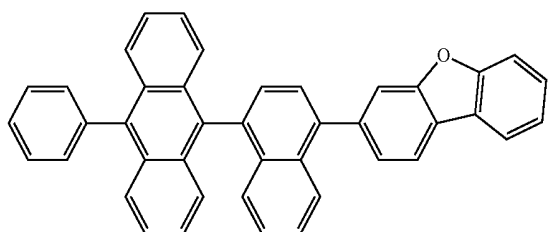
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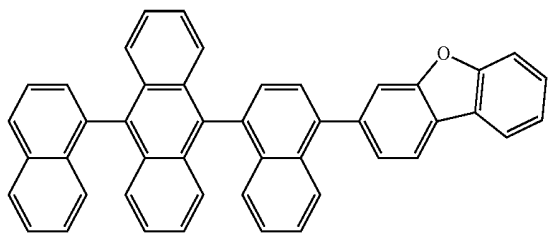
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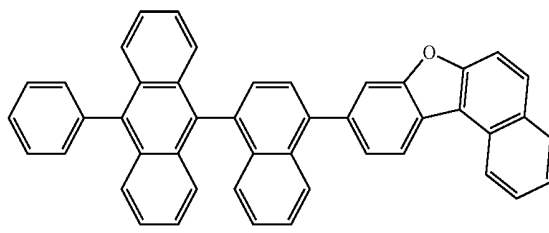
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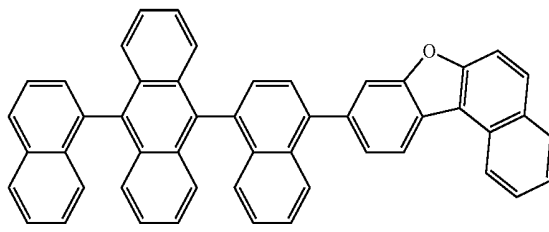
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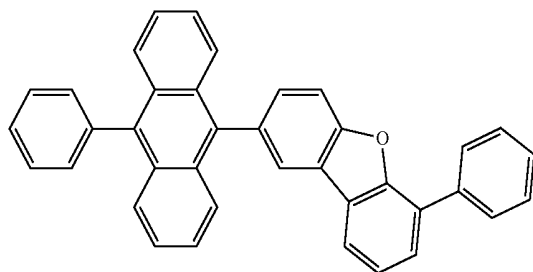
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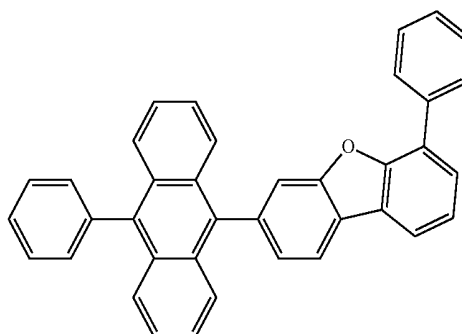
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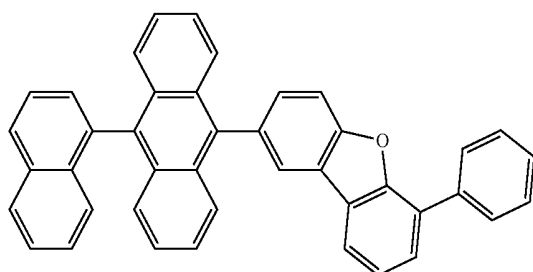
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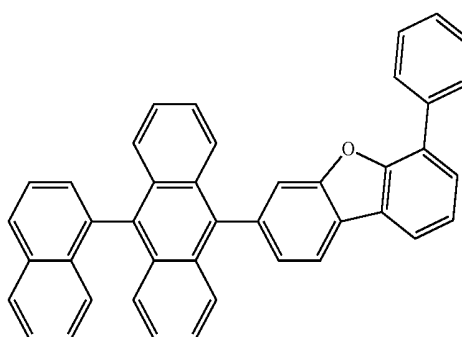
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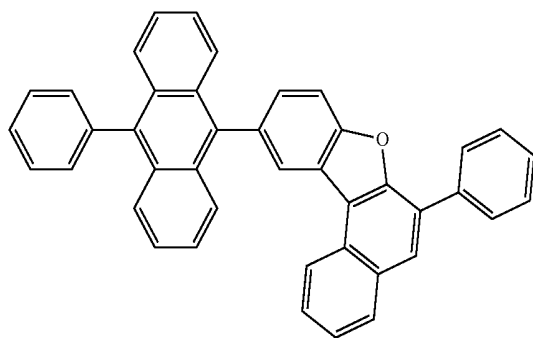
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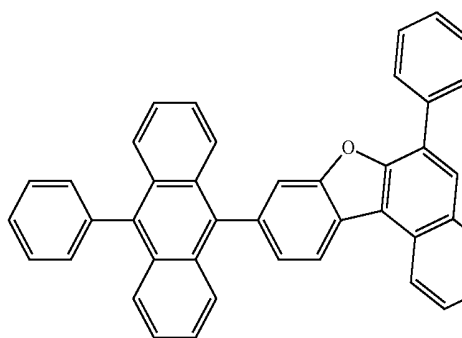
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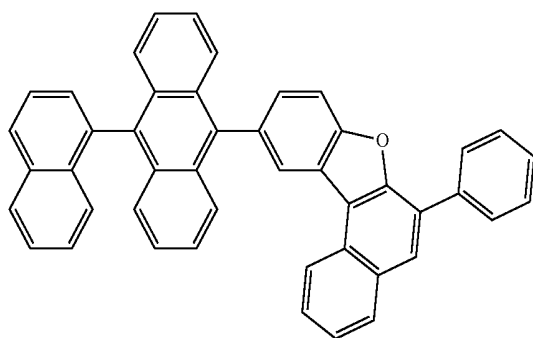
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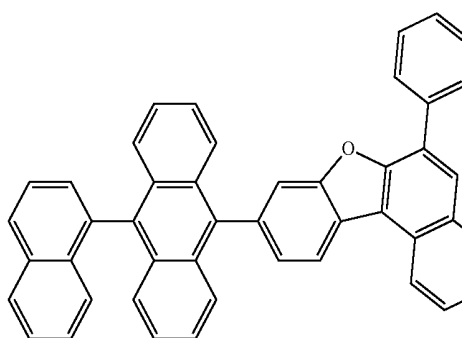
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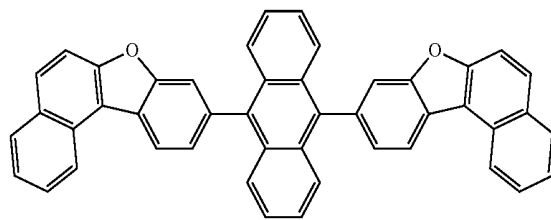
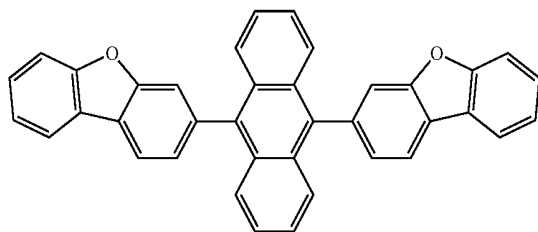
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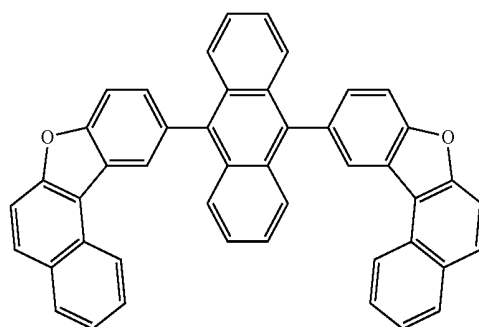
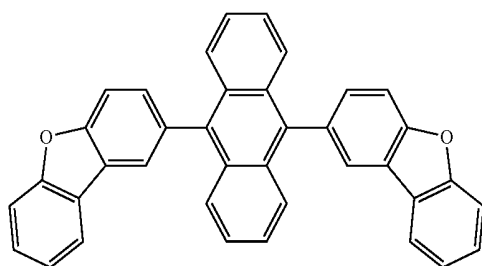
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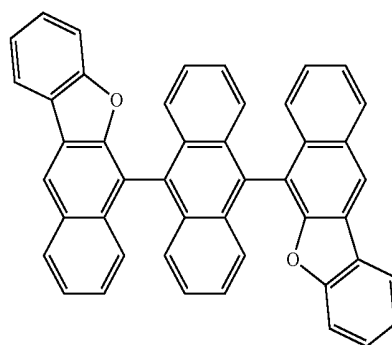
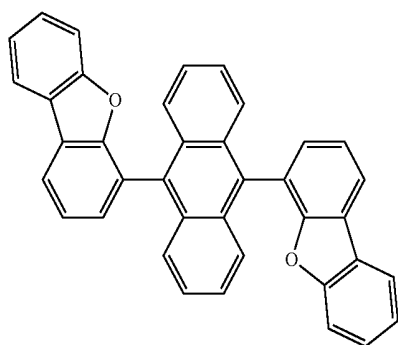
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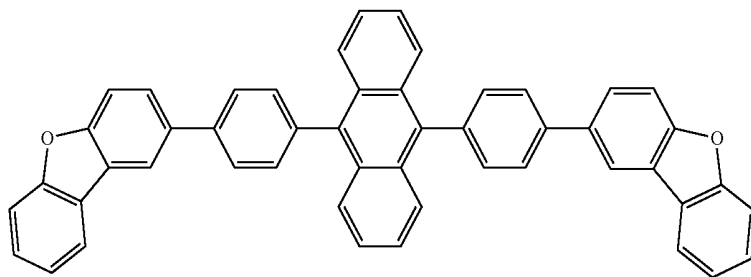


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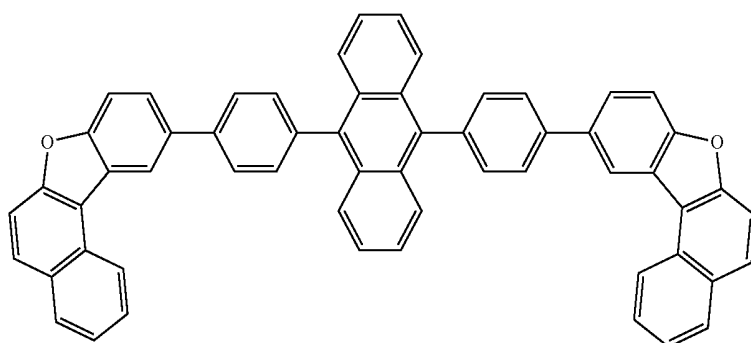
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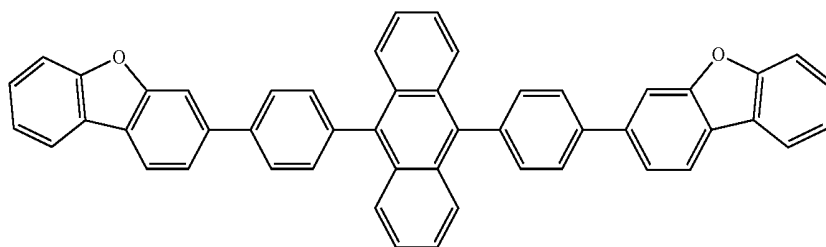


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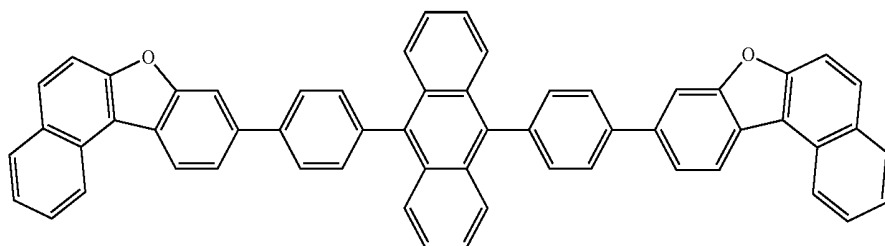


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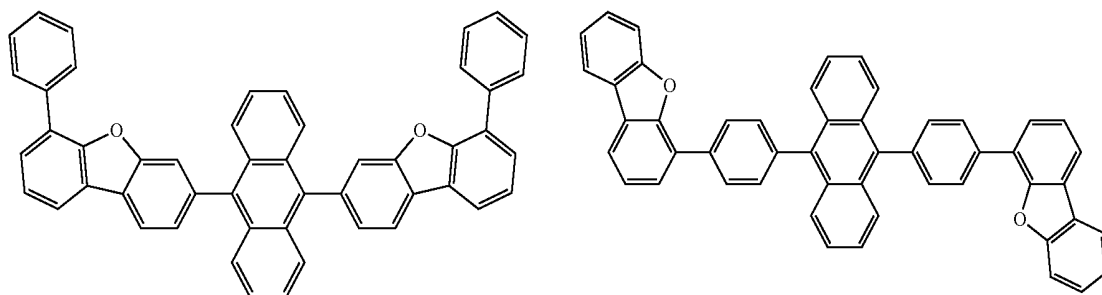


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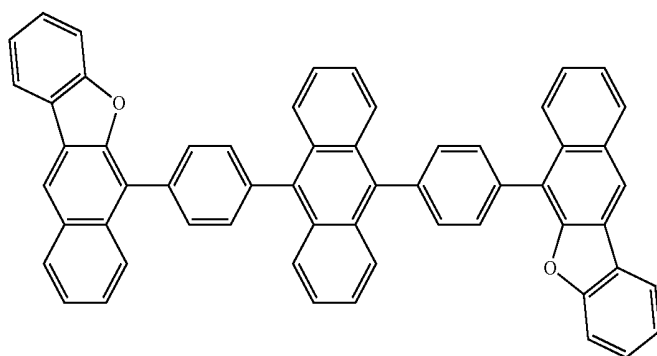


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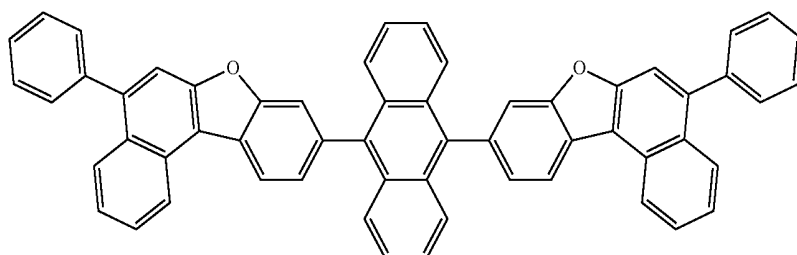
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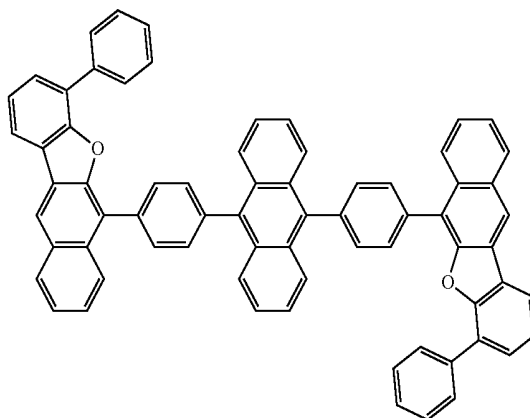
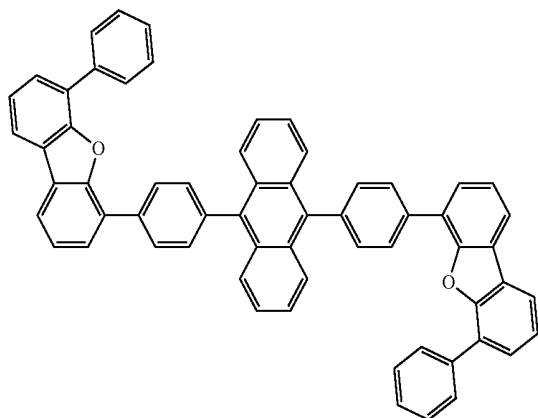


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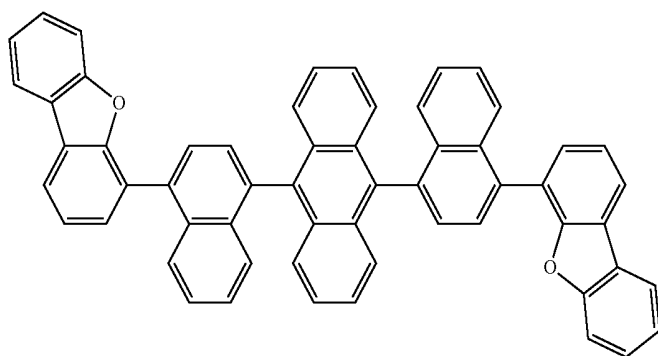


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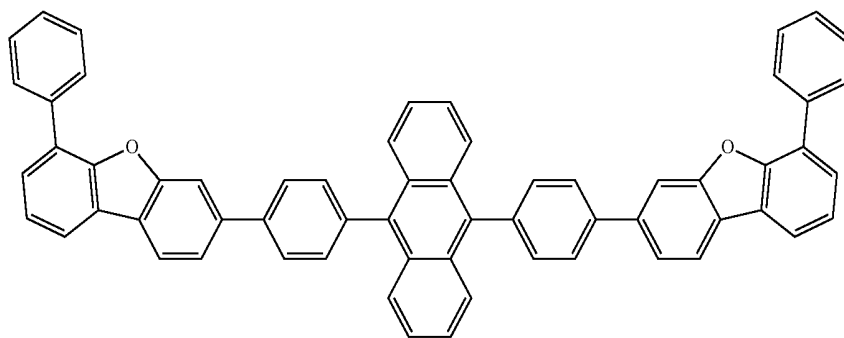
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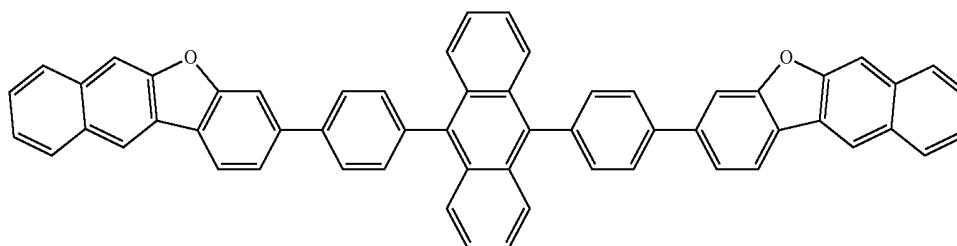
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2-87



[0093] In Formula 2, c21 may be an integer of 1 to 10. For example, in some embodiments, c21 in Formula 2 is not 0, at least one an anthracene group and at least one dibenzofuran group are essentially included in Formula 2. Accordingly, delocalization of electrons in the molecules may be induced to improve stability of the organic light-emitting device to holes/electrons, thereby achieving high efficiency and long lifespan effect of the organic light-emitting device.

[0094] In addition, Formula 1 has a backbone as depicted in the present specification. The molecular structure, which couples or connects a heteroatom with an aromatic ring, facilitates the control of a highest occupied molecular orbital (HOMO) energy level and a lowest unoccupied molecular orbital (LUMO) energy level in the molecule, and in this regard, the ionization potential or electron affinity may be optimized according to the surrounding materials (for example, a host).

[0095] [Description of FIG. 1]

[0096] 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.

[0097] 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.

[0098] [First Electrode 110]

[0099] 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.

[0100] The first electrode 110 may be formed by depositing or sputtering a material for forming the first electrode 110 on the substrate. When the first electrode 110 is an anode, the material for the first electrode 110 may be selected from materials with a high work function to facilitate hole injection.

[0101] 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, the material for forming the first electrode 110 may be selected from indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO₂), zinc oxide (ZnO), and any combinations thereof, but embodiments of the present disclosure are not limited thereto. In one or more embodiments, when the first electrode 110 is a semi-transmissive electrode or a reflective electrode, the material for forming the first electrode 110 may be selected from magnesium (Mg), silver (Ag), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), magnesium-silver (Mg—Ag), and any combinations thereof, but embodiments of the present disclosure are not limited thereto.

[0102] 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.

[0103] [Organic Layer 150]

[0104] The organic layer 150 is disposed on the first electrode 110. The organic layer 150 may include an emission layer.

[0105] In one embodiment, 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.

[0106] [Hole Transport Region in Organic Layer 150]

[0107] 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.

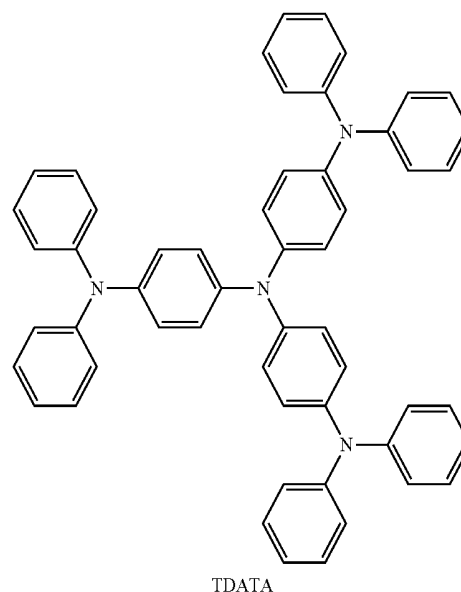
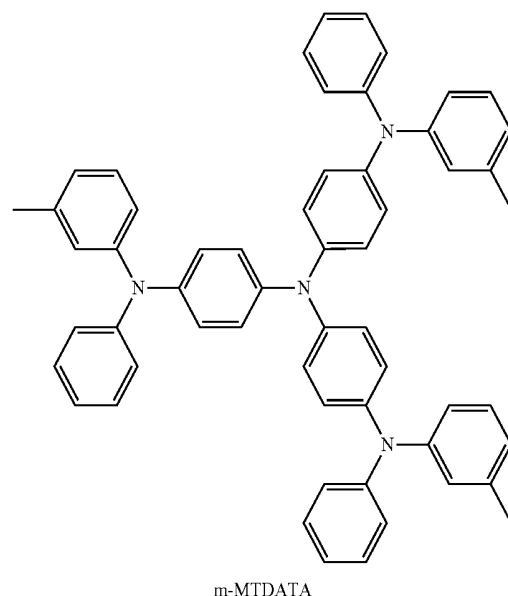
[0108] In one embodiment, the hole transport region may include at least one layer selected from a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer, and the electron transport region may include at least one layer selected from a hole blocking layer, an electron transport layer, and an electron injection layer.

[0109] 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

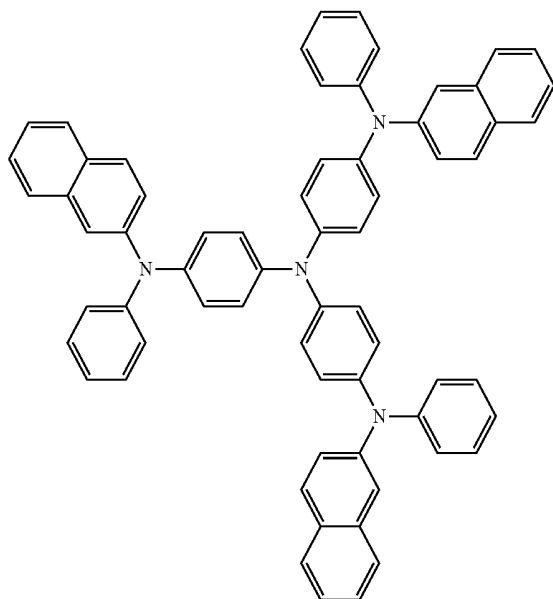
layer structure, a hole transport layer/emission auxiliary layer structure, or a hole injection layer/hole transport layer/emission auxiliary layer structure, wherein for each structure, constituting layers are sequentially stacked from the first electrode 110 in this stated order, but the structure of the hole transport region is not limited thereto.

[0110] The hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB (NPB), p-NPB, TPD, Spiro-TPD, Spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANT/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), and an amine-based compound.

[0111] The amine-based compound may include at least one of a compound represented by Formula 201 and a compound represented by Formula 202:

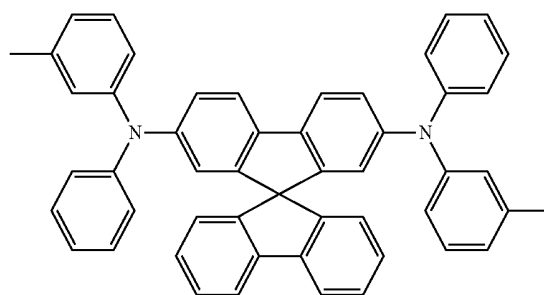


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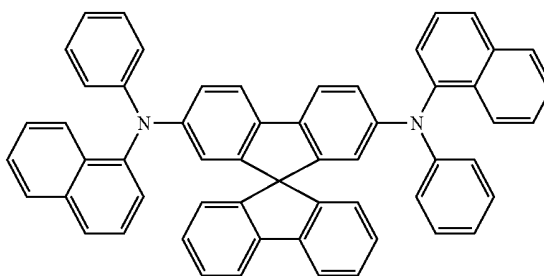


2-TNATA

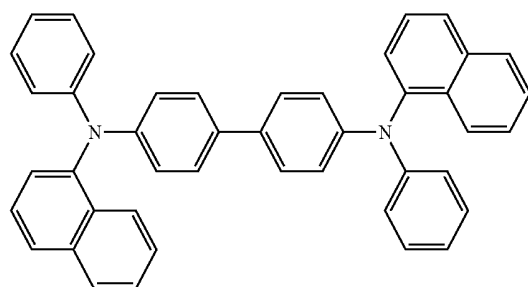
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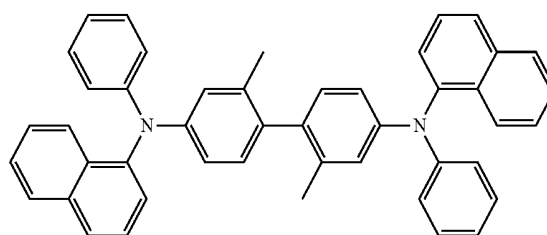
Spiro-TPD



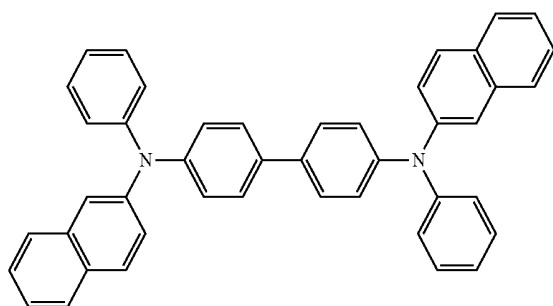
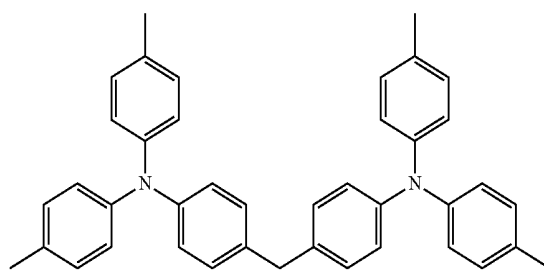
Spiro-NPB



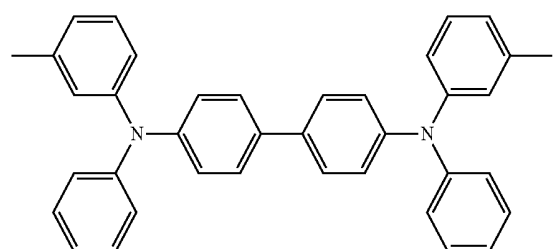
NPB



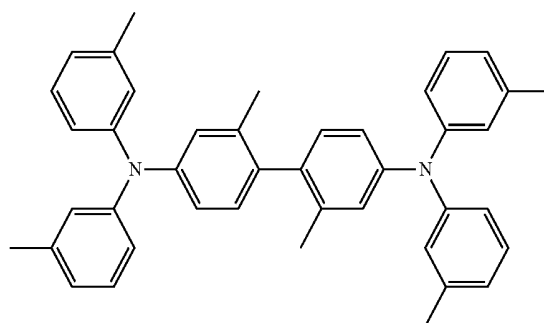
methylated NPB

 β -NPB

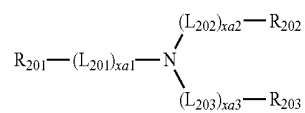
TAPC



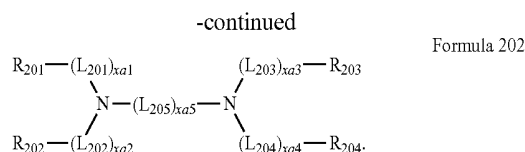
TPD



HMTPD



Formula 201



[0112] In Formulae 201 and 202,

[0113] L₂₀₁ to L₂₀₄ may each independently be selected from a substituted or unsubstituted C₃-C₁₀ cycloalkylene group, a substituted or unsubstituted heterocycloalkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkenylene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenylene group, a substituted or unsubstituted C₆-C₆₀ arylene group, a substituted or unsubstituted C₁-C₆₀ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group.

[0114] L_{205} may be selected from $-\text{O}-^*$, $^*-\text{S}-^*$, $^*-\text{N}(\text{Q}_{201})-^*$, a substituted or unsubstituted $\text{C}_1\text{-C}_{20}$ alkylene group, a substituted or unsubstituted $\text{C}_2\text{-C}_{20}$ alkenylene group, a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkylene group, a substituted or unsubstituted $\text{C}_1\text{-C}_{10}$ heterocycloalkylene group, a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkenylene group, a substituted or unsubstituted $\text{C}_1\text{-C}_{10}$ heterocycloalkenylene group, a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ 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.

[0115] xa1 to xa4 may each independently be an integer of 0 to 3.

[0116] xa5 may be an integer of 1 to 10, and

[0117] 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.

[0118] 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

[0119] R₂₀₄ may optionally be linked via a single bond, a dimethyl-methylene group, or a diphenyl-methylene group.

[0120] In one embodiment, in Formulae 201 and 202,

[0121] L₂₀₁ to L₂₀₅ may each independently be selected from:

[0122] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene

group, a naphthacenylenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylenylene group, a pentacenylenylene group, a rubicenylenylene group, a coronenylenylene group, an ovalenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, and a pyridinylenylene group; and

[10213] a phenylene group, a pentalenyne group, an indenylene group, a naphthylylene group, an azulenylylene 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 anthracenylylene group, a fluoranthenylylene group, a triphenylylene group, a pyrenylene group, a chrysenylene group, a naphthacenylylene group, a picenylene group, a perylenylene group, a pentaphenylylene group, a hexacenylylene group, a pentacenylene group, a rubicenylylene group, a coronenylylene group, an ovalenylylene group, a thiophenylylene group, a furanylylene group, a carbazolylylene group, an indolylylene group, an isoindolylylene group, a benzofuranylylene group, a benzothiophenylylene group, a dibenzofuranylylene group, a dibenzothiophenylylene group, a benzocarbazolylylene group, a dibenzocarbazolylylene group, a dibenzosilolylylene group, and a pyridinylylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_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 carbazoyl group, an indoyl group, an isoindoyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazoyl group, a dibenzocarbazoyl group, a dibenzosiloyl group, a pyridinyl group, —Si(Q_{31})(Q_{32})(Q_{33}), and —N(Q_{31})(Q_{32}), and

[0124] 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.

[0125] In one or more embodiments, xa1 to xa4 may each independently be 0, 1, or 2.

[0126] In one or more embodiments, xa5 may be 1, 2, 3, or 4.

[0127] In one or more embodiments, R₂₀₁ to R₂₀₄ and Q₂₀₁ may each independently be selected from:

[0128] 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

[0129] 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 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, a pyridinyl group, —Si(Q_{31})(Q_{32})(Q_{33}), and —N(Q_{31})(Q_{32}), and

[0130] Q_{31} to Q_{33} may be the same as described above.

[0131] In one or more embodiments, in Formula 201, at least one of R_{201} to R_{203} may each independently be selected from:

[0132] a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

[0133] a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_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 naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

[0134] In one or more embodiments, in Formula 202, i) R_{201} and R_{202} may be linked via a single bond, and/or ii) R_{203} and R_{204} may be linked via a single bond.

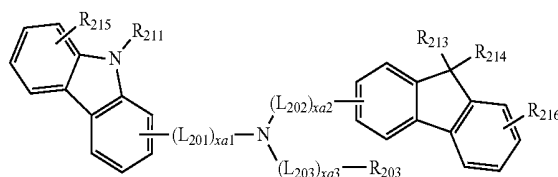
[0135] In one or more embodiments, in Formula 202, at least one of R_{201} to R_{204} may be selected from:

[0136] a carbazolyl group; and

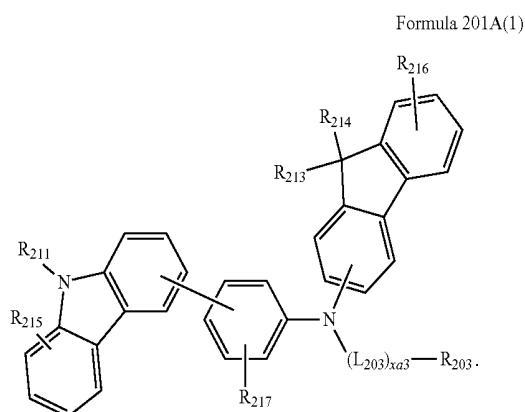
[0137] a carbazolyl group substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, 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 naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

[0138] The compound represented by Formula 201 may be represented by Formula 201A:

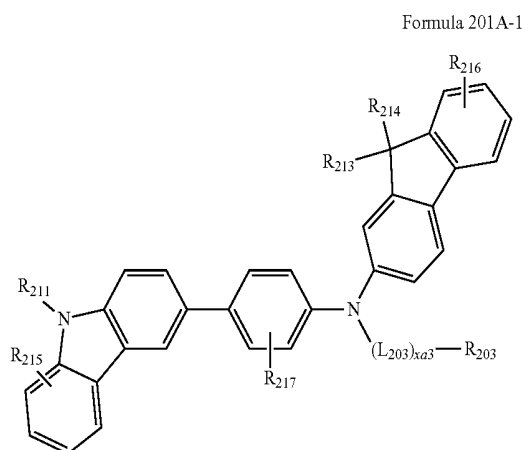
Formula 201A



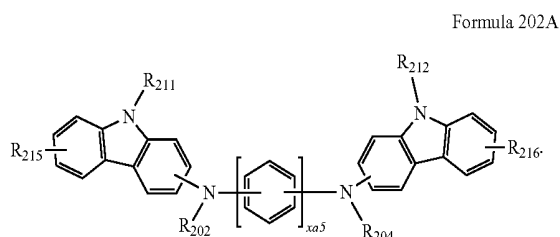
[0139] For example, the compound represented by Formula 201 may be represented by Formula 201A(1), but embodiments of the present disclosure are not limited thereto:



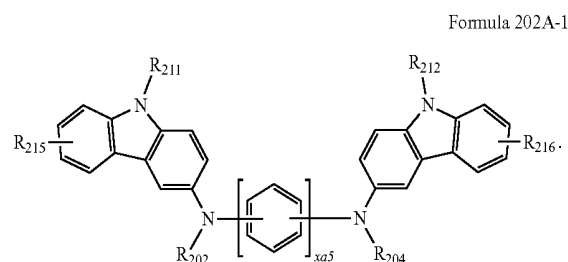
[0140] In one embodiment, the compound represented by Formula 201 may be represented by Formula 201A-1, but embodiments of the present disclosure are not limited thereto:



[0141] In one or more embodiments, the compound represented by Formula 202 may be represented by Formula 202A:



[0142] In one or more embodiments, the compound represented by Formula 202 may be represented by Formula 202A-1:



[0143] In Formulae 201A, 201A(1), 201A-1, 202A, and 202A-1,

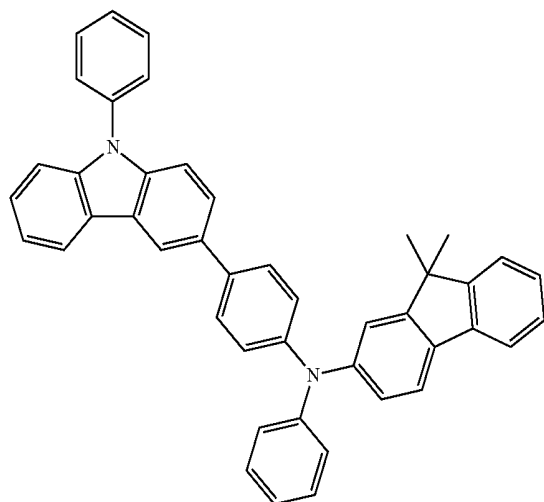
[0144] L_{201} to L_{203} , $xa1$ to $xa3$, $xa5$, and R_{202} to R_{204} may respectively be the same as described above,

[0145] R_{211} and R_{212} may each independently be the same as described in connection with R_{203} , and

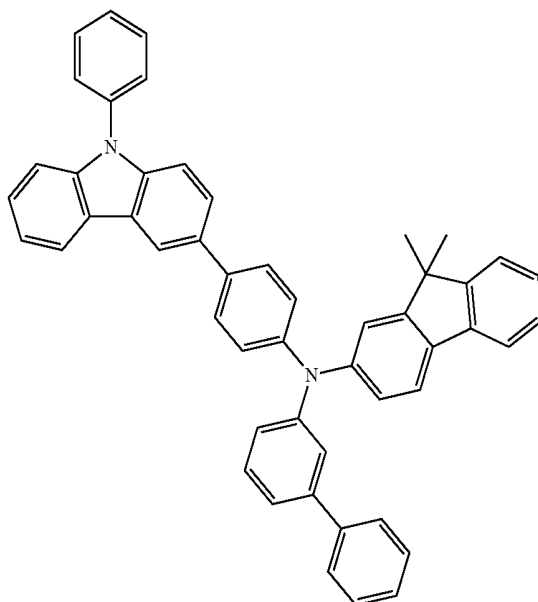
[0146] R_{213} to R_{217} may independently be selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl 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 fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a 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.

[0147] The hole transport region may include at least one compound selected from Compounds HT1 to HT45, but embodiments of the present disclosure are not limited thereto:

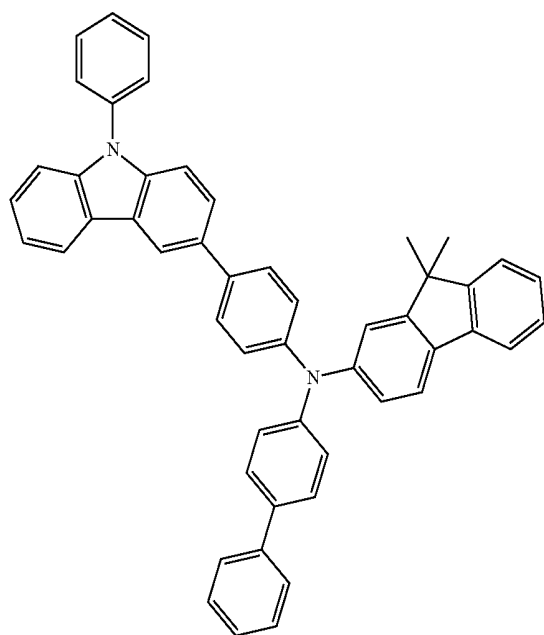
HT1



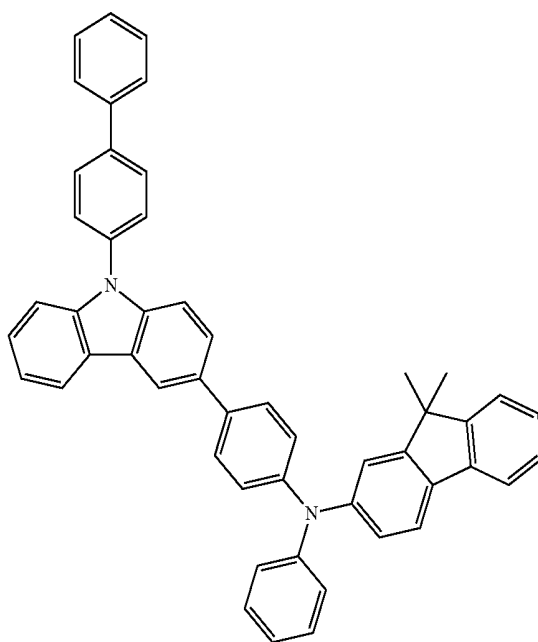
HT2



HT3



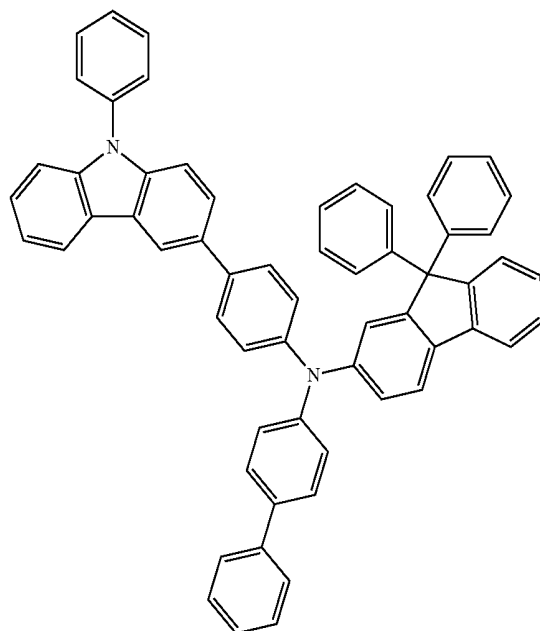
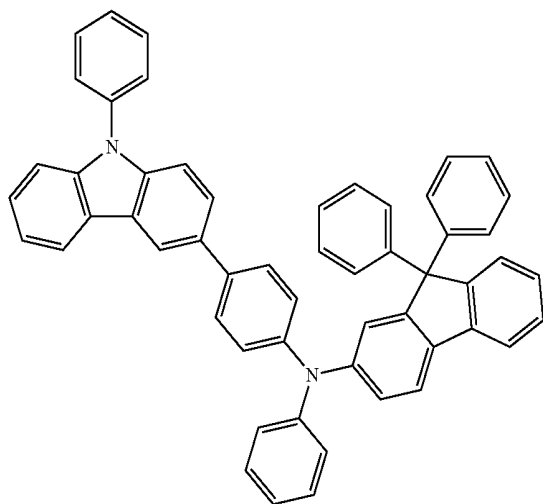
HT4



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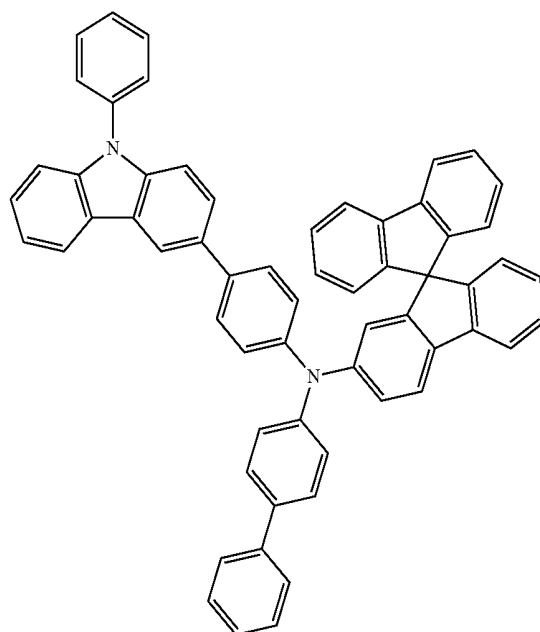
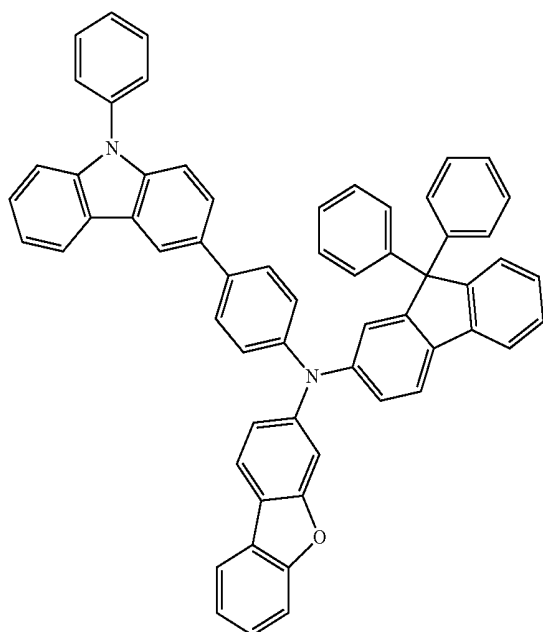
HT5

HT6



HT7

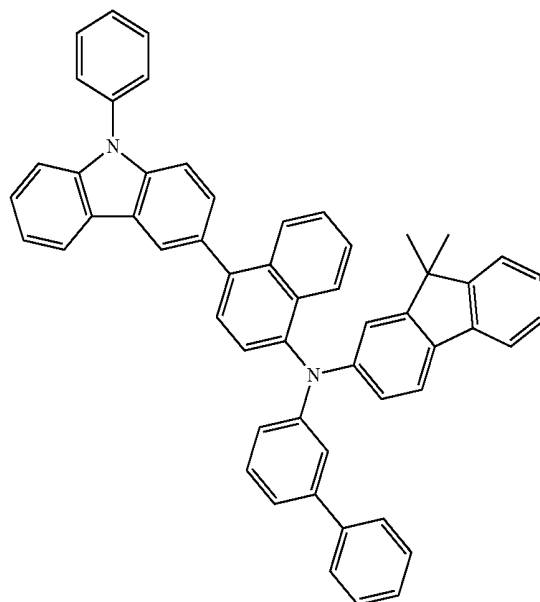
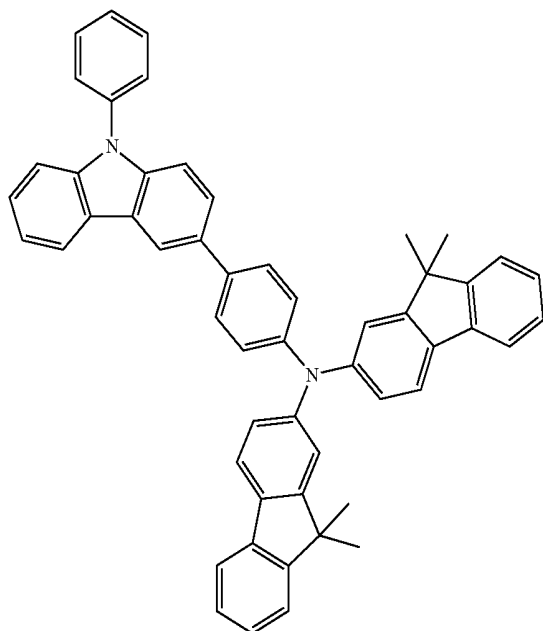
HT8



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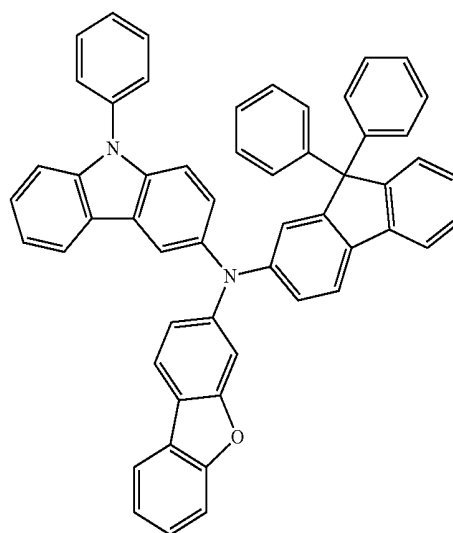
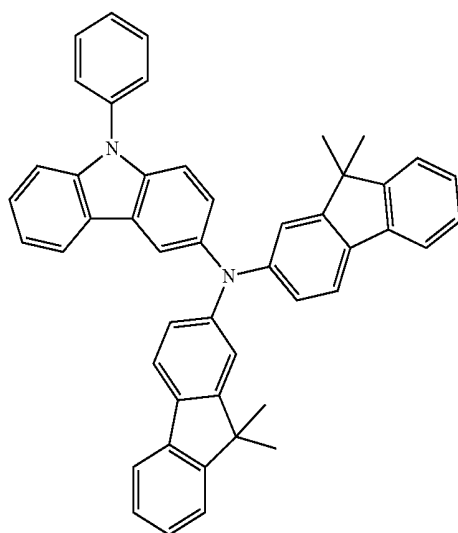
HT9

HT10

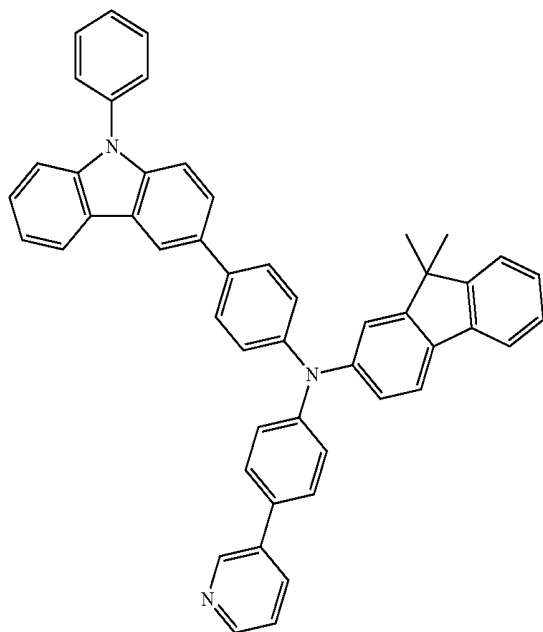


HT11

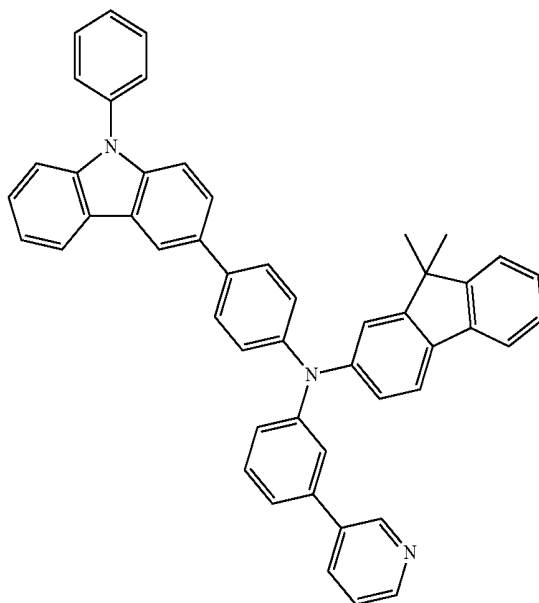
HT12



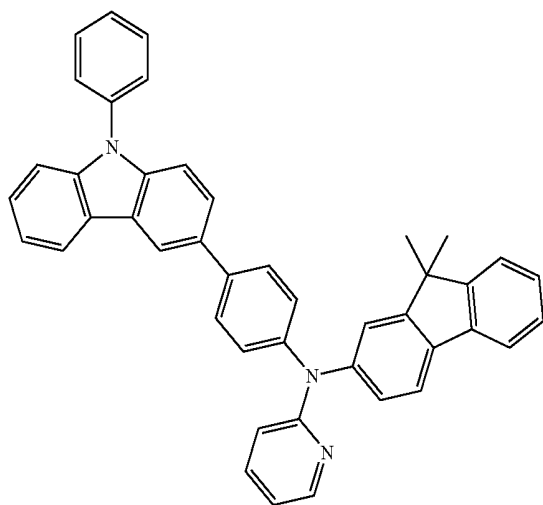
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HT13



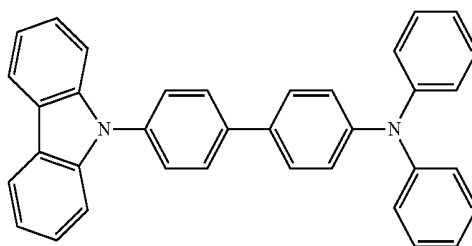
HT14



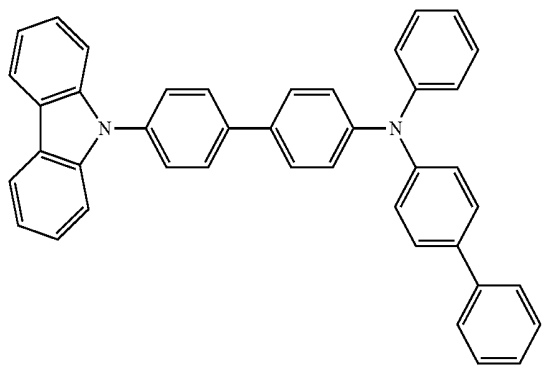
HT15



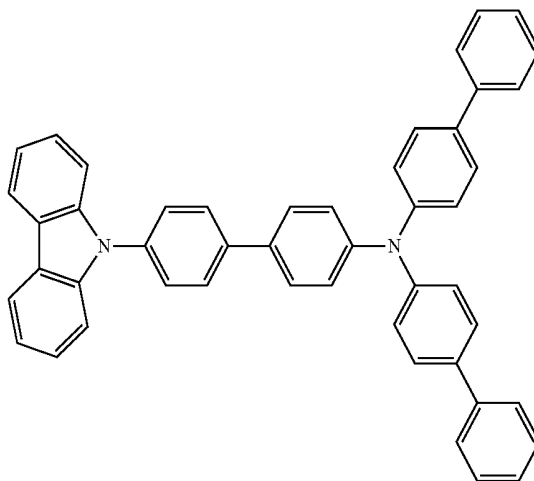
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HT17



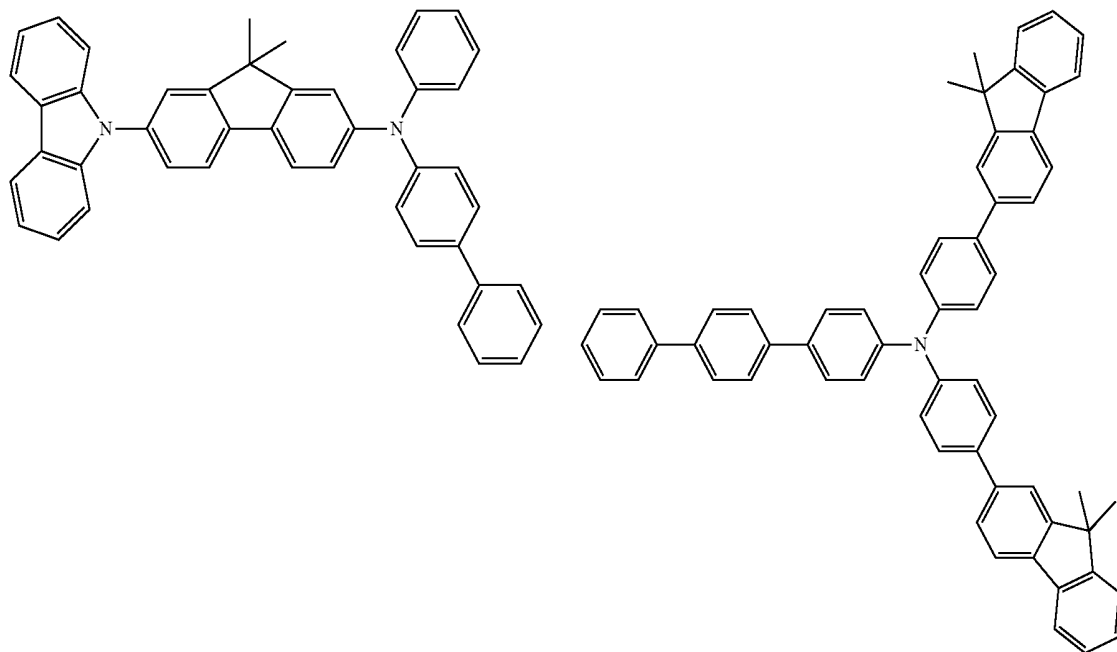
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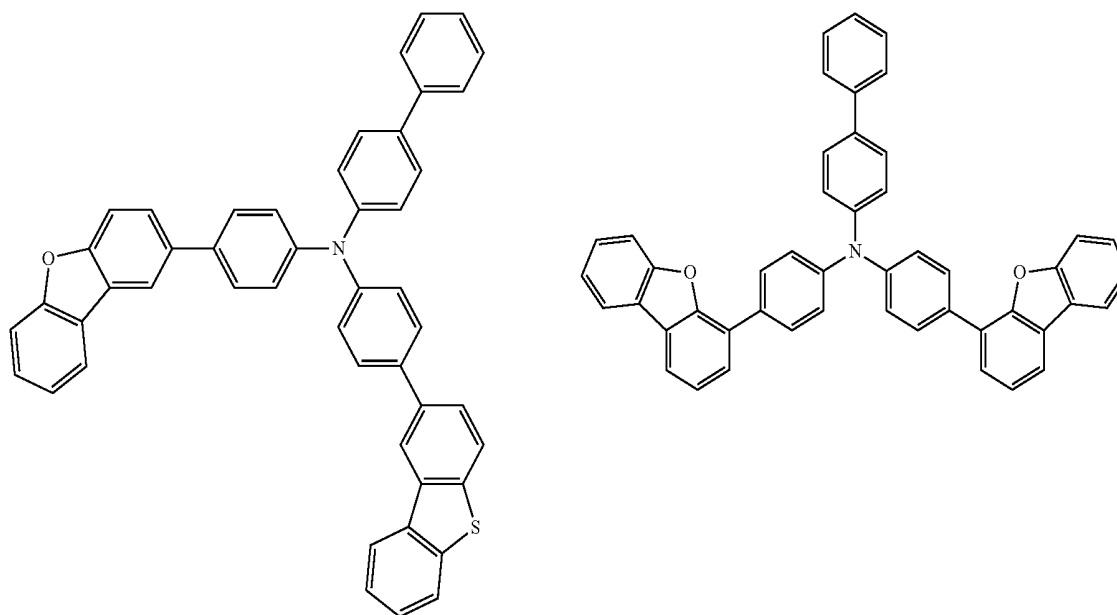
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HT20



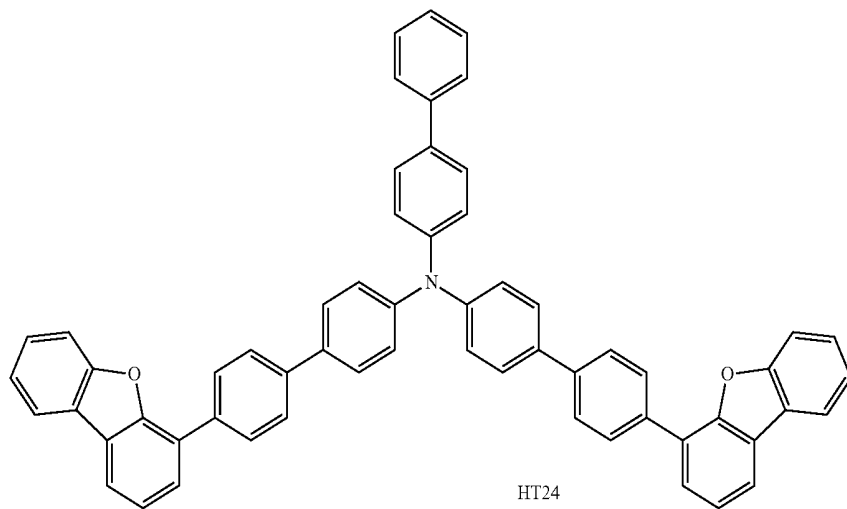
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HT22



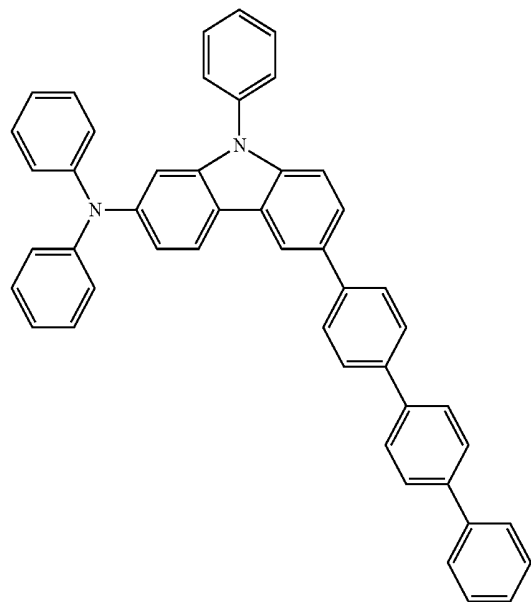
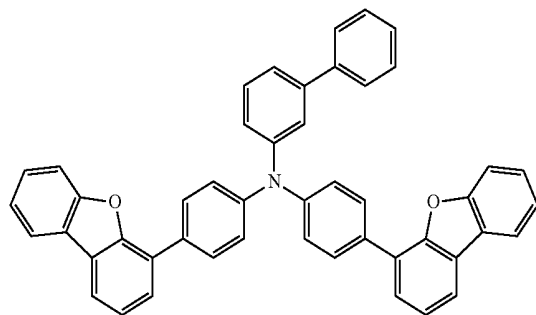
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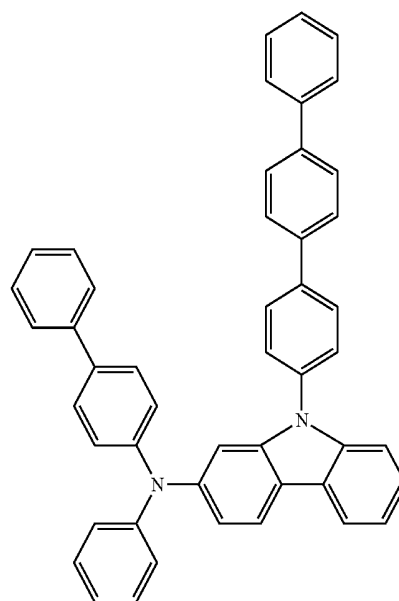
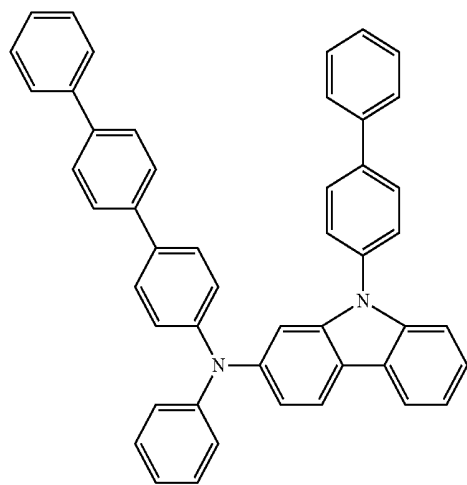
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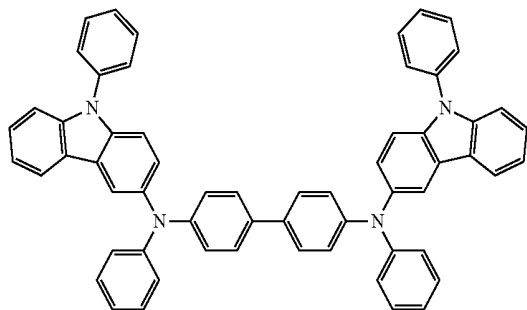


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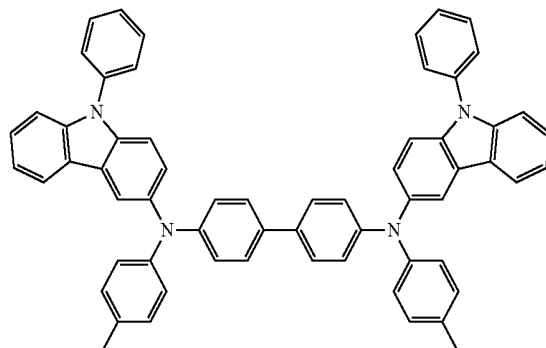
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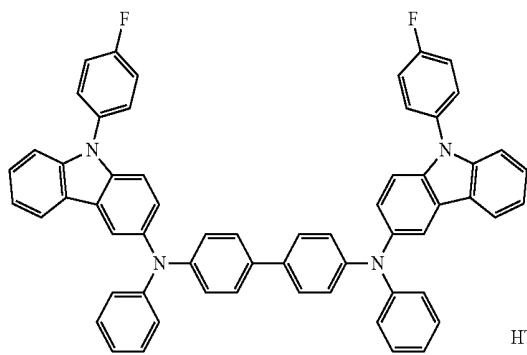
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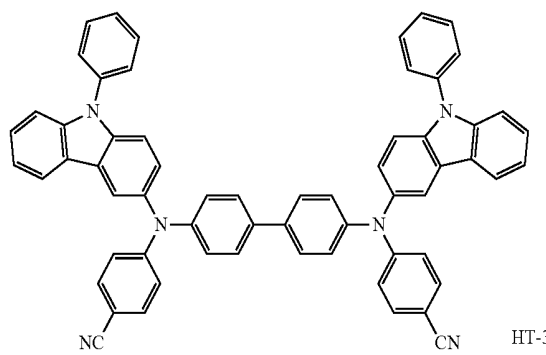
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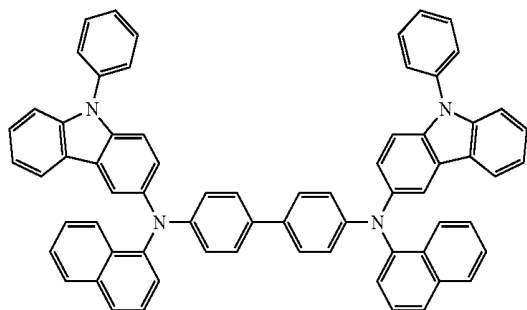
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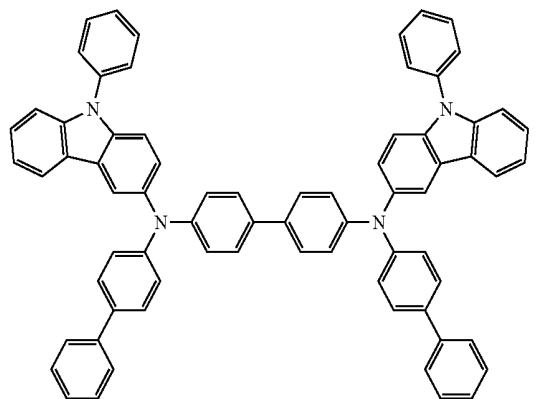
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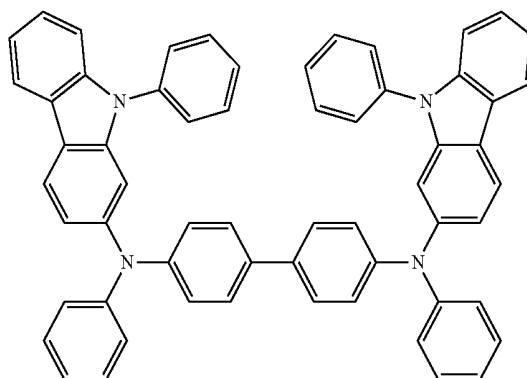
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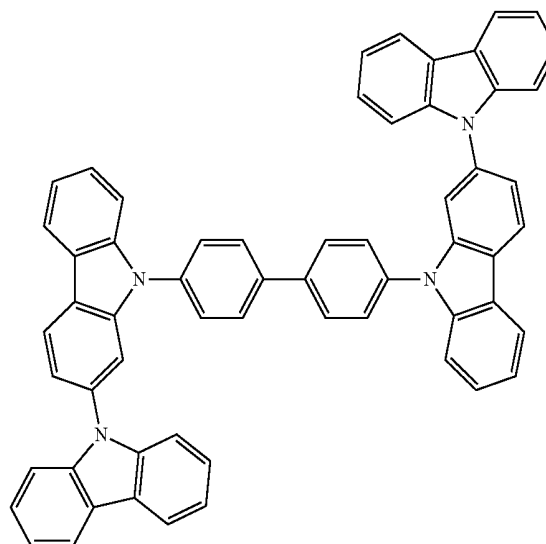
HT-33



HT-34



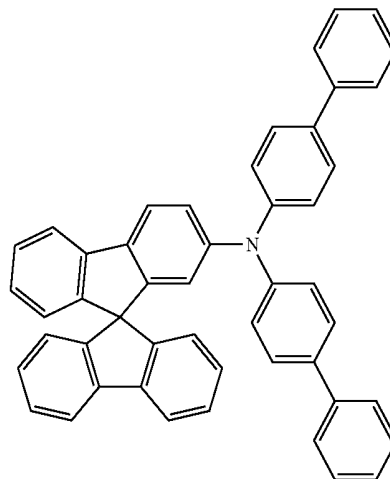
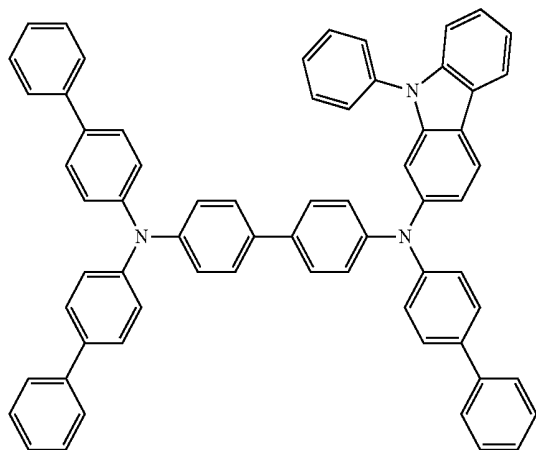
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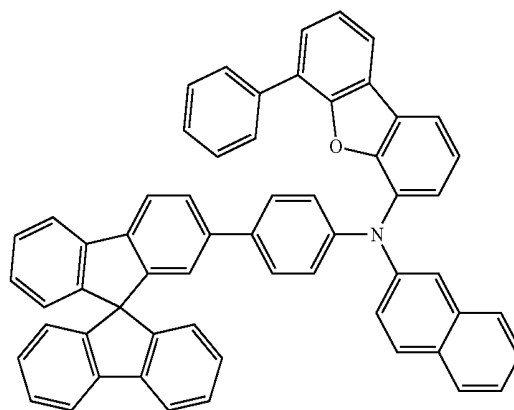
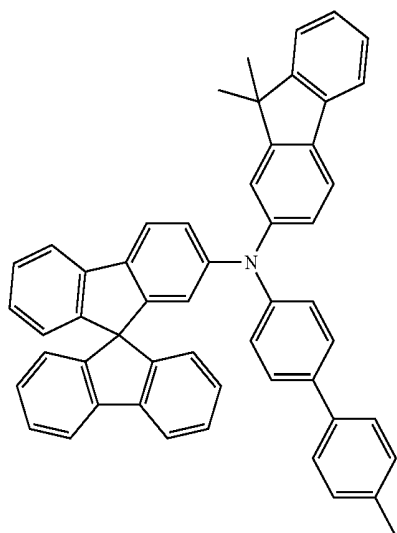
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HT-37



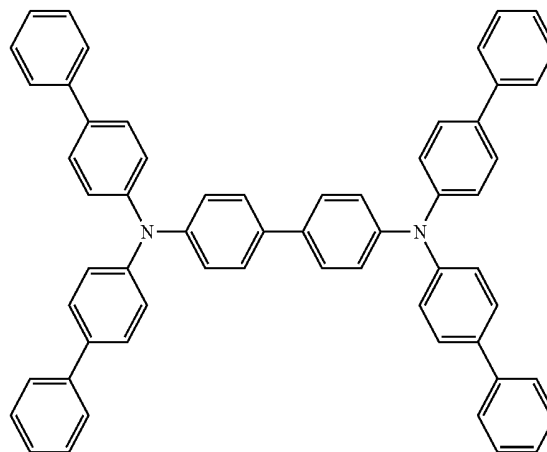
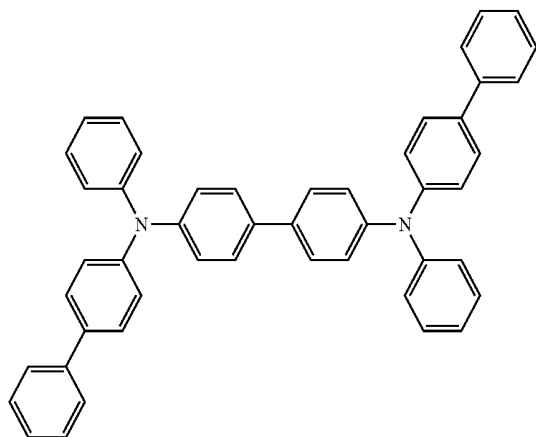
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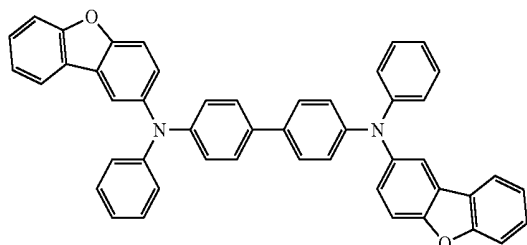
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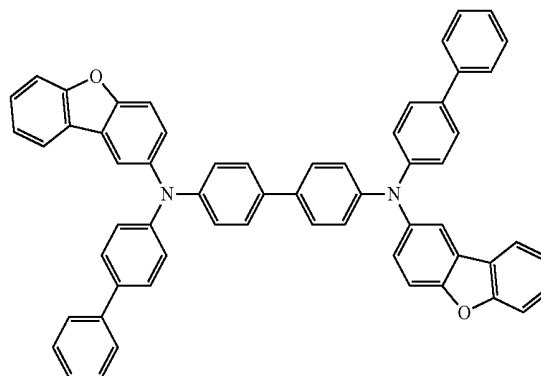
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HT-41

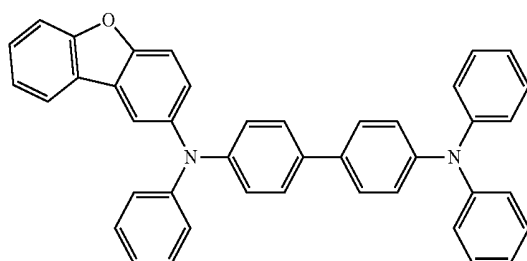


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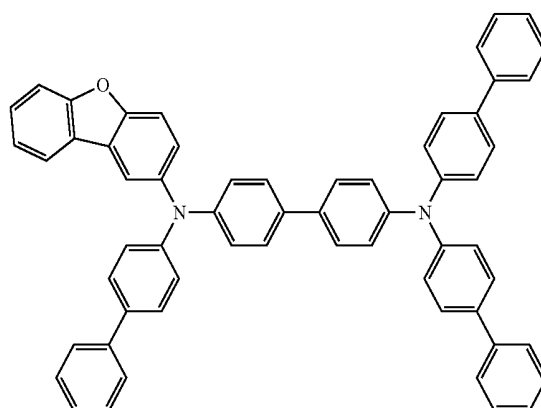
HT43



HT44



HT45



[0148] 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, a thickness of the hole injection layer may be in a range of about 100 Å to about 9,000 Å, for example, about 100 Å to about 1,000 Å, and a thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, for example, about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are within these ranges, suitable or satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

[0149] The emission auxiliary layer may increase light-emission efficiency by compensating for an optical resonance distance according to the wavelength of light emitted by the emission layer, and the electron blocking layer may block the flow of electrons from the electron transport region. The emission auxiliary layer and the electron blocking layer may include the materials as described above.

[0150] [P-Dopant]

[0151] 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.

[0152] The charge-generation material may be, for example, a p-dopant.

[0153] In one embodiment, the p-dopant may have an LUMO energy level of about -3.5 eV or less.

[0154] 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.

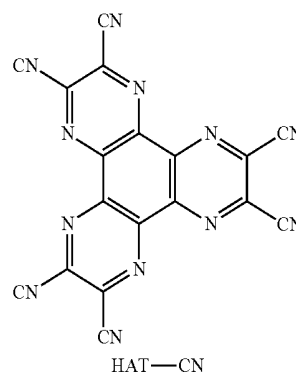
[0155] For example, the p-dopant may include at least one selected from:

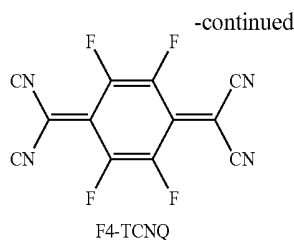
[0156] a quinone derivative, such as tetracyanoquinodimethane (TCNQ) or 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ);

[0157] a metal oxide, such as tungsten oxide or molybdenum oxide;

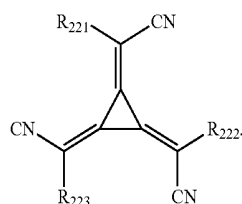
[0158] 1,4,5,8,9,12-hexaazatriphenylene-hexacarbonitrile (HAT-CN); and

[0159] a compound represented by Formula 221, but embodiments of the present disclosure are not limited thereto:





Formula 221



[0160] In Formula 221,

[0161] 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 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 $-I$.

[0162] [Emission Layer in Organic Layer 150]

[0163] 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.

[0164] In one embodiment, the emission layer may include the compound represented by Formula 1 and the compound represented by Formula 2.

[0165] In one embodiment, an amount of the compound represented by Formula 2 in the emission layer may be greater than that of the compound represented by Formula 1 in the emission layer.

[0166] In one embodiment, the compound represented by Formula 1 in the emission layer may be a thermally activated delayed fluorescence (TADF) emitter, and accordingly, the emission layer may emit delayed fluorescence.

[0167] The emission layer may include a host and a dopant. The dopant may include at least one of a phosphorescent dopant and a fluorescent dopant.

[0168] In one embodiment, the emission layer may include a host and a dopant, and the host may include the compound represented by Formula 2 and the dopant may include the compound represented by Formula 1.

[0169] An amount of the dopant may be in a range of about 0.01 part to about 30 parts by weight based on 100 parts by weight of the host. For example, an amount of the dopant may be in a range of about 0.1 part to about 20 parts by weight based on 100 parts by weight of the host. For example, an amount of the dopant may be in a range of about 1 part to about 10 parts by weight based on 100 parts by weight of the host. When the amount of the dopant is within these ranges, the movement of holes and electrons may be effectively balanced in the emission layer.

[0170] A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å. For example, a thickness of the emission layer may be in a range of about 100 Å to about 500 Å. For example, a thickness of the emission layer may be in a range of about 200 Å to about 400 Å. When the thickness of the emission layer is within these ranges, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

[0171] [Electron Transport Region in Organic Layer 150]

[0172] 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.

[0173] The electron transport region may include at least one layer 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.

[0174] 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, but embodiments of the present disclosure are not limited thereto.

[0175] 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.

[0176] 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.

[0177] 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.

[0178] Examples of the π electron-depleted nitrogen-containing ring include an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a

pyrimidine group, a pyridazine group, 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, but embodiments of the present disclosure are not limited thereto.

[0179] For example, the electron transport region may include a compound represented by Formula 601.



[0180] In Formula 601,

[0181] Ar_{601} may be a substituted or unsubstituted $\text{C}_5\text{-C}_{60}$ carbocyclic group or a substituted or unsubstituted $\text{C}_1\text{-C}_{60}$ heterocyclic group,

[0182] xe11 may be 1, 2, or 3,

[0183] L_{601} may be selected from a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkylene group, a substituted or unsubstituted $\text{C}_1\text{-C}_{10}$ heterocycloalkylene group, a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkenylene group, a substituted or unsubstituted $\text{C}_1\text{-C}_{10}$ heterocycloalkenylene group, a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ 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,

[0184] xe1 may be an integer of 0 to 5,

[0185] R_{601} may be selected from a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a substituted or unsubstituted $\text{C}_1\text{-C}_{10}$ heterocycloalkyl group, a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a substituted or unsubstituted $\text{C}_1\text{-C}_{10}$ heterocycloalkenyl group, a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ aryl group, a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ aryloxy group, a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ arylthio group, a substituted or unsubstituted $\text{C}_1\text{-C}_{60}$ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-\text{Si}(\text{Q}_{601})(\text{Q}_{602})(\text{Q}_{603})$, $-\text{C}(=\text{O})(\text{Q}_{601})$, $-\text{S}(=\text{O})_2(\text{Q}_{601})$, and $-\text{P}(=\text{O})(\text{Q}_{601})(\text{Q}_{602})$,

[0186] Q_{601} to Q_{603} may each independently be $\text{C}_1\text{-C}_{10}$ alkyl group, a $\text{C}_1\text{-C}_{10}$ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group, and

[0187] xe21 may be an integer of 1 to 5.

[0188] In one embodiment, at least one of $\text{Ar}_{601}(\text{s})$ in the number of xe11 may include then electron-depleted nitrogen-containing ring.

[0189] In one embodiment, in Formula 601, ring Ar_{601} may be selected from:

[0190] 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

[0191] 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, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a $\text{C}_1\text{-C}_{20}$ alkyl group, a $\text{C}_1\text{-C}_{20}$ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$, $-\text{S}(=\text{O})_2(\text{Q}_{31})$, and $-\text{P}(=\text{O})(\text{Q}_{31})(\text{Q}_{32})$, and

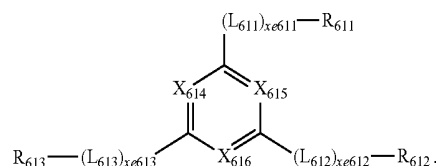
[0192] Q_{31} to Q_{33} may each independently be selected from a $\text{C}_1\text{-C}_{10}$ alkyl group, a $\text{C}_1\text{-C}_{10}$ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0193] In Formula 601, when xe11 is two or more, two or more of $\text{Ar}_{601}(\text{s})$ may be linked via a single bond.

[0194] In one or more embodiments, in Formula 601, Ar_{601} may be an anthracene group.

[0195] In one or more embodiments, the compound represented by 601 may be represented by Formula 601-1:

Formula 601-1



[0196] In Formula 601-1,

[0197] X_{614} may be N or C(R_{614}), X_{615} may be N or C(R_{615}), X_{616} may be N or C(R_{616}), and at least one selected from X_{614} to X_{616} may be N,

[0198] L_{611} to L_{613} may each independently be the same as described in connection with L_{601} ,

[0199] xe611 to xe613 may each independently be the same as described in connection with xe1,

[0200] R₆₁₁ to R₆₁₃ may each independently be the same as described in connection with R₆₀₁, and

[0201] 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.

[0202] In one embodiment, in Formulae 601 and 601-1, L₆₀₁ and L₆₁₁ to L₆₁₃ may each independently be selected from:

[0203] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a thiophenylenylene group, a furanylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a benzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, a pyridinylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a thiadiazolylenylene group, an oxadiazolylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a triazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzimidazolylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an imidazopyridinylenylene group, an imidazopyrimidinylenylene group, and an azacarbazolylenylene group; and

[0204] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a thiophenylenylene group, a furanylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a benzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, a pyridinylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a thiadiazolylenylene group, an oxadiazolylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a triazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group,

a benzimidazolylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an imidazopyridinylenylene group, an imidazopyrimidinylenylene group, and an azacarbazolylenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a 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, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a phthalazinyl group, a naphthyridinyl group, a quinoxaliny group, a quinazoliny group, a cinnoliny group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, but embodiments of the present disclosure are not limited thereto.

[0205] In one or more embodiments, in Formulae 601 and 601-1, xe1 and xe611 to xe613 may each independently be 0, 1, or 2.

[0206] In one or more embodiments, in Formulae 601 and 601-1, R₆₀₁ and R₆₁₁ to R₆₁₃ may each independently be selected from:

[0207] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a phthalazinyl group, a naphthyridinyl group, a quinoxaliny group, a quinazoliny group, a cinnoliny group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetra-

zoyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group;

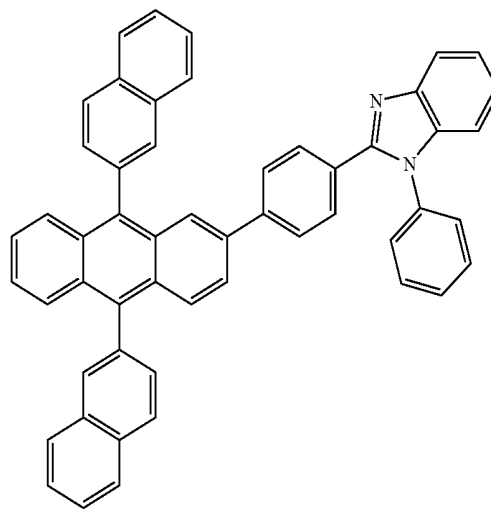
[0208] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinoiiny 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 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 fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinoiiny 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

[0209] —S(=O)₂(Q₆₀₁) and —P(=O)(Q₆₀₁)(Q₆₀₂), and

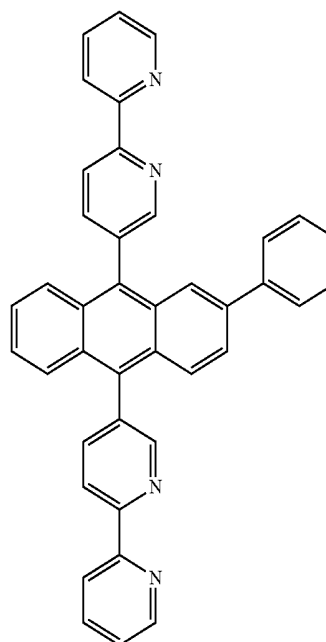
[0210] Q₆₀₁ and Q₆₀₂ may be the same as described above.

[0211] 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:

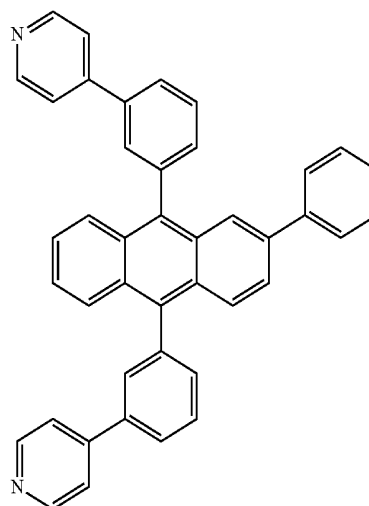
ET1



ET2

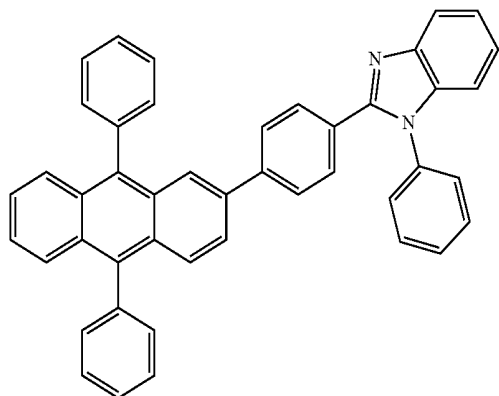


ET3



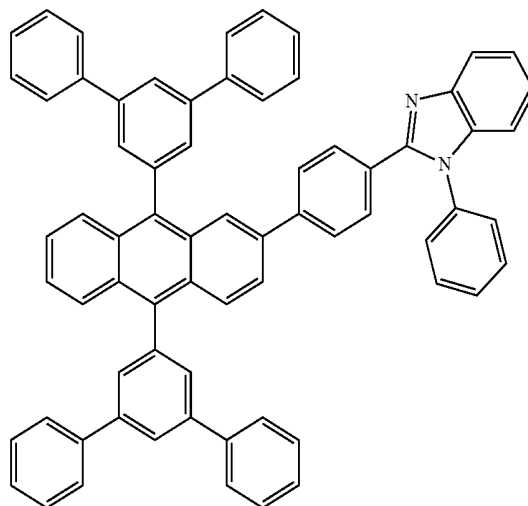
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ET4

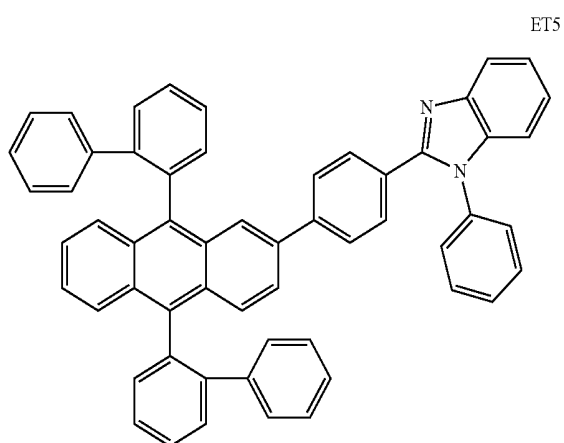


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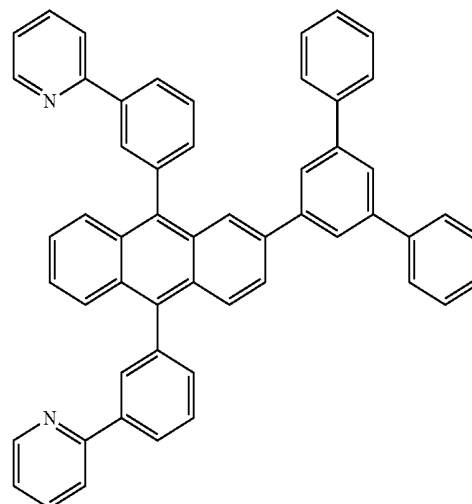
ET7



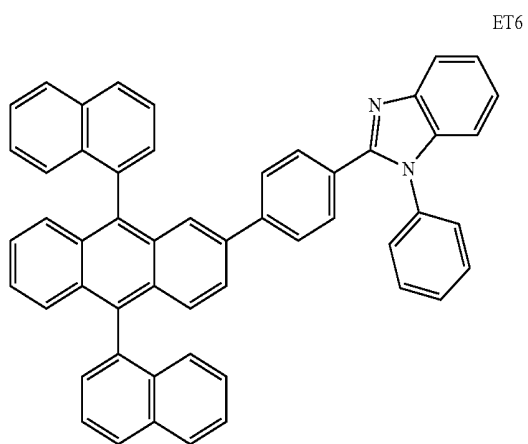
ET8



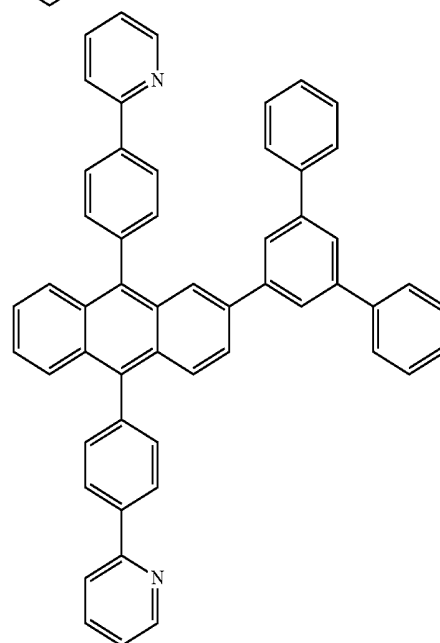
ET5



ET9

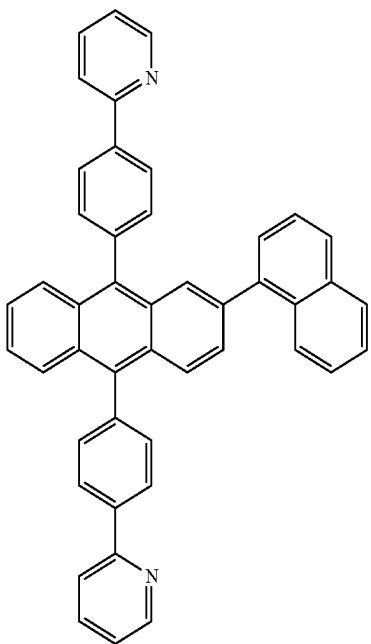


ET6

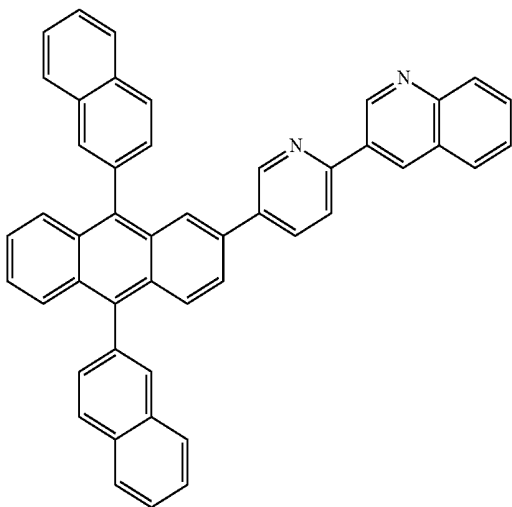


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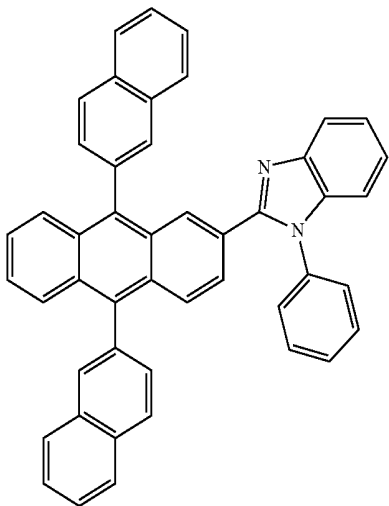
ET10



ET11

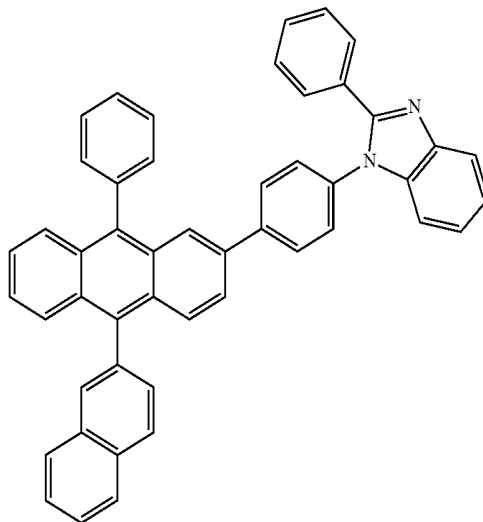


ET12

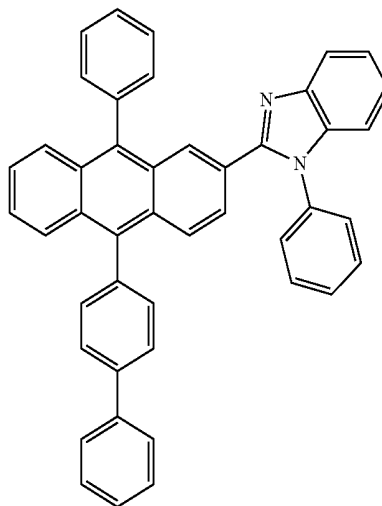


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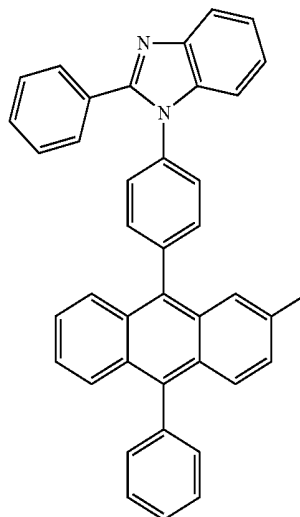
ET13



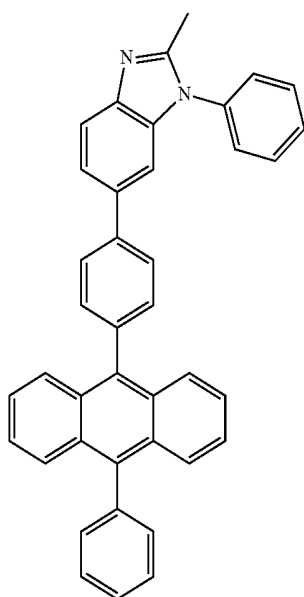
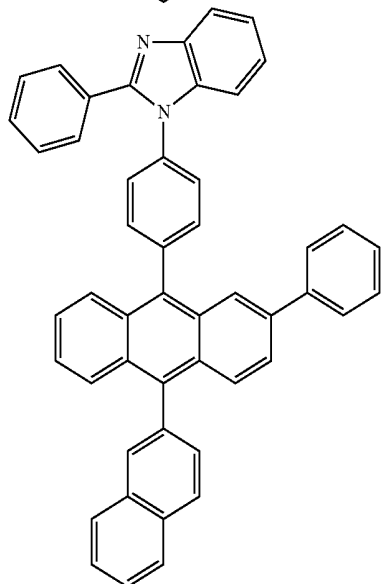
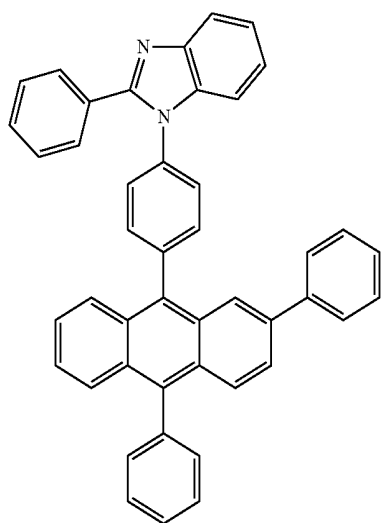
ET14



ET15



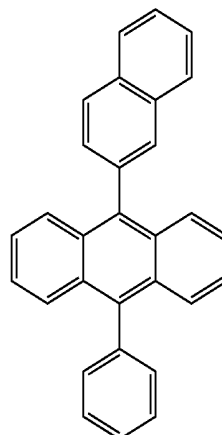
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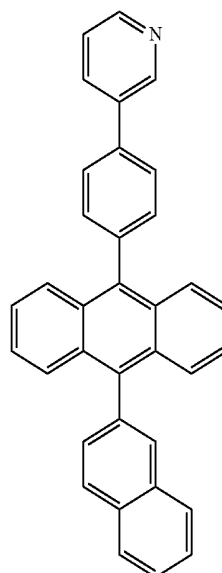
ET16

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ET19

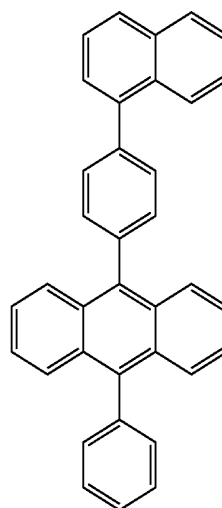


ET17



ET20

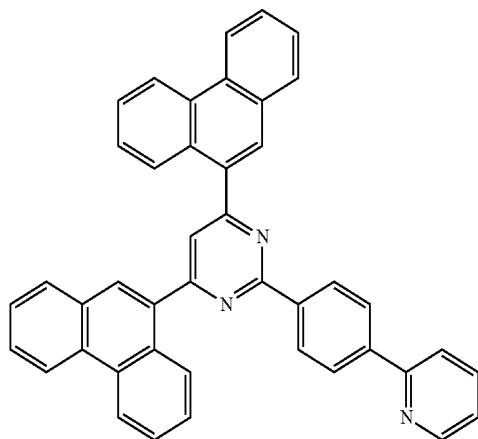
ET18



ET21

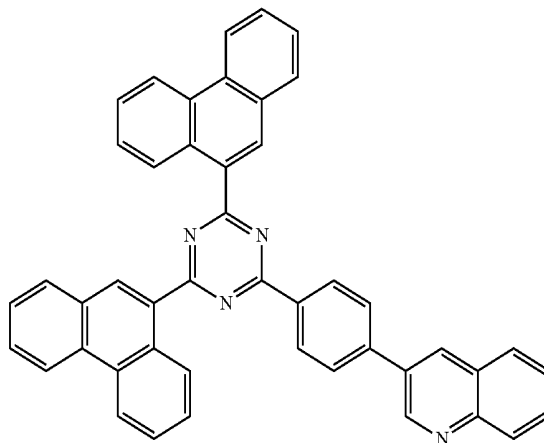
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ET22

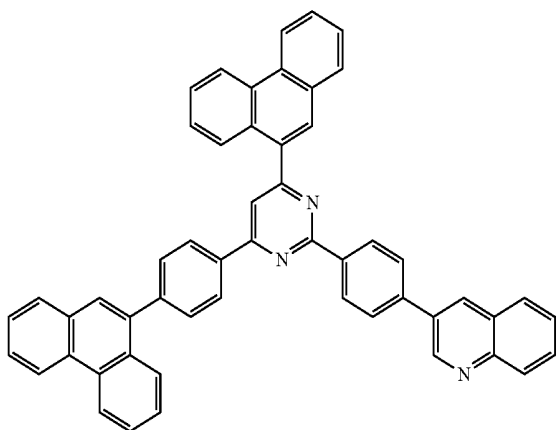


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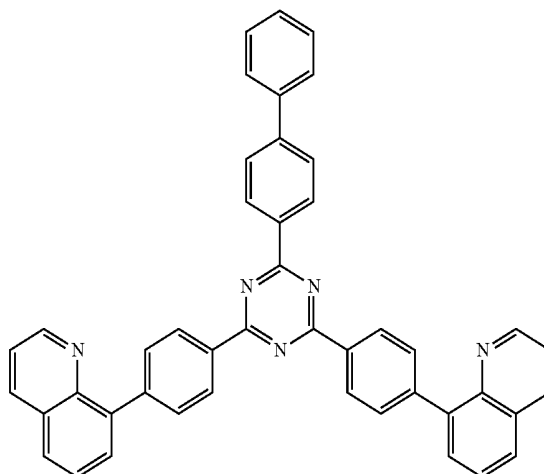
ET25



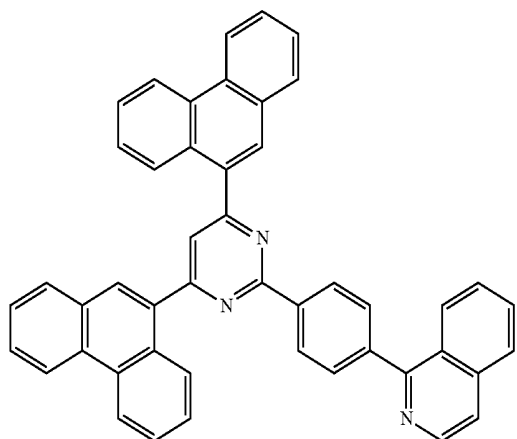
ET23



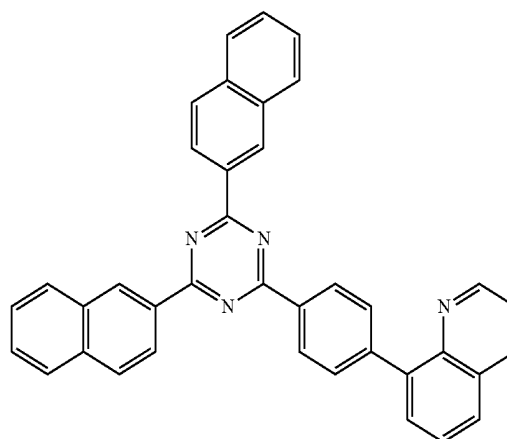
ET26



ET24

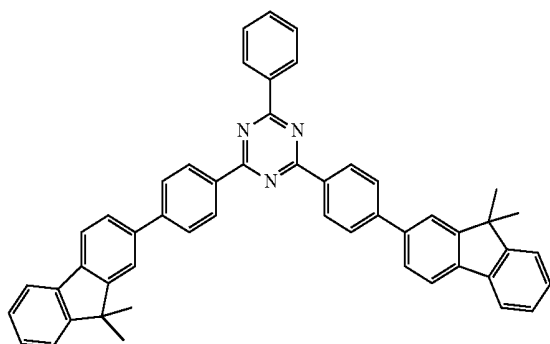


ET27



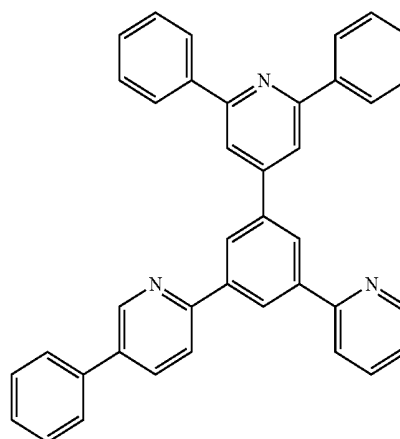
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ET28

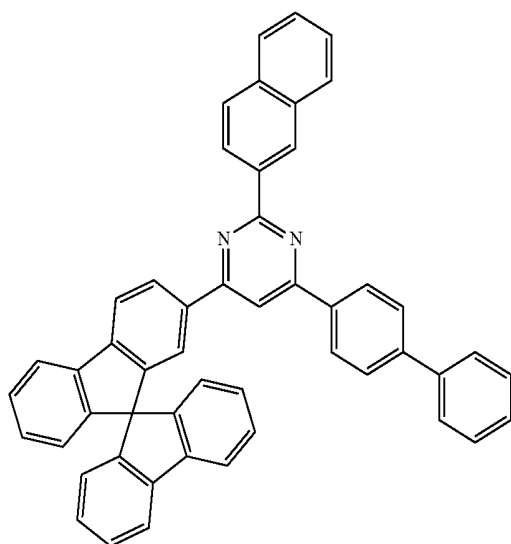


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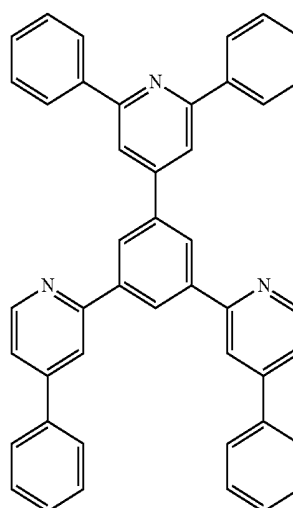
ET31



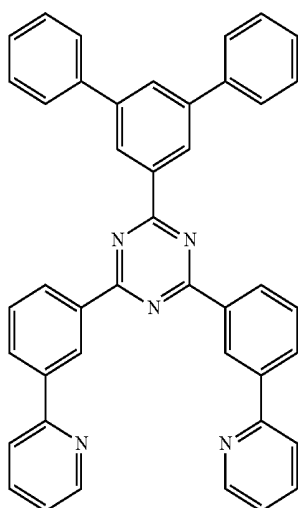
ET29



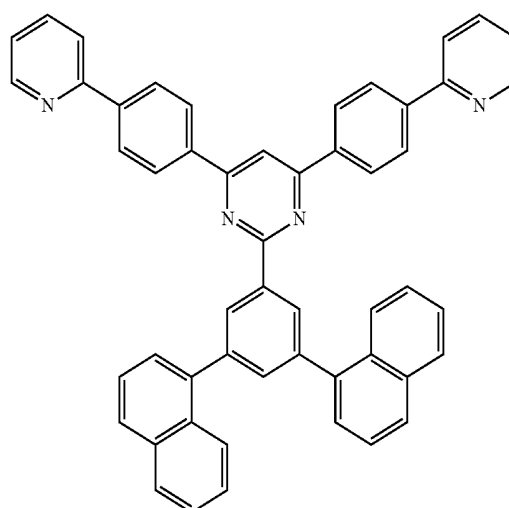
ET32



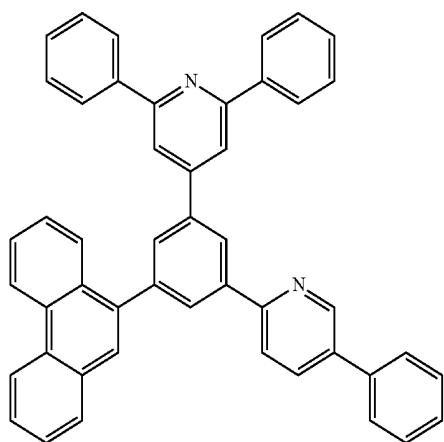
ET30



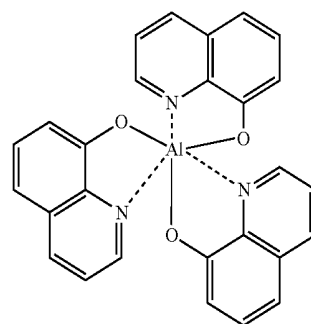
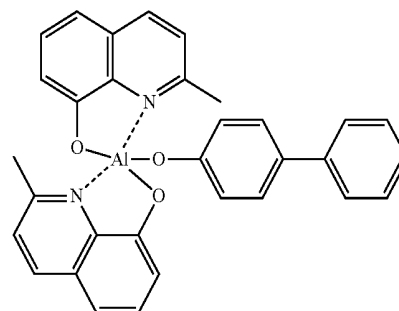
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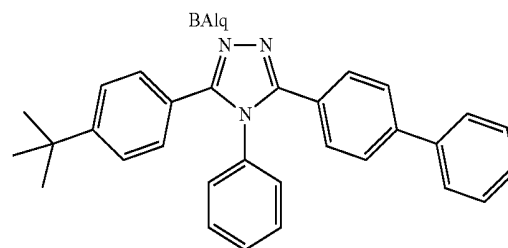
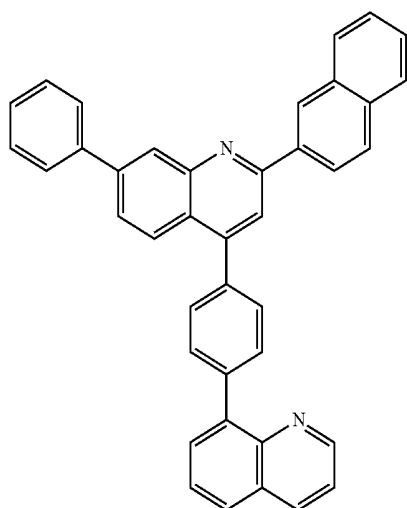
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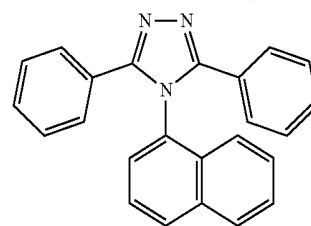
ET34

Alq₃

ET35

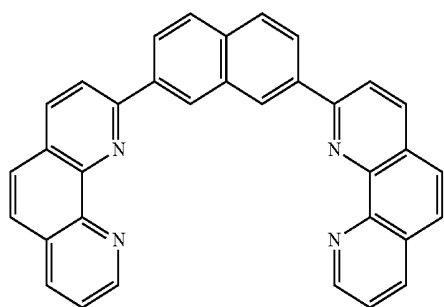


TAZ



NTAZ

ET36



[0212] 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-(bi-phenyl-4-yl)-5-(4-tert-butylphenyl)-4-phenyl-4H-1,2,4-triazole (TAZ), and NTAZ:

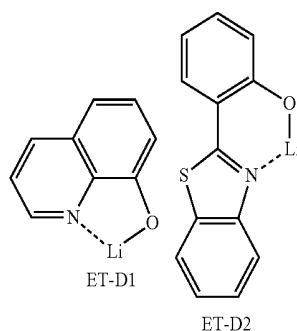
[0213] A thickness of the buffer layer, the hole blocking layer, or the electron control layer may be in a range of about 20 Å to about 1,000 Å, for example, about 30 Å to about 300 Å. When the thickness of the buffer layer, the hole blocking layer, or the electron control layer is within these ranges, excellent hole blocking characteristics or electron control characteristics may be obtained without a substantial increase in driving voltage.

[0214] 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 these ranges, suitable or satisfactory electron transport characteristics may be obtained without a substantial increase in driving voltage.

[0215] 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.

[0216] The metal-containing material may include at least one of an alkali metal complex and an alkaline earth-metal complex. The alkali metal complex may include a metal ion selected from a Li ion, a Na ion, a K ion, a Rb ion, and a Cs ion, and the alkaline earth-metal complex may include a metal ion selected from a Be ion, a Mg ion, a Ca ion, a Sr ion, and a Ba ion. A ligand coordinated with the metal ion of the alkali metal complex or the metal ion of the alkaline earth-metal complex may be selected from a hydroxy quinoline, a hydroxy isoquinoline, a hydroxy benzoquinoline, a hydroxy acridine, a hydroxy phenanthridine, a hydroxy phenyloxazole, a hydroxy phenylthiazole, a hydroxy diphenyloxadiazole, a hydroxy diphenylthiadiazol, a hydroxy phenylpyridine, a hydroxy phenylbenzimidazole, a hydroxy phenylbenzothiazole, a bipyridine, a phenanthroline, and a cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

[0217] For example, the metal-containing material may include a Li complex. The Li complex may include, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2:



[0218] 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.

[0219] 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.

[0220] 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.

[0221] The alkali metal may be selected from Li, Na, K, Rb, and Cs. In one embodiment, the alkali metal may be Li, Na, or Cs. In one or more embodiments, the alkali metal may be Li or Cs, but embodiments of the present disclosure are not limited thereto.

[0222] The alkaline earth metal may be selected from Mg, Ca, Sr, and Ba.

[0223] The rare earth metal may be selected from Sc, Y, Ce, Tb, Yb, and Gd.

[0224] 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.

[0225] 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.

[0226] The alkaline earth-metal compound may be selected from alkaline earth-metal oxides, such as BaO, SrO, CaO , $\text{BaSr}_{1-x}\text{O}$ ($0 < x < 1$), or $\text{Ba}_x\text{Ca}_{1-x}\text{O}$ ($0 < x < 1$). In one embodiment, the alkaline earth-metal compound may be selected from BaO, SrO, and CaO, but embodiments of the present disclosure are not limited thereto.

[0227] 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.

[0228] 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 diphenylthiadiazol, hydroxy phenylpyridine, hydroxy phenylbenzimidazole, hydroxy phenylbenzothiazole, bipyridine, phenanthroline, and cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

[0229] 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.

[0230] 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 these ranges, suitable or satisfactory electron injection characteristics may be obtained without a substantial increase in driving voltage.

[0231] [Second Electrode 190]

[0232] The second electrode 190 may be disposed on the organic layer 150 having such a structure. The second electrode 190 may be a cathode which is an electron injection electrode, and in this regard, a material for forming the second electrode 190 may be selected from a metal, an

alloy, an electrically conductive compound, and a combination thereof, which have a relatively low work function.

[0233] The second electrode **190** may include at least one selected from Li, Ag, Mg, Al, Al—Li, Ca, Mg—In, 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.

[0234] The second electrode **190** may have a single-layered structure, or a multi-layered structure including two or more layers.

[0235] [Description of FIGS. 2-4]

[0236] 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**.

[0237] Regarding FIGS. 2-4, the first electrode **110**, the organic layer **150**, and the second electrode **190** may be understood by referring to the description presented in connection with FIG. 1.

[0238] 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.

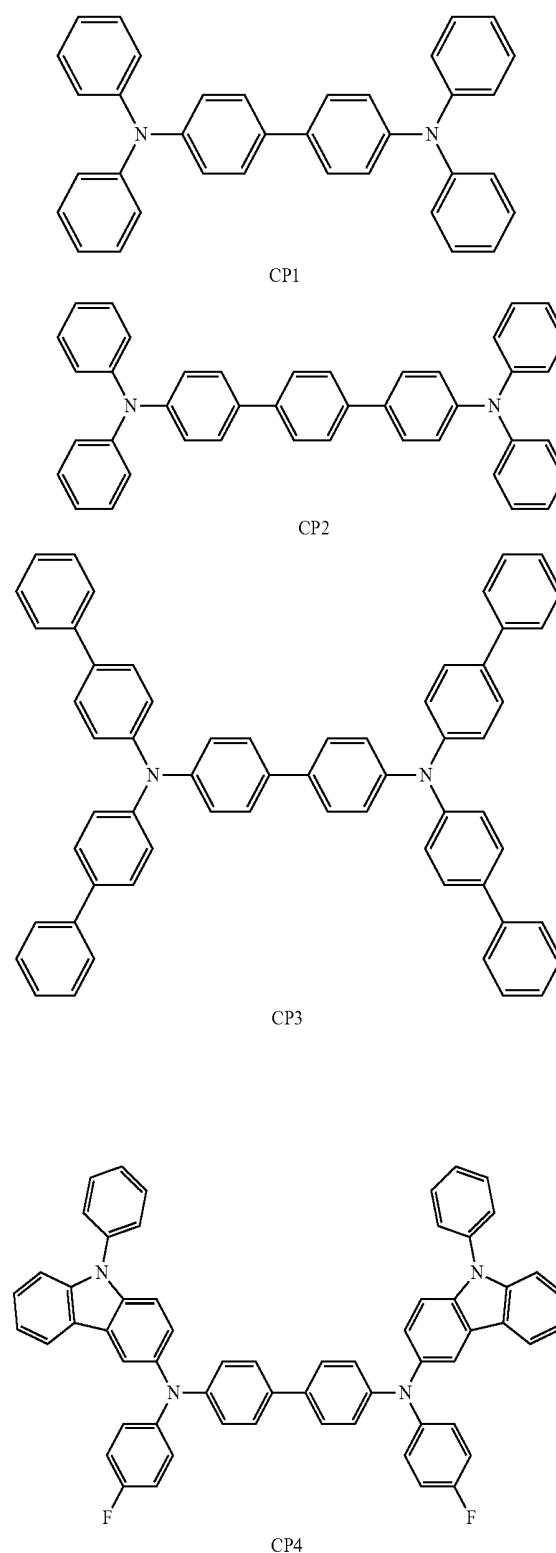
[0239] The first capping layer **210** and the second capping layer **220** may increase external luminescent efficiency according to the principle of constructive interference.

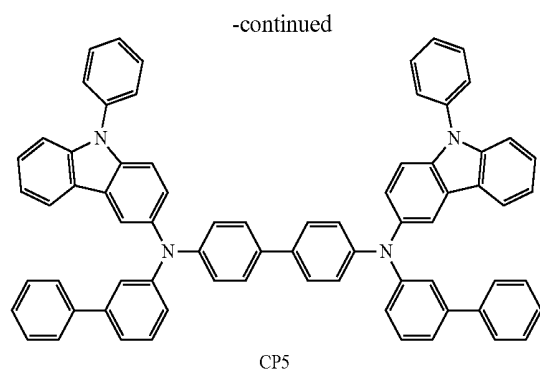
[0240] The first capping layer **210** and the second capping layer **220** may each independently be an organic capping layer including an organic material, an inorganic capping layer including an inorganic material, or a composite capping layer including an organic material and an inorganic material.

[0241] At least one of the first capping layer **210** and the second capping layer **220** may each independently include at least one material selected from a carbocyclic compound, a heterocyclic compound, an amine-based compound, a porphyrine derivative, a phthalocyanine derivative, a naphthalocyanine derivative, an alkali metal complex, and an alkaline earth-based complex. The carbocyclic compound, the heterocyclic compound, and the amine-based compound may be optionally substituted with a substituent containing at least one element selected from O, N, S, Se, Si, F, Cl, Br, and I. In one embodiment, at least one of the first capping layer **210** and the second capping layer **220** may each independently include an amine-based compound.

[0242] In one or more embodiments, at least one of 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.

[0243] In one or more embodiments, at least one of 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:





[0244] Hereinbefore, the organic light-emitting device according to an embodiment has been described in connection with FIGS. 1-4. However, embodiments of the present disclosure are not limited thereto.

[0245] 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 (LITI).

[0246] When layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region are formed by vacuum deposition, the vacuum deposition may be performed, for example, at a deposition temperature of about 100° C. to about 500° C., at a vacuum degree of about 10⁻⁸ torr to about 10⁻³ torr, and at a deposition rate of about 0 Å/sec to about 100 Å/sec by taking into account a material to be included in a layer to be formed, and the structure of a layer to be formed.

[0247] 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 200° C. by taking into account a material to be included in a layer to be formed, and the structure of a layer to be formed.

[0248] [Flat Display Apparatus]

[0249] The organic light-emitting device described above may be included in a flat display apparatus.

[0250] For example, an aspect of an embodiment provides a flat display apparatus including:

[0251] the organic light-emitting device; and

[0252] a thin film transistor,

[0253] wherein the thin film transistor may include a source electrode, a drain electrode, and an active layer, and

[0254] the first electrode of the organic light-emitting device may be electrically coupled or connected to at least one of the source electrode and the drain electrode of the thin film transistor.

[0255] [General Definition of Substituents]

[0256] The term “C₁-C₆₀ alkyl group,” as used herein, refers to a linear or branched aliphatic saturated hydrocarbon monovalent group having 1 to 60 carbon atoms, and examples thereof include a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an iso-amyl group, and a hexyl group. The term “C₁-C₆₀ alkylene group,” as used herein,

refers to a divalent group having substantially the same structure as the C₁-C₆₀ alkyl group.

[0257] The term “C₂-C₆₀ alkenyl group,” as used herein, refers to a hydrocarbon group having at least one double bond at a main chain (e.g., in the middle) or at the terminus of the C₂-C₆₀ alkyl group, and 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 substantially the same structure as the C₂-C₆₀ alkenyl group.

[0258] The term “C₂-C₆₀ alkynyl group,” as used herein, refers to a hydrocarbon group having at least one triple bond at a main chain (e.g., in the middle) or at the terminus of the C₂-C₆₀ alkyl group, and 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 substantially the same structure as the C₂-C₆₀ alkynyl group.

[0259] 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 examples thereof include a methoxy group, an ethoxy group, and an isopropoxy group.

[0260] The term “C₃-C₁₀ cycloalkyl group,” as used herein, refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term “C₃-C₁₀ cycloalkylene group,” as used herein, refers to a divalent group having substantially the same structure as the C₃-C₁₀ cycloalkyl group.

[0261] The term “C₁-C₁₀ heterocycloalkyl group,” as used herein, refers to a monovalent monocyclic group having at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom and 1 to 10 carbon atoms, and examples thereof include a 1, 2,3,4-oxatriazolidinyl group, a tetrahydrofuran group, and a tetrahydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkylene group,” as used herein, refers to a divalent group having substantially the same structure as the C₁-C₁₀ heterocycloalkyl group.

[0262] 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 double bond in the ring thereof and no aromaticity (e.g., the group is not aromatic), and 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 substantially the same structure as the C₃-C₁₀ cycloalkenyl group.

[0263] 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 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-dihydrofuran group, and a 2,3-dihydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkenylene group,” as used herein, refers to a divalent group having substantially the same structure as the C₁-C₁₀ heterocycloalkenyl group.

[0264] 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 a C₆-C₆₀ arylene group used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms.

Non-limiting examples of the C_6 - C_{60} aryl group include a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C_6 - C_{60} aryl group and the C_6 - C_{60} arylene group each include two or more rings, the rings may be fused to each other (e.g., combined together).

[0265] The term " C_1 - C_{60} 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 " C_1 - C_{60} 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, P, and S as a ring-forming atom, in addition to 1 to 60 carbon atoms. Non-limiting examples of the C_1 - C_{60} 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 C_1 - C_{60} heteroaryl group and the C_1 - C_{60} heteroarylene group each include two or more rings, the rings may be condensed with each other (e.g., combined together).

[0266] The term " C_6 - C_{60} aryloxy group," as used herein, indicates $-OA_{102}$ (wherein A_{102} is the C_6 - C_{60} aryl group), and the term " C_6 - C_{60} arylthio group," as used herein, indicates $-SA_{103}$ (wherein A_{103} is the C_6 - C_{60} aryl group).

[0267] The term "monovalent non-aromatic condensed polycyclic group," as used herein, refers to a monovalent group (for example, having 8 to 60 carbon atoms) having two or more rings condensed with each other (e.g., combined together), only carbon atoms as ring-forming atoms, and no aromaticity in its entire molecular structure (e.g., the entire molecular structure is not aromatic). An example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. The term "divalent non-aromatic condensed polycyclic group," as used herein, refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed polycyclic group.

[0268] The term "monovalent non-aromatic condensed heteropolycyclic group," as used herein, refers to a monovalent group (for example, having 1 to 60 carbon atoms) having two or more rings condensed to each other (e.g., combined together), at least one heteroatom selected from N, O, Si, P, and S, other than carbon atoms, as a ring-forming atom, and no aromaticity in its entire molecular structure (e.g., the entire molecular structure is not aromatic). An example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. The term "divalent non-aromatic condensed heteropolycyclic group," as used herein, refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0269] The term " C_5 - C_{60} carbocyclic group," as used herein, refers to a monocyclic or polycyclic group having 5 to 60 carbon atoms in which a ring-forming atom is a carbon atom only. The C_5 - C_{60} carbocyclic group may be an aromatic carbocyclic group or a non-aromatic carbocyclic group. The C_5 - C_{60} 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 coupled or connected to the C_5 - C_{60} carbocyclic group, the C_5 - C_{60} carbocyclic group may be a trivalent group or a quadrivalent group.

[0270] The term " C_1 - C_{60} heterocyclic group," as used herein, refers to a group having substantially the same structure as the C_1 - C_{60} 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).

[0271] At least one substituent of the substituted C_5 - C_{50} carbocyclic group, the substituted C_1 - C_{60} heterocyclic group, the substituted C_3 - C_{10} cycloalkylene group, the substituted C_1 - C_{10} heterocycloalkylene group, the substituted C_3 - C_{10} cycloalkenylene group, the substituted C_1 - C_{10} heterocycloalkenylene group, the substituted C_6 - C_{60} arylene group, the substituted C_1 - C_{60} heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_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:

[0272] 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;

[0273] 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 $-P(=O)(Q_{11})(Q_{12})$;

[0274] 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;

[0275] 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 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

[0276] —Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), —B(Q₃₁)(Q₃₂), —C(=O)(Q₃₁), —S(=O)₂(Q₃₁), and —P(=O)(Q₃₁)(Q₃₂), and

[0277] Q₁₁ to Q₁₃, Q₂₁ to Q₂₃, and Q₃₁ to Q₃₃ 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.

[0278] 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 “But”, as used herein, may refer to a tert-butyl group; and the term “OMe” as used herein may refer to a methoxy group.

[0279] 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 C₆-C₆₀ aryl group as a substituent.

[0280] 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 C₆-C₆₀ aryl group substituted with a C₆-C₆₀ aryl group.

[0281] * and *, as used herein, unless defined otherwise, each refer to a binding site to a neighboring atom in a corresponding formula.

[0282] 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 expression “B was used instead of A” used in describing Synthesis Examples means that an identical number of molar equivalents of A was used in place of molar equivalents of B.

EXAMPLES

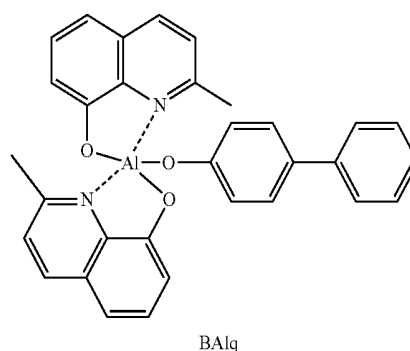
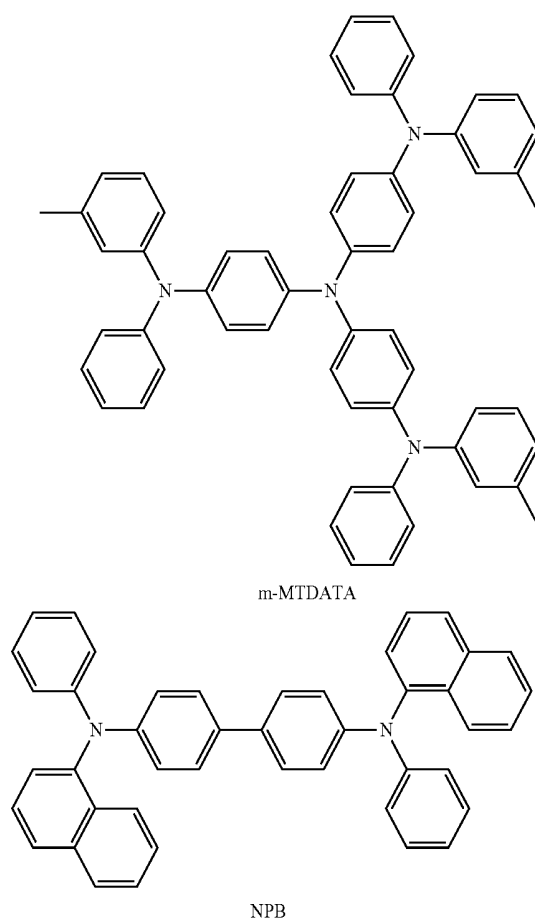
Example 1

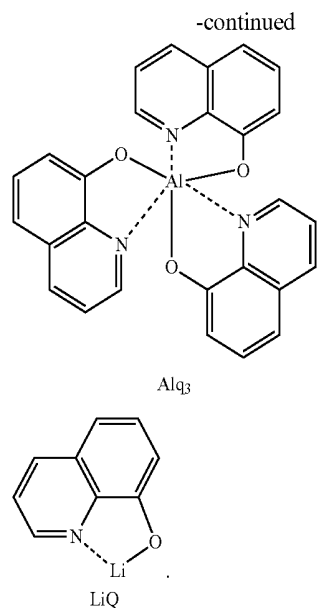
[0283] As a substrate and an anode, a Corning 15 Ω/cm² (1,200 Å) ITO glass substrate was cut to a size of 50 mm×50 mm×0.5 mm, sonicated with isopropyl alcohol and pure water each for 15 minutes, and then, cleaned by exposure to ultraviolet rays and ozone for 30 minutes. The ITO glass substrate was provided to a vacuum deposition apparatus.

[0284] m-TDATA was vacuum-deposited on the ITO glass substrate to form a hole injection layer having a thickness of 600 Å. NPB was vacuum-deposited on the hole injection layer to form a hole transport layer having a thickness of 100 Å.

[0285] Compound 2-2 (host) and Compound 1-1 (dopant) were co-deposited on the hole transport layer to form an emission layer having a thickness of 300 Å, wherein a weight ratio of the host to the dopant was 97:3.

[0286] BAlq was deposited on the emission layer to form a hole blocking layer having a thickness of 100 Å, Alq₃ was deposited on the hole blocking layer to form an electron transport layer having a thickness of 200 Å, LiF was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and then, Al was vacuum-deposited on the electron injection layer to form a cathode having a thickness of 2,000 Å, thereby completing the manufacture of an organic light-emitting device:





Examples 2 to 28 and Comparative Examples 1
and 2

[0287] Organic light-emitting devices were manufactured in substantially the same manner as in Example 1, except that Compounds shown in <Table 1> were each used instead of Compound 2-2 and Compound 1-1 in forming an emission layer.

Evaluation Example 1

[0288] Driving voltage, current density, luminance, and the emission efficiency of the organic light-emitting devices manufactured according to Examples 1 to 28 and Comparative Examples 1 and 2 were measured using Keithley SMU 236 and PR650 luminance meter, and results thereof are shown in Table 1.

[0289] Here, the emission efficiency of each of the organic light-emitting devices was measured when the current density was 10 mA/cm², and the lifespan (T₉₀) each of the organic light-emitting devices indicates an amount of time in hours that lapsed when luminance was 90% of initial luminance (100%) (at the current density of 10 mA/cm²).

TABLE 1

	Emission layer		Driving voltage	Emission efficiency	Lifespan
	Host	Dopant	(V)	(cd/A)	(T ₉₀) (hr)
Example 1	Compound 2-2	Compound 1-1	4.5	5.3	147
Example 2	Compound 2-2	Compound 1-8	4.5	5.2	155

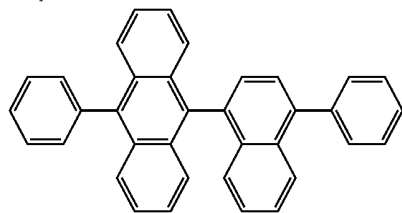
TABLE 1-continued

	Emission layer		Driving voltage	Emission efficiency	Lifespan
	Host	Dopant	(V)	(cd/A)	(T ₉₀) (hr)
Example 3	Compound 2-2	Compound 1-15	4.6	5.2	160
Example 4	Compound 2-2	Compound 1-23	4.4	5.4	150
Example 5	Compound 2-3	Compound 1-1	4.5	5.5	123
Example 6	Compound 2-3	Compound 1-8	4.4	5.6	115
Example 7	Compound 2-3	Compound 1-15	4.6	5.5	101
Example 8	Compound 2-3	Compound 1-23	4.4	5.6	124
Example 9	Compound 2-18	Compound 1-1	4.2	5.6	98
Example 10	Compound 2-18	Compound 1-8	4.3	5.8	105
Example 11	Compound 2-18	Compound 1-15	4.2	5.5	112
Example 12	Compound 2-18	Compound 1-23	4.1	5.7	120
Example 13	Compound 2-31	Compound 1-1	4.5	5.4	135
Example 14	Compound 2-31	Compound 1-8	4.7	5.2	119
Example 15	Compound 2-31	Compound 1-15	4.5	5.3	109
Example 16	Compound 2-31	Compound 1-23	4.6	5.4	125
Example 17	Compound 2-36	Compound 1-1	4.7	5.5	109
Example 18	Compound 2-36	Compound 1-8	4.5	5.6	98
Example 19	Compound 2-36	Compound 1-15	4.6	5.6	88
Example 20	Compound 2-36	Compound 1-23	4.6	5.4	116
Example 21	Compound 2-62	Compound 1-1	4.5	5.3	107
Example 22	Compound 2-62	Compound 1-8	4.4	5.4	95
Example 23	Compound 2-62	Compound 1-15	4.3	5.2	118
Example 24	Compound 2-62	Compound 1-23	4.4	5.3	112
Example 25	Compound 2-78	Compound 1-1	4.7	5.5	95
Example 26	Compound 2-78	Compound 1-8	4.8	5.3	105
Example 27	Compound 2-78	Compound 1-15	4.8	5.4	114
Example 28	Compound 2-78	Compound 1-23	4.8	5.3	121
Comparative Example 1	Compound A	Compound 1-1	5.2	4.8	52

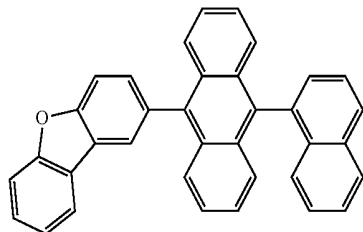
TABLE 1-continued

	Emission layer		Driving voltage (V)	Emission efficiency (cd/A)	Lifespan (T ₉₀) (hr)
	Host	Dopant			
Comparative Example 2	Compound B	Compound C	5.3	4.8	77

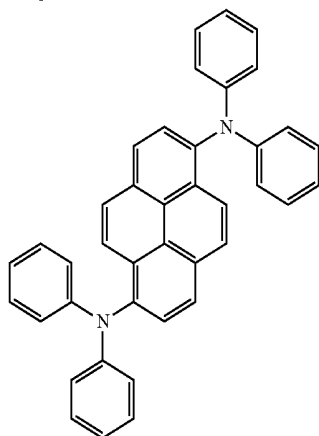
Compound A



Compound B



Compound C



[0290] Referring to <Table 1>, it was confirmed that the organic light-emitting devices of Examples 1 to 5 had low driving voltage, high efficiency, and long lifespan, as compared with those of Comparative Examples 1 and 2.

[0291] As described above, an organic light-emitting device and a flat display apparatus including the same have low driving voltage, high efficiency, and long lifespan concurrently (e.g., at the same time).

[0292] 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.

[0293] It will be understood that, although the terms “first,” “second,” “third,” etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These

terms are used to distinguish one element, component, region, layer or section from another element, component, region, layer or section.

[0294] Thus, a first element, component, region, layer or section described below could be termed a second element, component, region, layer or section, without departing from the spirit and scope of the present disclosure.

[0295] Spatially relative terms, such as “beneath,” “below,” “lower,” “under,” “above,” “upper,” and the like, may be used herein for ease of explanation to describe one element or feature’s relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or in operation, in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as “below” or “beneath” or “under” other elements or features would then be oriented “above” the other elements or features. Thus, the example terms “below” and “under” can encompass both an orientation of above and below. The device may be otherwise oriented (e.g., rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein should be interpreted accordingly.

[0296] It will be understood that when an element or layer is referred to as being “on,” “connected to,” or “coupled to” another element or layer, it can be directly on, connected to, or coupled to the other element or layer, or one or more intervening elements or layers may be present. In addition, it will also be understood that when an element or layer is referred to as being “between” two elements or layers, it can be the only element or layer between the two elements or layers, or one or more intervening elements or layers may also be present.

[0297] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms “a” and “an” are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms “comprises,” “comprising,” “includes,” and “including,” when used in this specification, specify the presence of the stated features, integers, acts, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, acts, operations, elements, components, and/or groups thereof.

[0298] As used herein, the terms “substantially,” “about,” and similar terms are used as terms of approximation and not as terms of degree, and are intended to account for the inherent deviations in measured or calculated values that would be recognized by those of ordinary skill in the art. Further, the use of “may” when describing embodiments of the present disclosure refers to “one or more embodiments of the present disclosure.” As used herein, the terms “use,” “using,” and “used” may be considered synonymous with the terms “utilize,” “utilizing,” and “utilized,” respectively. Also, the term “exemplary” is intended to refer to an example or illustration.

[0299] Also, any numerical range recited herein is intended to include all subranges of the same numerical precision subsumed within the recited range. For example, a range of “1.0 to 10.0” is intended to include all subranges between (and including) the recited minimum value of 1.0 and the recited maximum value of 10.0, that is, having a minimum value equal to or greater than 1.0 and a maximum

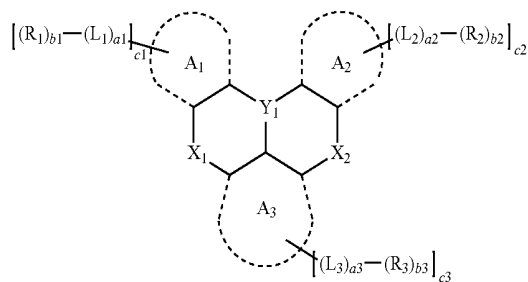
value equal to or less than 10.0, such as, for example, 2.4 to 7.6. Any maximum numerical limitation recited herein is intended to include all lower numerical limitations subsumed therein, and any minimum numerical limitation recited in this specification is intended to include all higher numerical limitations subsumed therein. Accordingly, Applicant reserves the right to amend this specification, including the claims, to expressly recite any sub-range subsumed within the ranges expressly recited herein.

[0300] 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, and equivalents thereof.

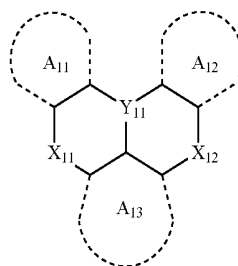
What is claimed is:

1. 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 and comprising an emission layer,
wherein the organic layer comprises a compound represented by Formula 1 and a compound represented by Formula 2:

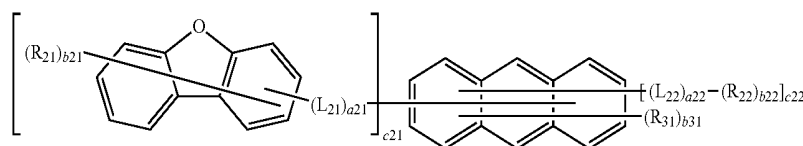
Formula 1



Formula 1A



Formula 2



wherein, in Formula 1, rings A₁, A₂, and A₃ are each independently a C₅-C₆₀ carbocyclic group, a C₂-C₆₀ heterocyclic group, or a group represented by Formula 1A,

in Formula 1A, rings A₁₁, A₁₂, and A₁₃ are each independently a C₅-C₆₀ carbocyclic group or a C₂-C₆₀ heterocyclic group,

in Formula 1, Y₁ is B, P, P=O, P=S, Al, Ga, As, Si(R₄₁), or Ge(R₄₁), X₁ is O, S, or N(R₄₂), and X₂ is O, S, or N(R₄₃),

in Formula 1A, Y₁₁ is B, P, P=O, P=S, Al, Ga, As, Si(R₅₁), or Ge(R₅₁), X₁₁ is O, S, or N(R₅₂), and X₁₂ is O, S, or N(R₅₃),

in Formulae 1 and 2, L₁ to L₃, L₂₁, and L₂₂ are each independently selected from substituted or unsubstituted C₅-C₆₀ carbocyclic group and a substituted or unsubstituted C₂-C₆₀ heterocyclic group,

in Formulae 1 and 2, a₁ to a₃ and a₂₁ are each independently an integer of 0 to 5, wherein, when a₁ is 0,

-(L₁)_{a1}- is a single bond, when a₂ is 0, *-(L₂)_{a2}-* is a single bond, when a₃ is 0, *-(L₃)_{a3}-* is a single bond, and when a₂₁ is 0, *-(L₂₁)_{a21}-* is a single bond,

in Formula 2, a₂₂ is an integer of 1 to 5,

in Formulae 1 and 2, R₁ to R₃, R₂₁, R₂₂, R₃₁, R₄₁ to R₄₃, and R₅₁ to R₅₃ are each independently 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-C₃₀ cycloalkyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₃₀ cycloalkenyl group, a substituted or unsubstituted C₂-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 C₂-C₆₀ heteroaryl group, a substituted or unsubstituted C₁-C₆₀ hetero aryloxy group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted

or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁)(Q₂)(Q₃), —B(Q₁)(Q₂), —C(=O)(Q₁), —P(=O)(Q₁)(Q₂), —P(=S)(Q₁)(Q₂), —S(=O)(Q₁)(Q₂), and —S(=O)₂(Q₁)(Q₂),

at least two groups selected from R₁ to R₃, R₂₁, R₂₂, R₃₁, R₄₁ to R₄₃, and R₅₁ to R₅₃ are optionally linked to form a substituted or unsubstituted C₅-C₆₀ carbocyclic group or a substituted or unsubstituted C₂-C₆₀ heterocyclic group,

in Formulae 1 and 2, b₁ to b₃, b₂₁, b₂₂, and b₃₁ are each independently an integer of 0 to 7,

in Formula 1, c₁ to c₃ are each independently an integer of 0 to 10,

in Formula 2, c₂₁ is an integer of 1 to 10, and c₂₂ is an integer of 0 to 9,

at least one substituent selected from the substituted C₅-C₆₀ carbocyclic group, the substituted C₂-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-C₃₀ cycloalkyl group, the substituted C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₃₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₂-C₆₀ heteroaryl group, the substituted C₁-C₆₀ hetero aryloxy 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-C₃₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₃₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₁₁)(Q₁₂)(Q₁₃), —B(Q₁₁)(Q₁₂), —C(=O)(Q₁₁), —S(=O)₂(Q₁₁), and —P(=O)(Q₁₁)(Q₁₂);

a C₃-C₃₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₃₀ cycloalkenyl group, a C₂-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;

a C₃-C₃₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₃₀ cycloalkenyl group, a C₂-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-C₃₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₃₀ cycloalkenyl group, a C₂-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), —B(Q₂₁)(Q₂₂), —C(=O)(Q₂₁), —S(=O)₂(Q₂₁), and —P(=O)(Q₂₁)(Q₂₂); and

—Si(Q₃₁)(Q₃₂)(Q₃₃), —B(Q₃₁)(Q₃₂), —C(=O)(Q₃₁), —S(=O)₂(Q₃₁), and —P(=O)(Q₃₁)(Q₃₂),

Q₁ to Q₃, Q₄ to Q₁₃, Q₂₁ to Q₂₃, Q₃₁ to Q₃₃, Q₄₁, Q₄₂, Q₅₁, Q₅₂, Q₆₁, and Q₇₁ 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-C₃₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₃₀ cycloalkenyl group, a C₂-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 independently indicate a binding site to a neighboring atom.

2. The organic light-emitting device of claim 1, wherein rings A₁, A₂, A₃, A₁₁, A₁₂, and A₁₃ are each independently a benzene group, a naphthalene group, an anthracene group, a phenanthrene group, a triphenylene group, a pyrene group, a chrysene group, a cyclopentadiene group, a 1,2,3,4-tetrahydronaphthalene group, a thiophene group, a furan group, a pyrrole group, an indole group, an indene group, a benzosilole group, a benzothiophene group, a benzofuran group, a carbazole group, a fluorene group, a dibenzosilole group, a dibenzothiophene group, a benzofuran group, a pyridine group, a pyrimidine group, a pyrazine group, a pyridazine group, a triazine group, a quinoline group, an isoquinoline group, a quinoxaline group, a quinazoline group, a phenanthroline group, a pyrazole group, an imidazole group, a triazole group, an oxazole group, an iso-oxazole group, a thiazole group, an isothiazole group, an oxadiazole group, a thiadiazole group, a benzopyrazole group, a benzimidazole group, a benzoxazole group, a benzothiazole group, a benzooxadiazole group, a benzothiadiazole group, a 5,6,7,8-tetrahydroisoquinoline group, a 5,6,7,8-tetrahydroquinoline group, or a group represented by Formula 1A, wherein rings A₁₁, A₁₂, and A₁₃ are not the group represented by Formula 1A.

3. The organic light-emitting device of claim 1, wherein L₁ to L₃, L₂₁, and L₂₂ are each independently selected from:

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene group, a heptalenylene group, an indacenylene group, an acenaphthylenylene group, a fluorenylenylene group, a spiro-fluorenylenylene group, a benzofluorenylenylene group, a dibenzofluorenylenylene group, a phenalenylene(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 pyrrolylenylene group, a thiophenylenylene group, a furanylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isooxazolylenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, an isoindolylenylene group, an indolylenylene group, an indazolylenylene group, a purinylenylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylene group, a cinolinylene group, a carbazolylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a

benzimidazolylenes group, a benzofuranylenes group, a benzothiophenylene group, an isobenzothiazolylenes group, a benzooxazolylenes group, an isobenzooxazolylenes group, a triazolylenes group, a tetrazolylenes group, an oxadiazolylenes group, a triazinyl group, a dibenzofuranylenes group, a dibenzothiophenylene group, a benzocarbazolylenes group, and a dibenzocarbazolylenes group; and

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenes group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylenes group, a spiro-fluorenylenes group, a benzofluorenylenes group, a dibenzofluorenylenes group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylenes group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylenes group, a coronenylene group, an ovalenylene group, a pyrrolylenes group, a thiophenylene group, a furanylenes group, an imidazolylenes group, a pyrazolylenes group, a thiazolylenes group, an isothiazolylenes group, an oxazolylenes group, an isoxazolylenes group, a pyridinylenes group, a pyrazinylenes group, a pyrimidinylenes group, a pyridazinylenes group, an isoindolylenes group, an indolylenes group, an indazolylenes group, a purinylenes group, a quinolinylenes group, an isoquinolinylenes group, a benzoquinolinylenes group, a phthalazinylenes group, a naphthyridinylenes group, a quinoxalinylenes group, a quinazolinylenes group, a cinnolinylenes group, a carbazolylenes group, a phenanthridinylenes group, an acridinylenes group, a phenanthrolinylenes group, a phenazinylenes group, a benzimidazolylenes group, a benzofuranylenes group, a benzothiophenylene group, an isobenzothiazolylenes group, a benzoxazolylenes group, an isobenzoxazolylenes group, a triazolylenes group, a tetrazolylenes group, an oxadiazolylenes group, a triazinyl group, a dibenzofuranylenes group, a dibenzothiophenylene group, a benzocarbazolylenes group, and a dibenzocarbazolylenes 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 hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_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 pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphe-nyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl

group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a phthalazinyl group, a naphthyridinyl group, a quinoxaliny group, a quinazoliny group, a cinnoliny group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, and an imidazopyridinyl group.

4. The organic light-emitting device of claim 1, wherein R_1 to R_3 , R_{21} , R_{22} , R_{31} , R_{41} to R_{43} , and R_{51} to R_{53} 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_2 - C_{20} alkenyl group, a C_2 - C_{20} alkynyl group, and a C_1 - C_{20} alkoxy group;

a C_1 - C_{20} alkyl group, a C_2 - C_{20} alkenyl group, a C_2 - C_{20} alkynyl group, and a C_1 - C_{20} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a pyridinyl group, a pyrimidinyl 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});

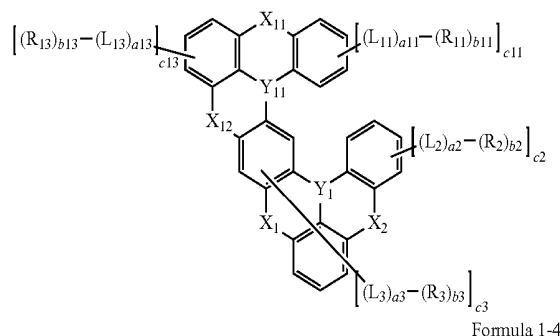
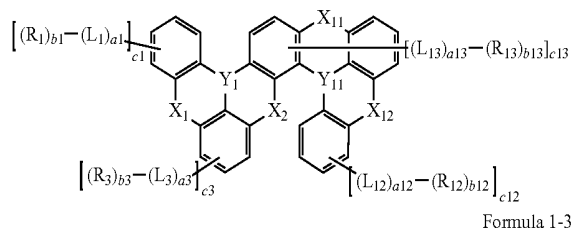
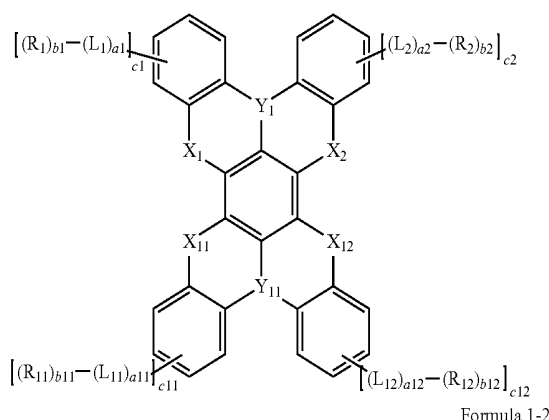
a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinoi-nyl group, an isoquinoliny group, a benzoquinoliny group, a quinoxaliny group, a quinazoliny group, a cinnoliny group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothienophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, —CD₃, —CD₂H, —CDH₂, —CF₃, —CF₂H, —CFH₂, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₂-C₂₀ alkenyl group, a C₂-C₂₀ alkynyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a cyclopentenyl group, a cyclohexenyl group, a cycloheptenyl group, a phenyl group, a naphthyl group, a fluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthrolinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), —B(Q₃₁)(Q₃₂), —C(=O)(Q₃₁), —S(=O)₂(Q₃₁), and —P(=O)(Q₃₁)(Q₃₂); and B(Q₁)(Q₂), —P(Q₁)(Q₂) and —C(=O)(Q₁), and Q₁ to Q₃ and Q₃₁ to Q₃₃ are the same as those described in claim 1.

5. The organic light-emitting device of claim 1, wherein the sum of c1 to c3 is 0, 1, or 2.

6. The organic light-emitting device of claim 1, wherein c21 and c22 are each independently 1 or 2.

7. The organic light-emitting device of claim 1, wherein the compound represented by Formula 1 is represented by one of Formulae 1-1 to 1-4:



wherein, in Formulae 1-1 to 1-4,

Y₁, X₁, X₂, Y₁₁, X₁₁, X₁₂, L₁ to L₃, a₁ to a₃, R₁ to R₃, b₁ to b₃, and c₁ to c₃ are the same as those described in claim 1,

L₁₁ to L₁₃ are each independently the same as described in connection with L₁ to L₃ in claim 1,

a11 to a13 are each independently the same as described in connection with a1 to a3 in claim 1,

R₁₁ to R₁₃ are each independently the same as described in connection with R₁ to R₃ in claim 1,

b11 to b13 are each independently the same as described in connection with b1 to b3 in claim 1, and

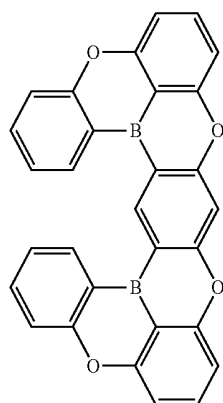
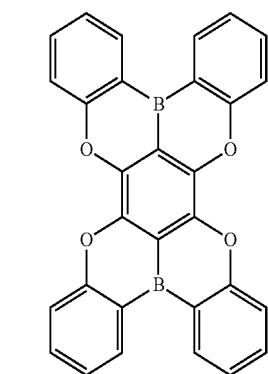
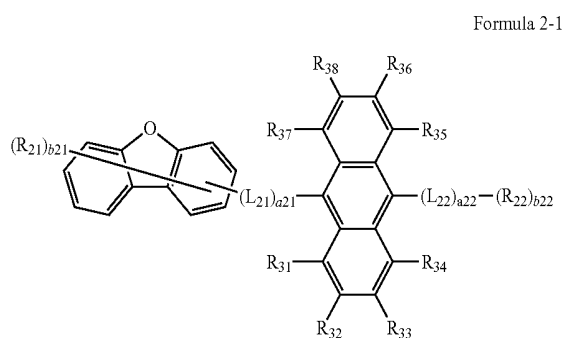
c11 to c13 are each independently the same as described in connection with c1 to c3 in claim 1.

8. The organic light-emitting device of claim 7, wherein, in Formulae 1-1 to 1-4,

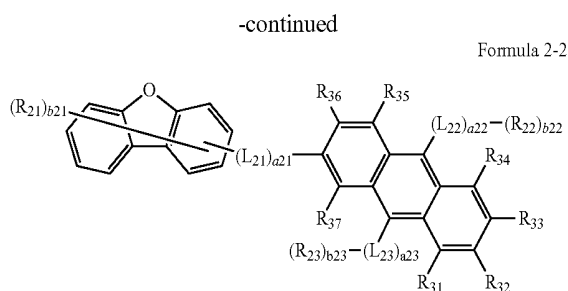
Y_1 is B, P=O, or P=S, X_1 is O, S, or N(R_{42}), X_2 is O, S, or N(R_{43}), Y_{11} is B, X_{11} and X_{12} are each independently O, and

R_{42} and R_{43} are each independently the same as those described in claim 1.

9. The organic light-emitting device of claim 1, wherein the compound represented by Formula 2 is represented by Formula 2-1 or Formula 2-2:



1-1



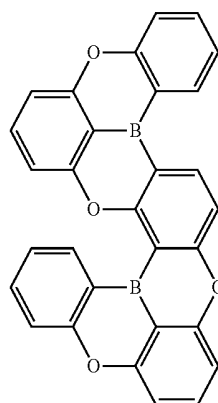
wherein, in Formulae 2-1 and 2-2,

L_{21} , L_{22} , a_{21} , a_{22} , R_{21} , R_{22} , b_{21} , b_{22} , and R_{31} are the same as those described in claim 1,

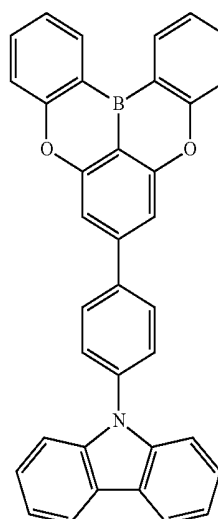
L_{23} , a_{23} , R_{23} , and b_{23} are each independently the same as described in connection with L_{22} , a_{22} , R_{22} , and b_{22} , and

R_{32} to R_{37} are each independently the same as R_{31} in claim 1.

10. The organic light-emitting device of claim 1, wherein the group represented by Formula 1 is selected from Compounds 1-1 to 1-53, and the group represented by Formula 2 is selected from Compounds 2-1 to 2-87:



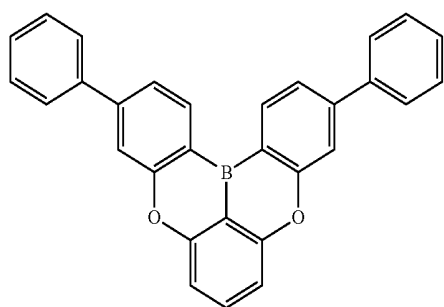
1-3



1-2

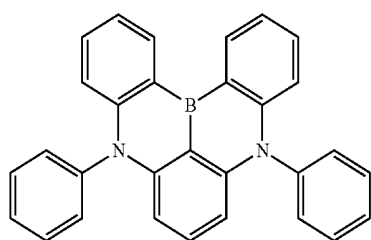
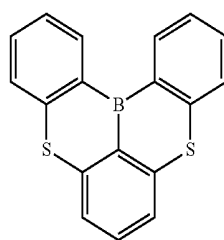
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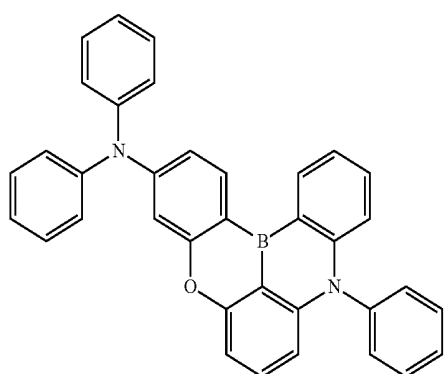
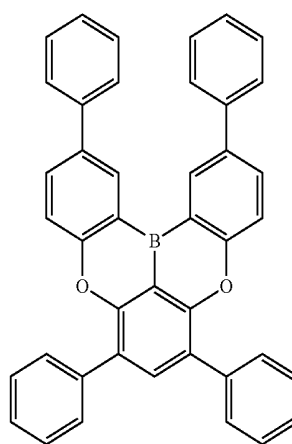
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1-6



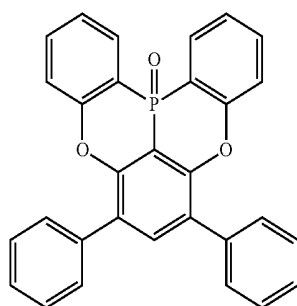
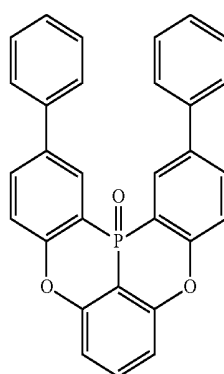
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1-8



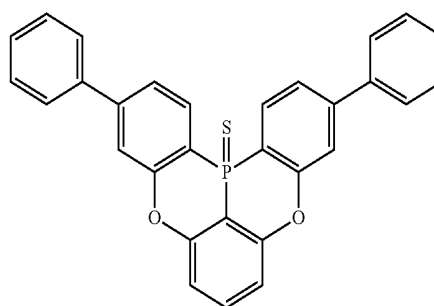
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1-10

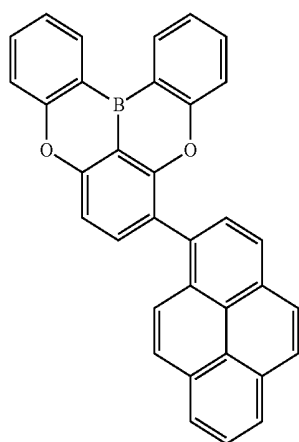


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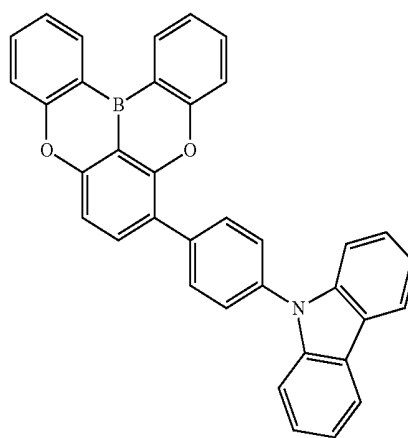
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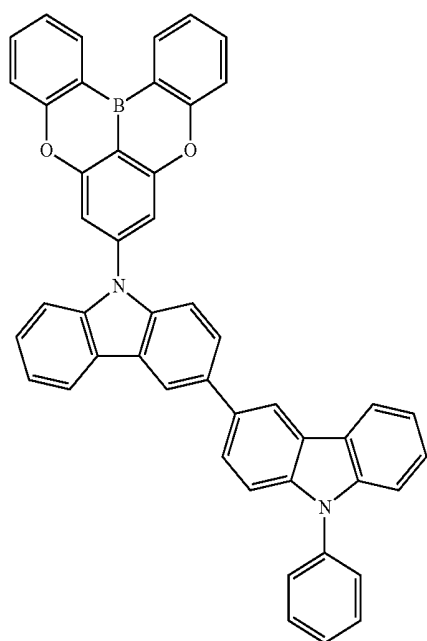
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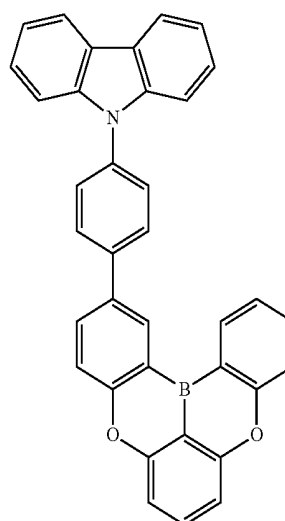
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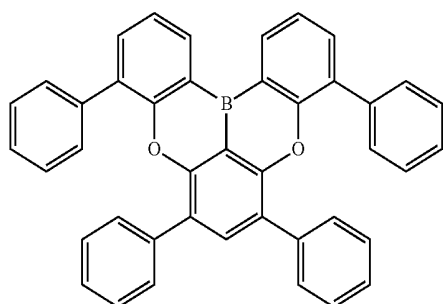
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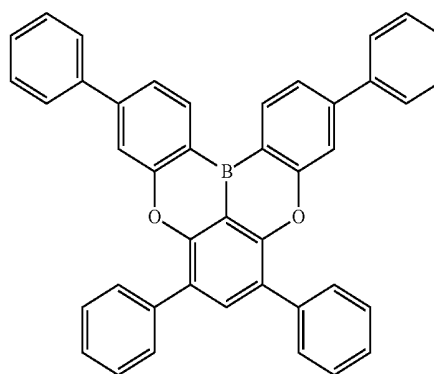
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1-17



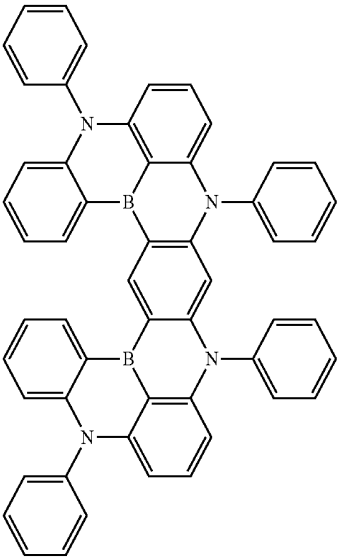
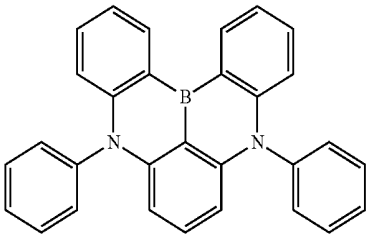
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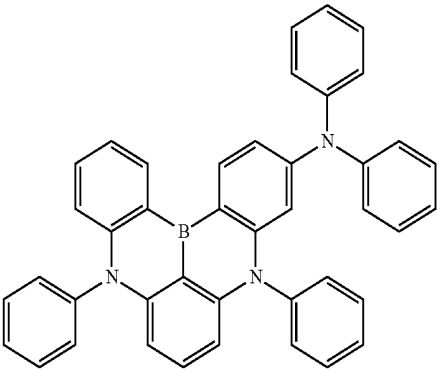
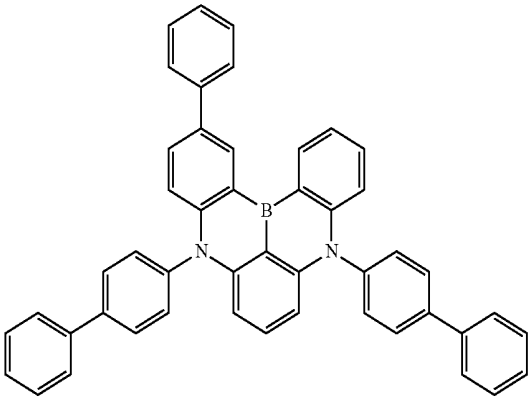
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1-20



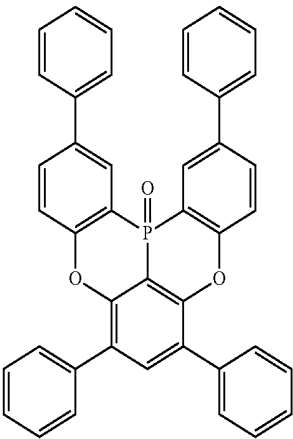
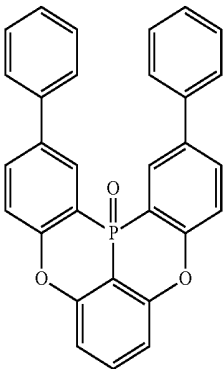
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1-22



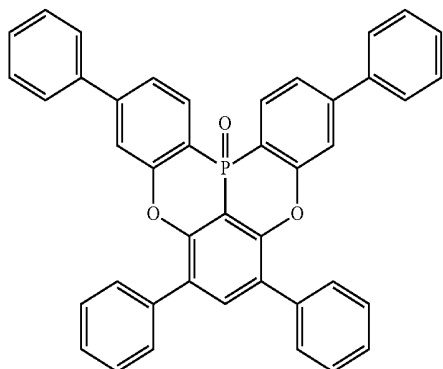
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1-24

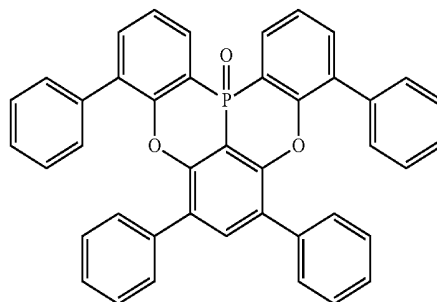


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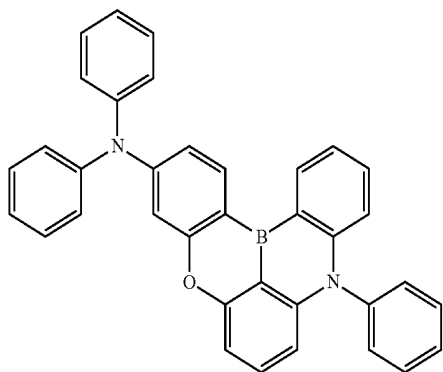
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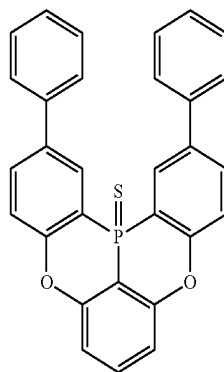
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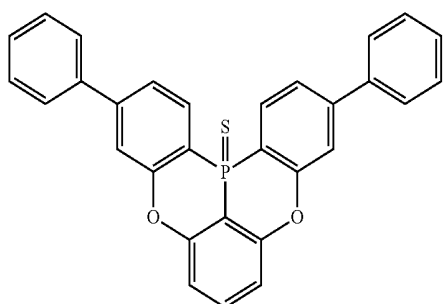
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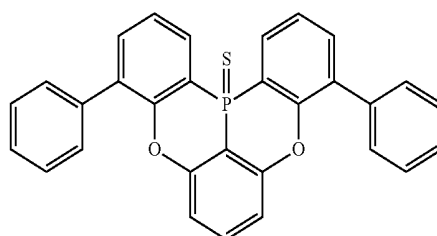
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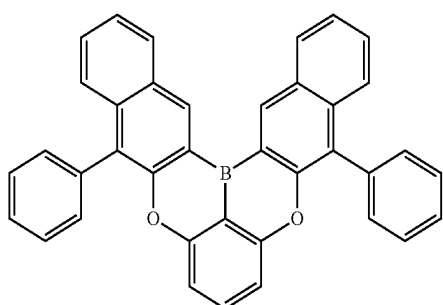
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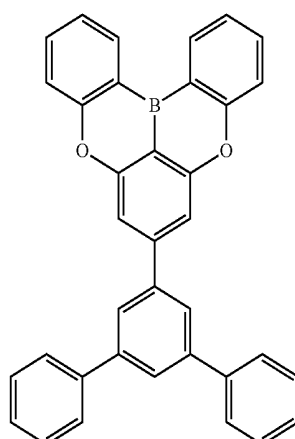
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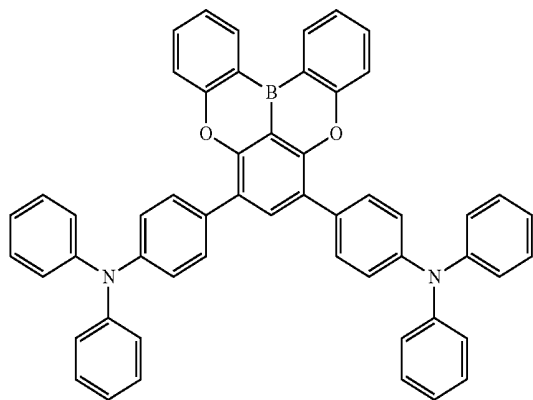
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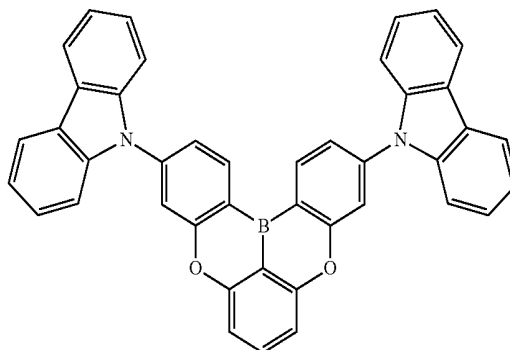
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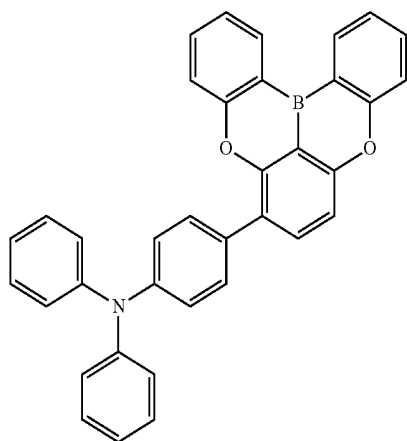
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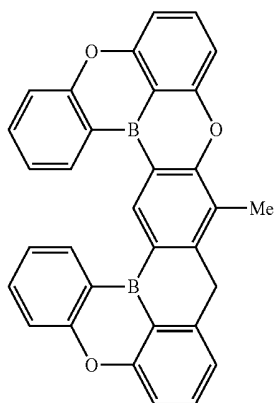
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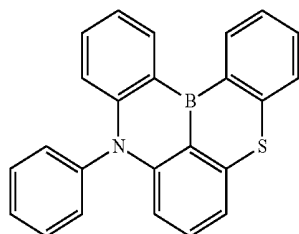
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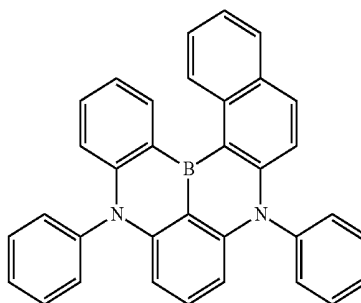
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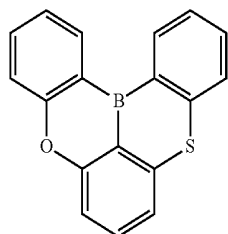
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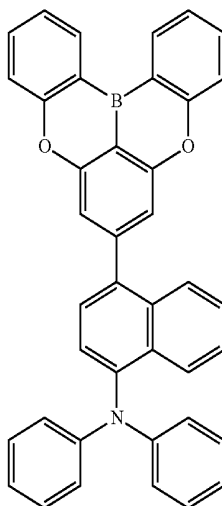
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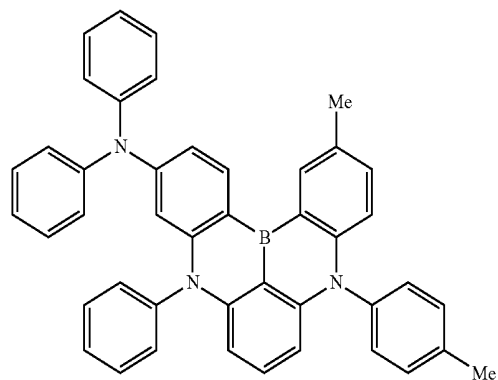


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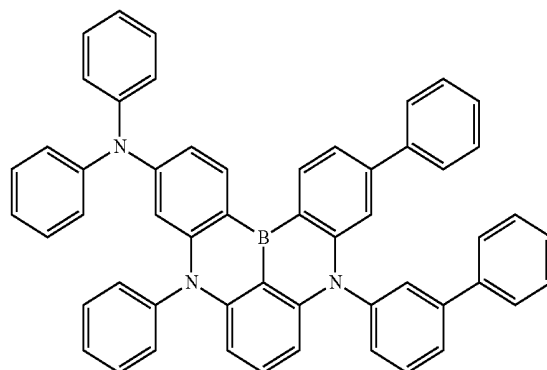


1-40

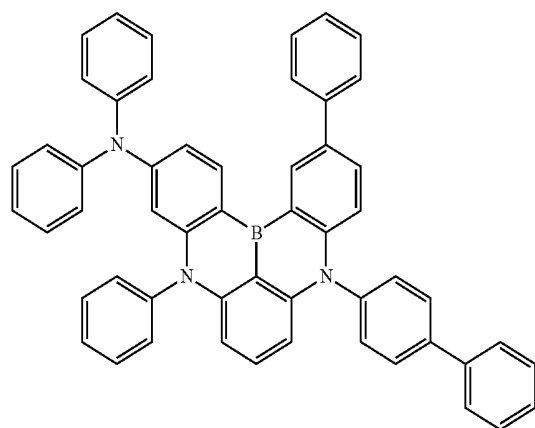


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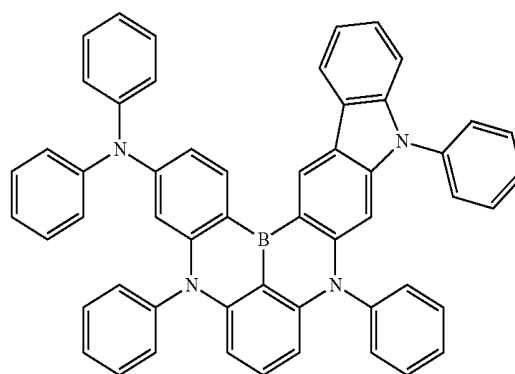
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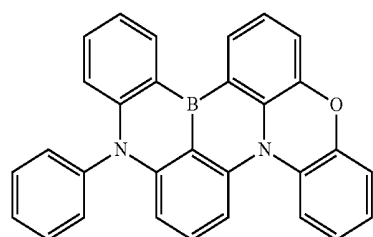
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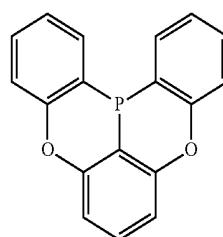
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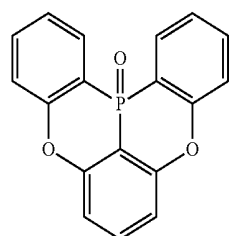
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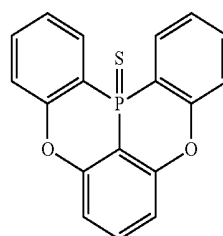
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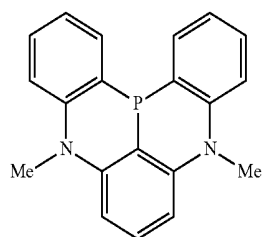
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1-48

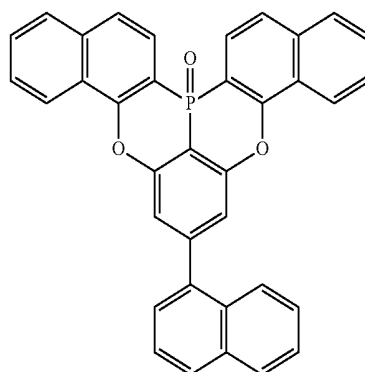


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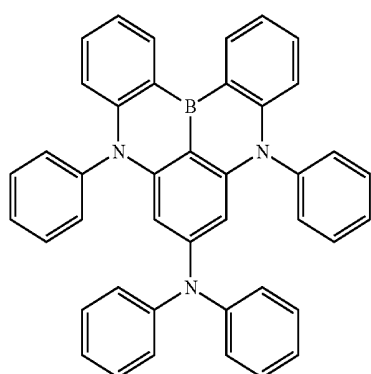
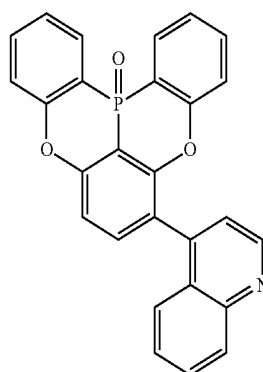
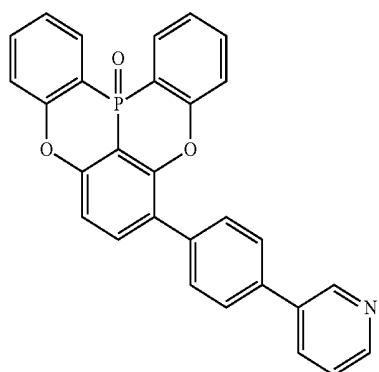
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1-50

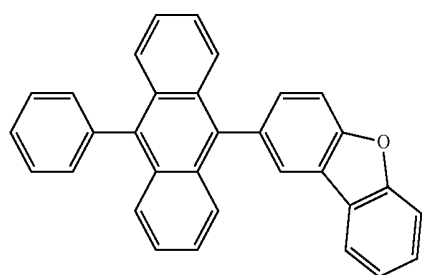


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1-52

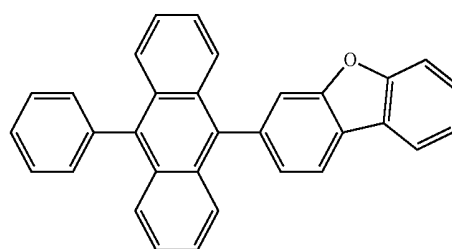


1-53



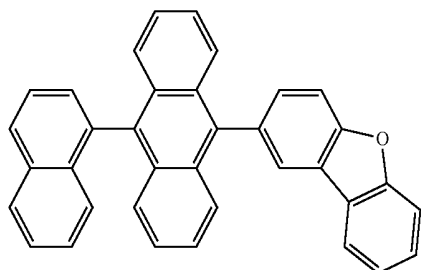
2-1

2-2

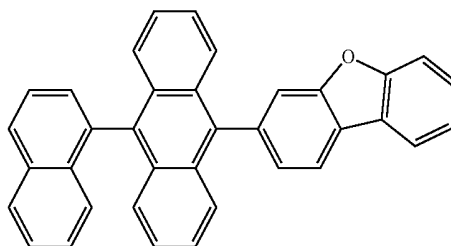


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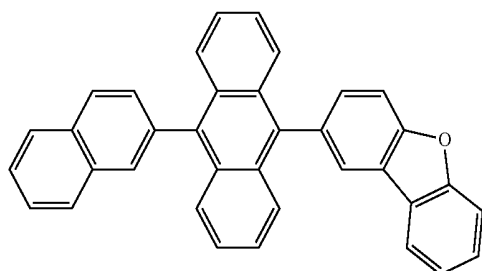
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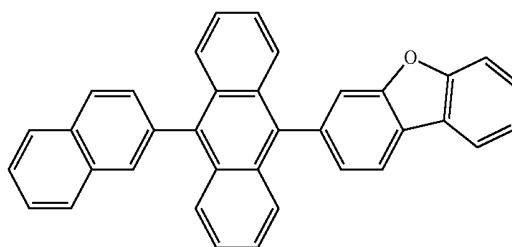
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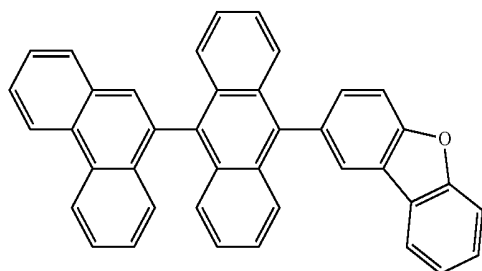
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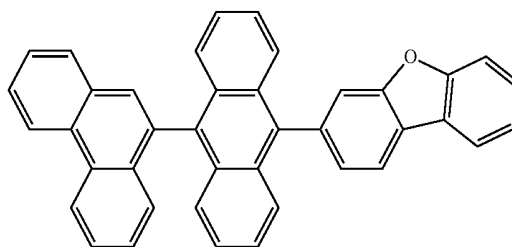
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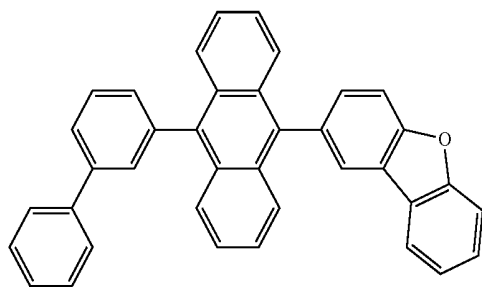
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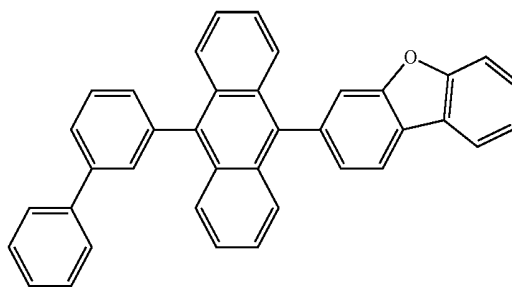
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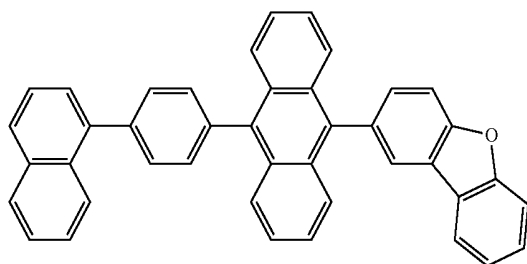
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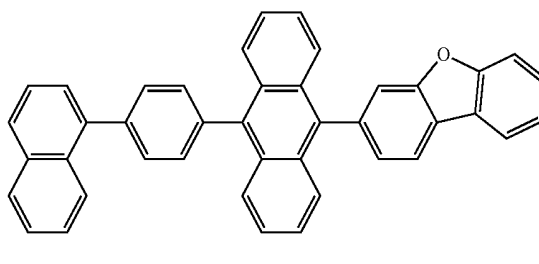
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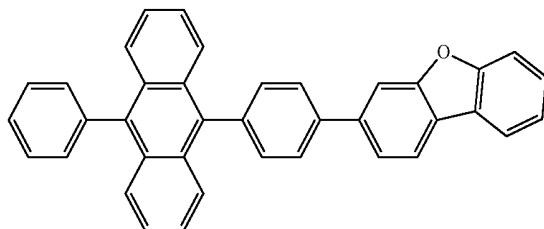
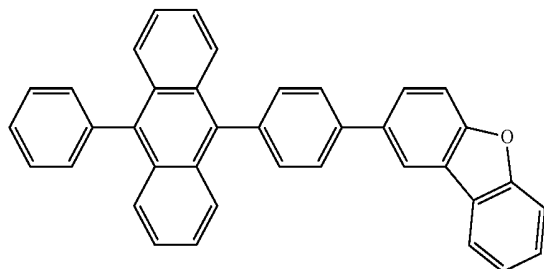
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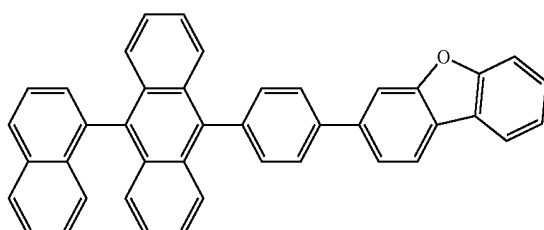
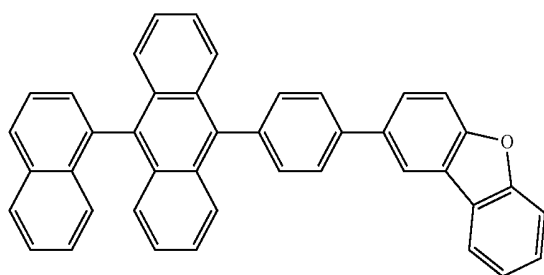
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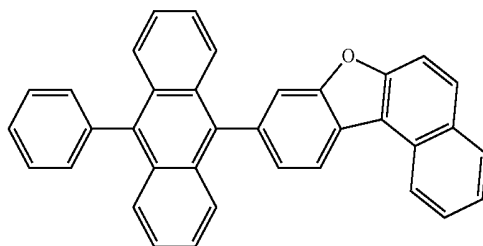
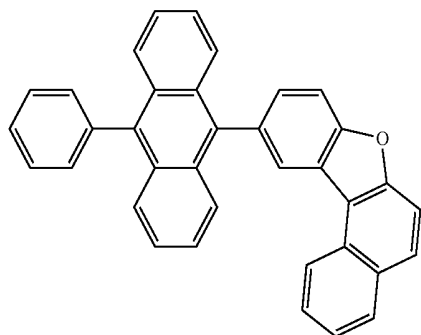
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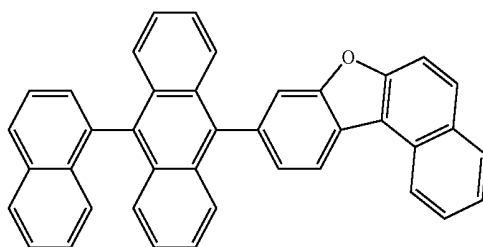
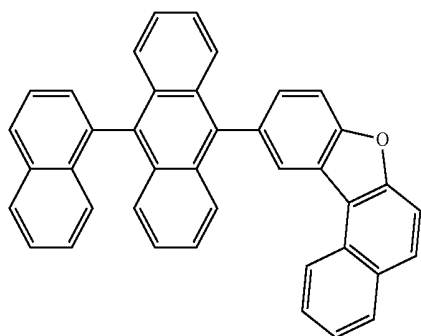
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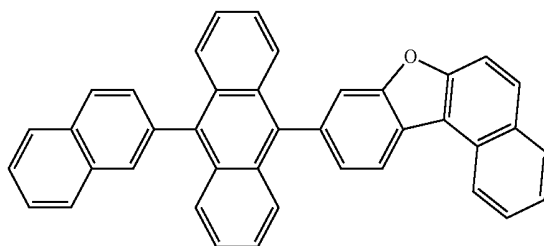
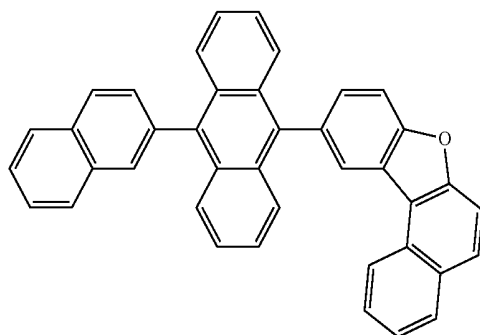
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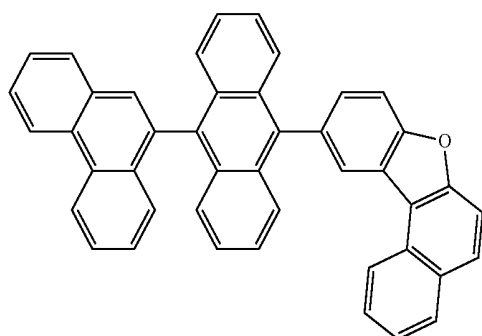
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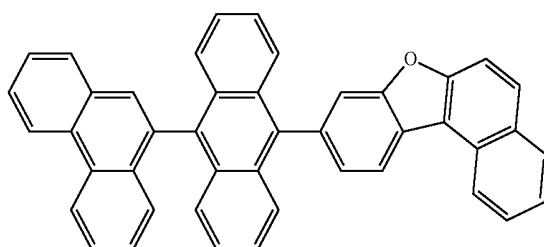
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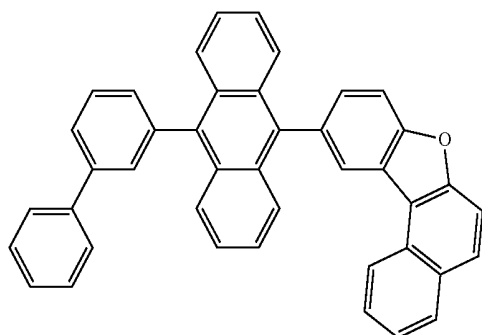


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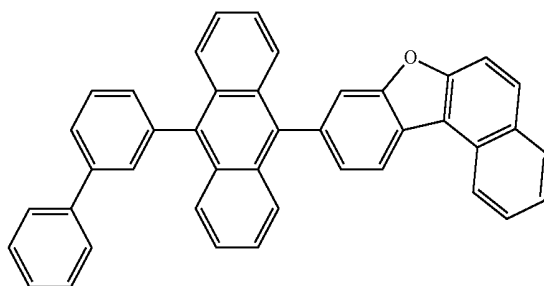
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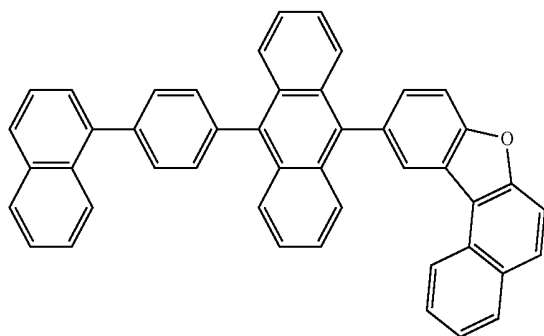
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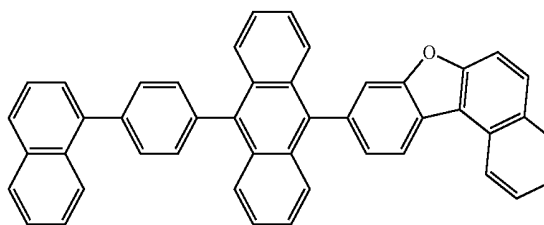
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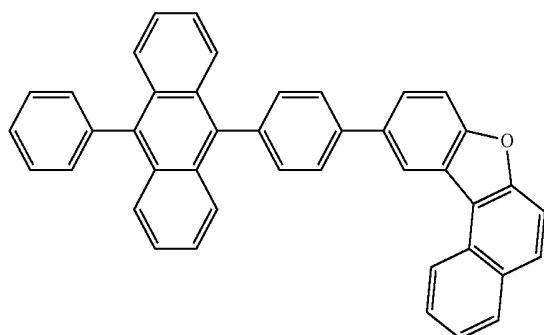
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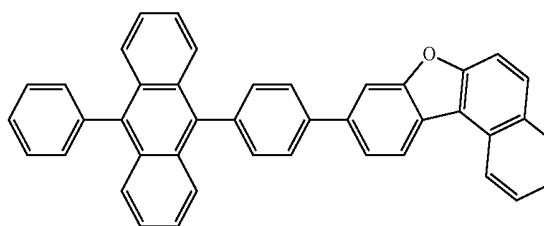
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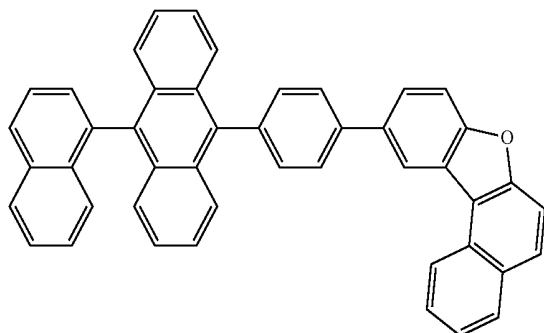


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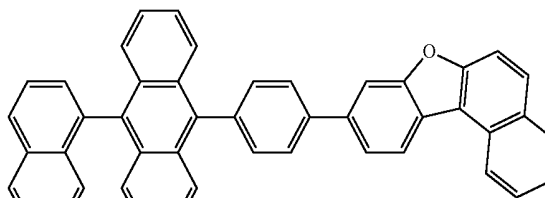


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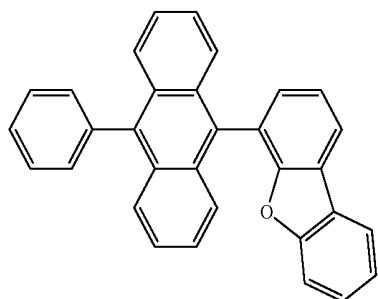
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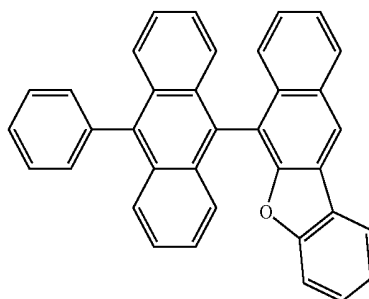
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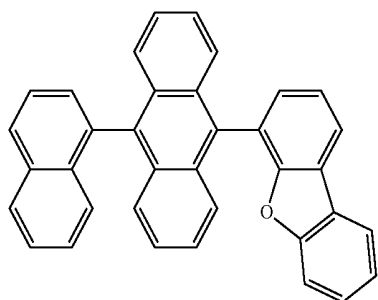
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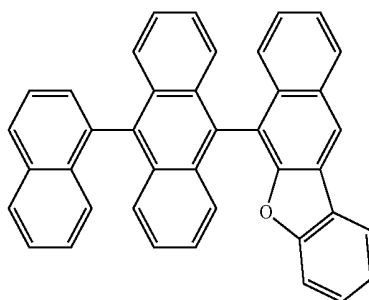
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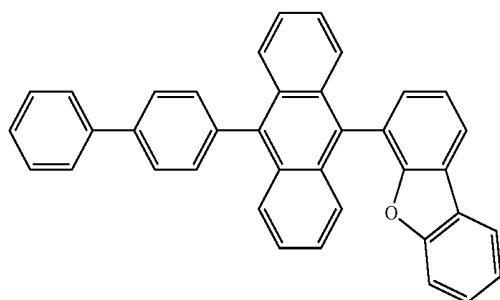
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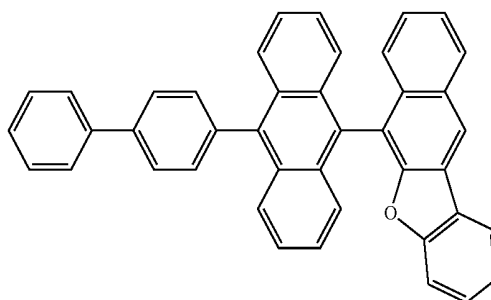
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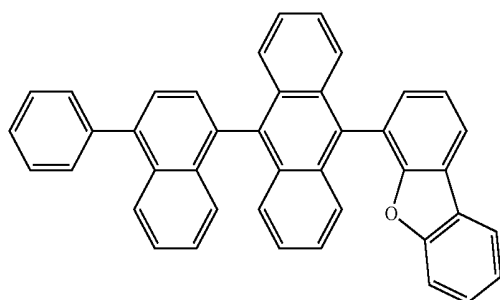
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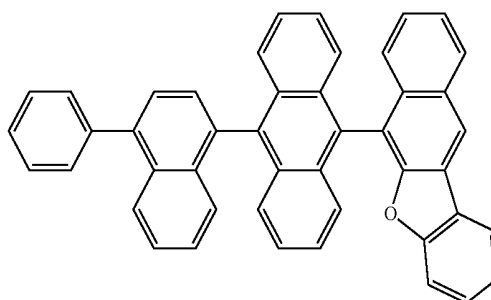
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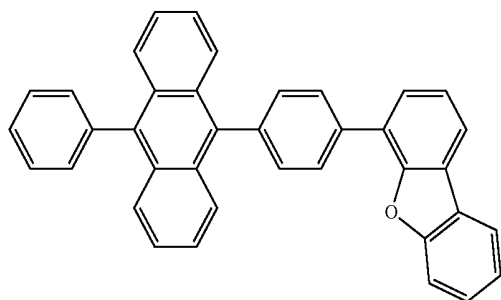


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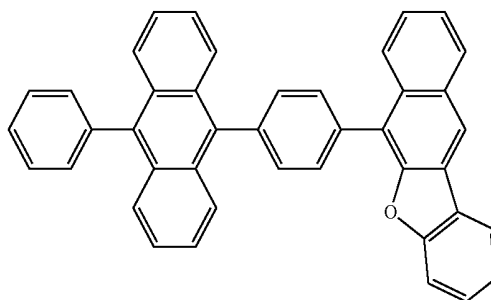


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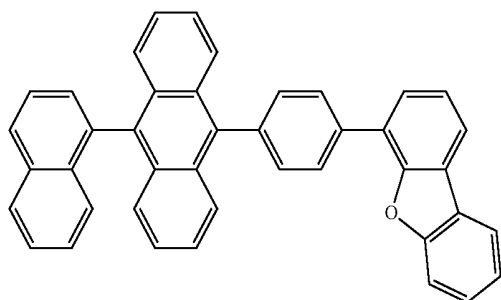
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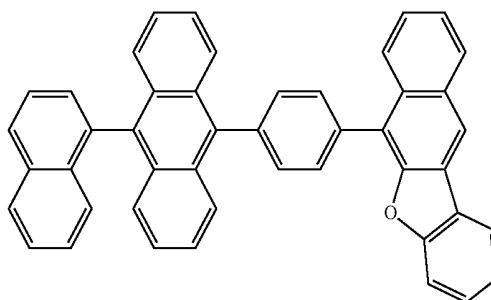
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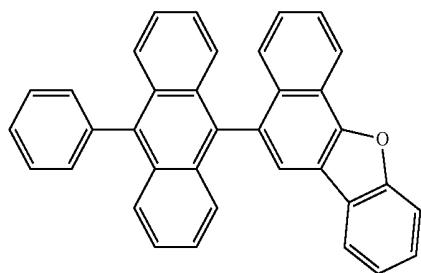
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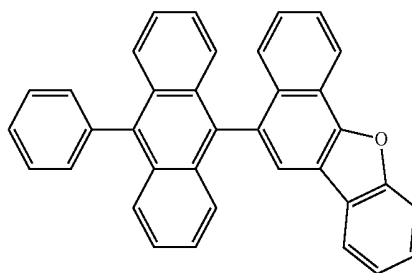
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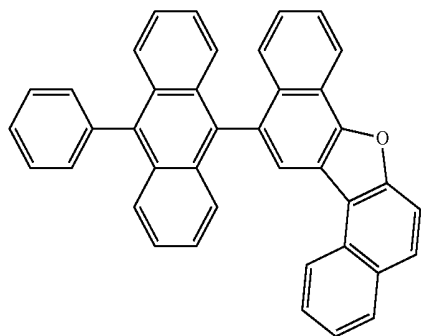
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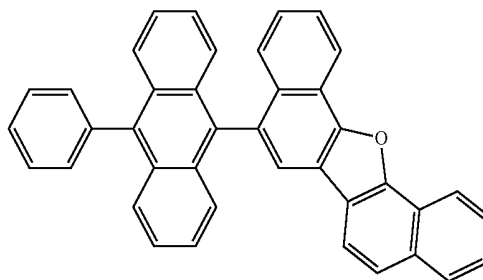
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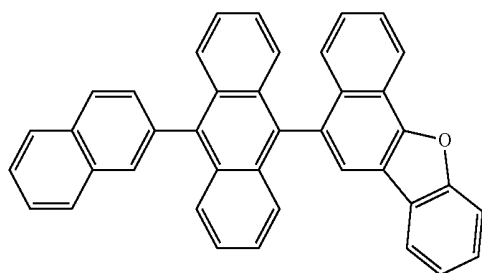
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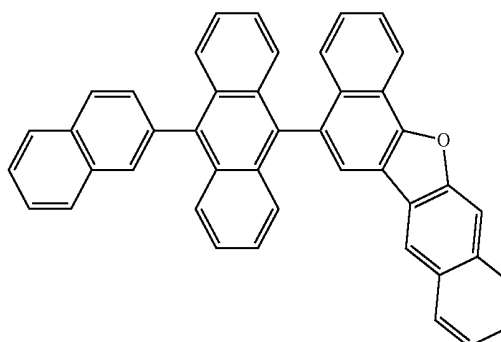
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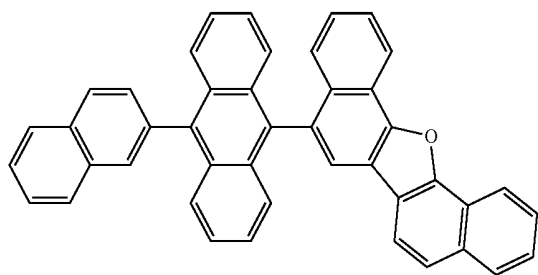


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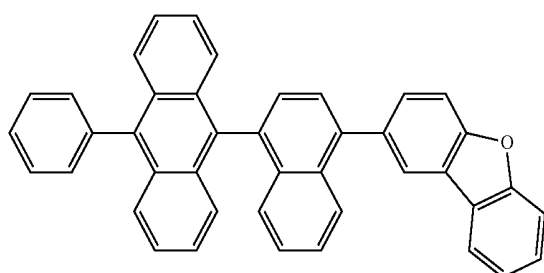


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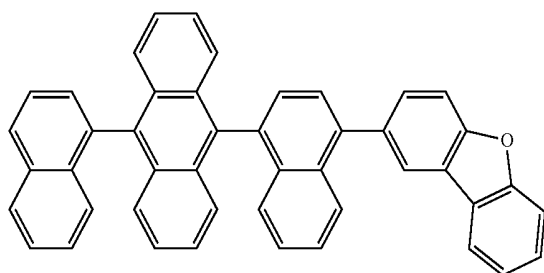
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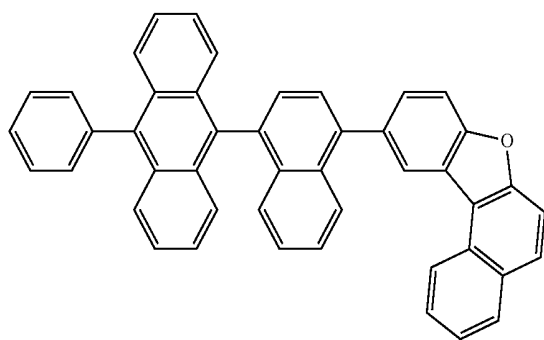
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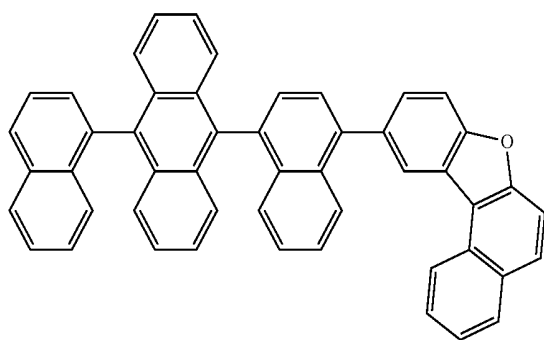
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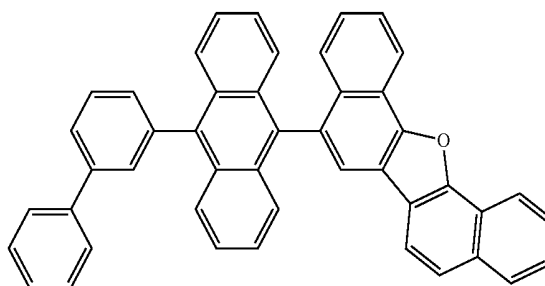
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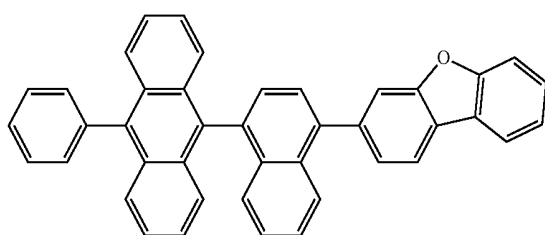
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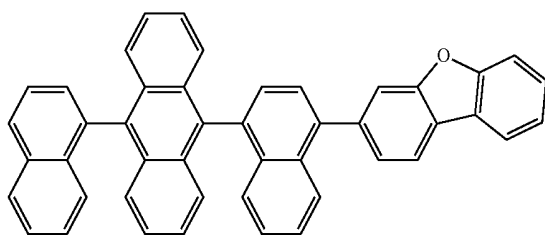
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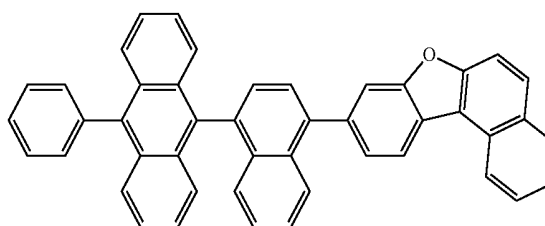
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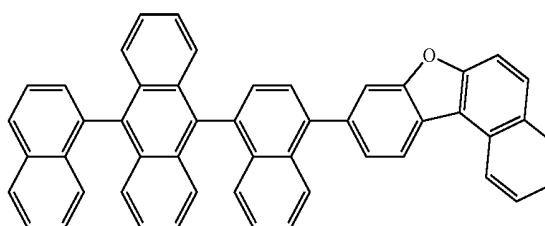
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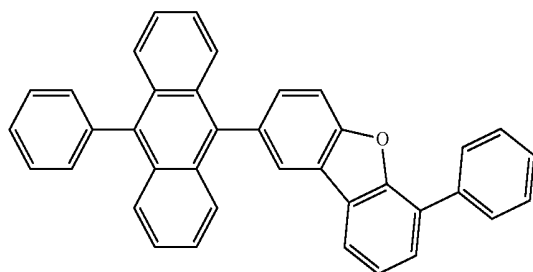
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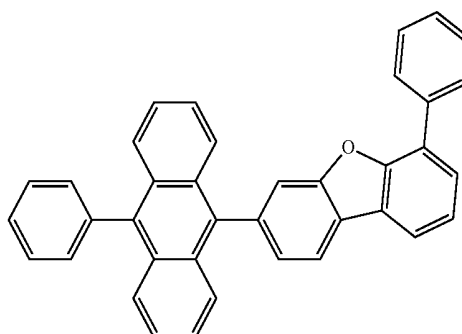
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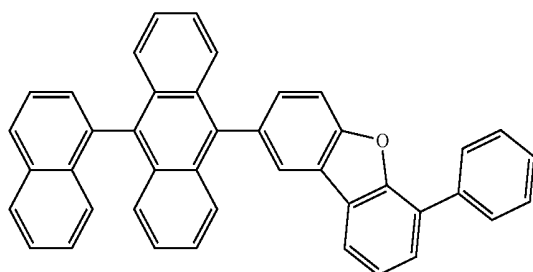
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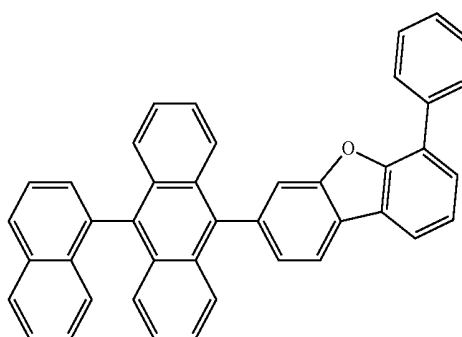
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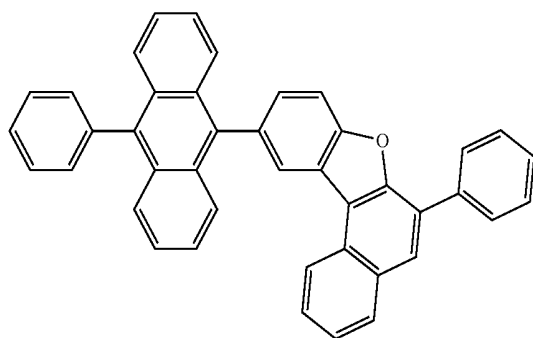
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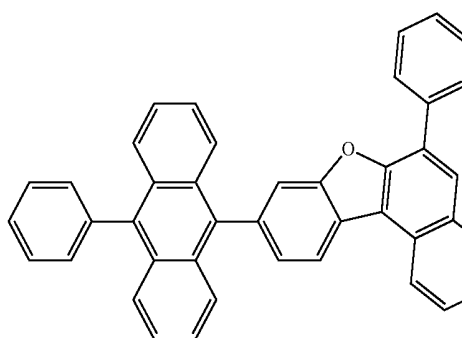
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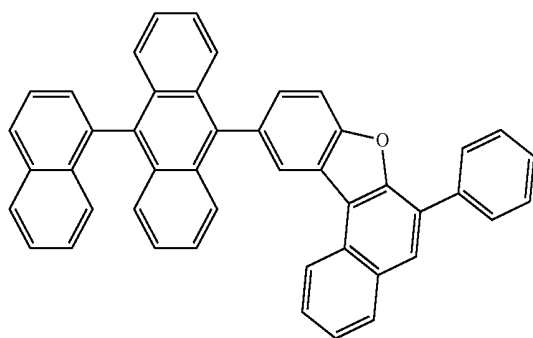
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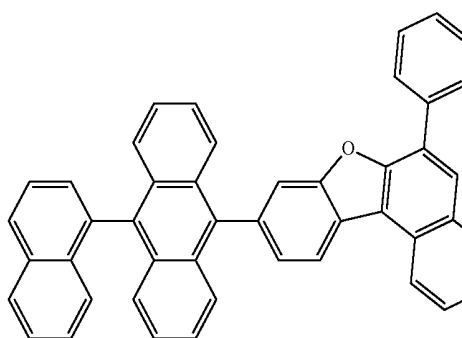
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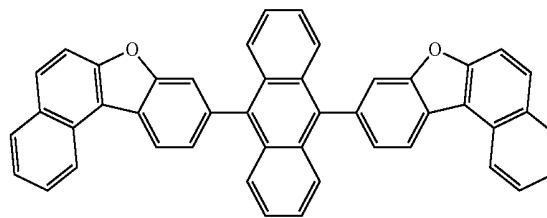
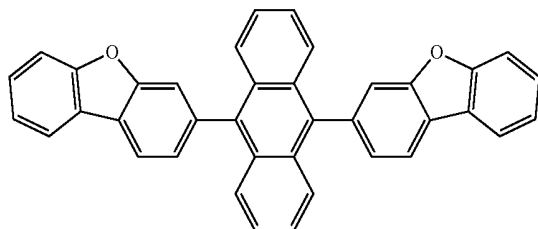
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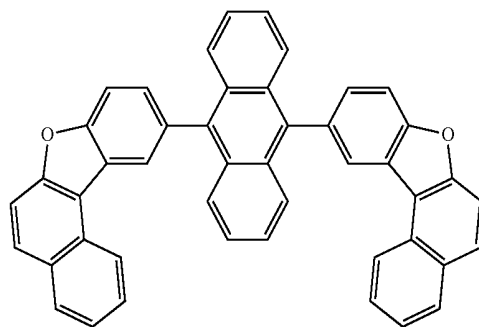
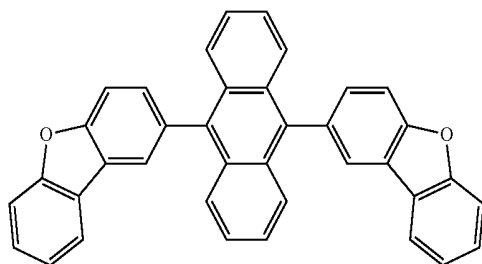
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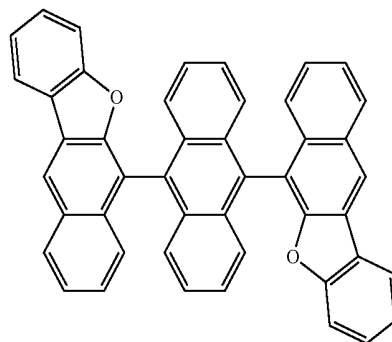
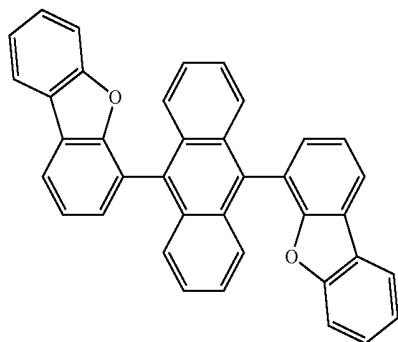
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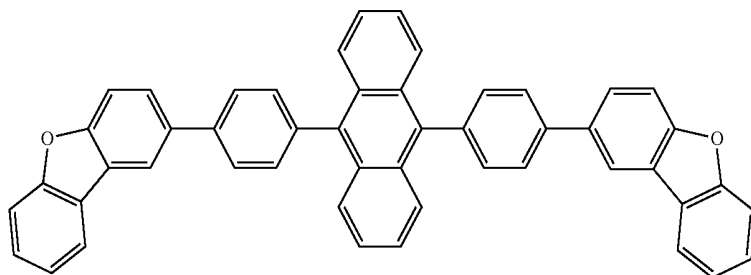


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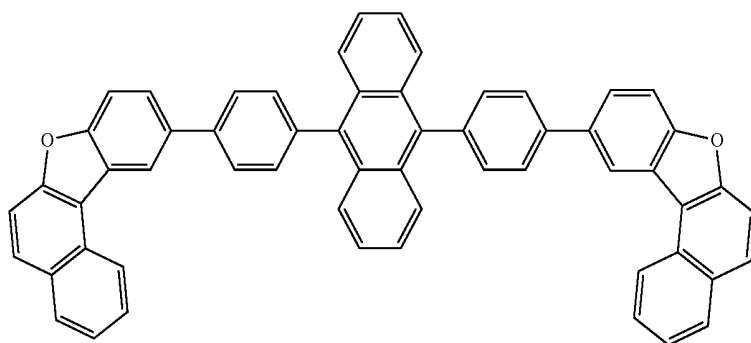
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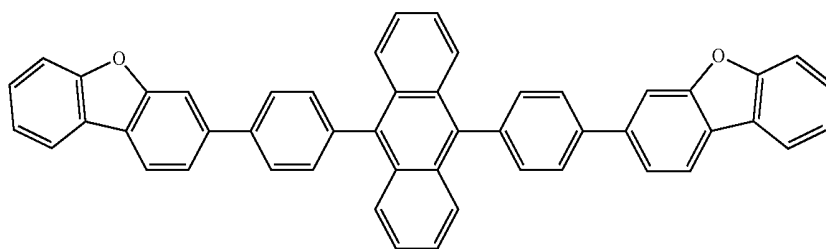


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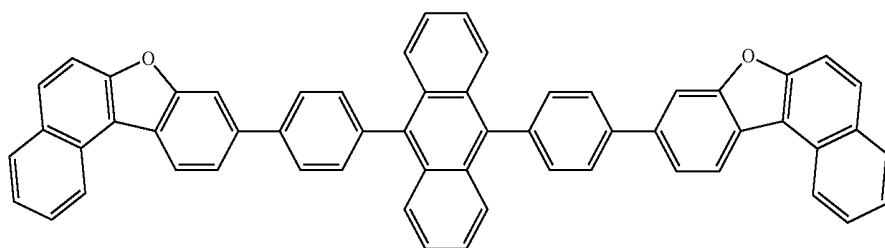


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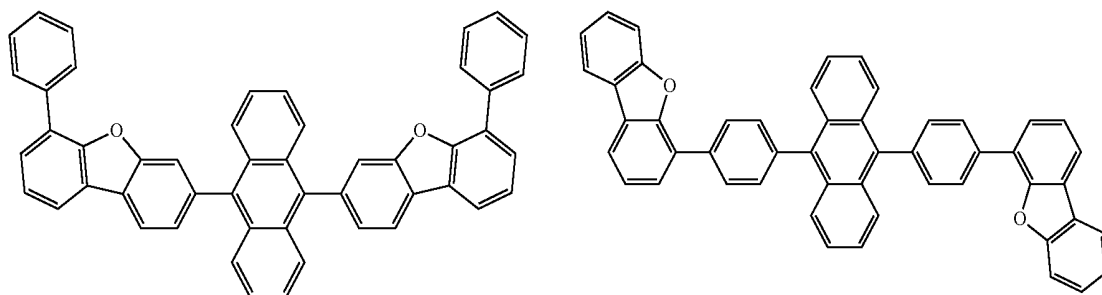


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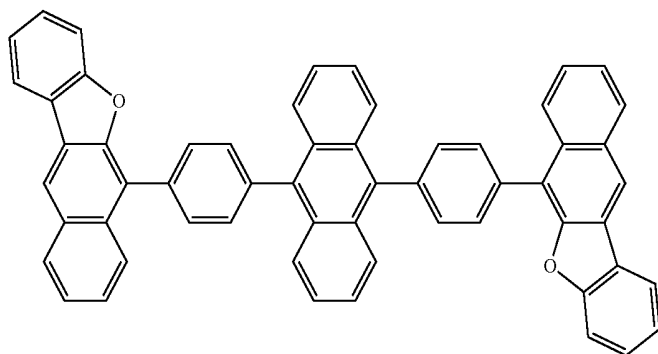


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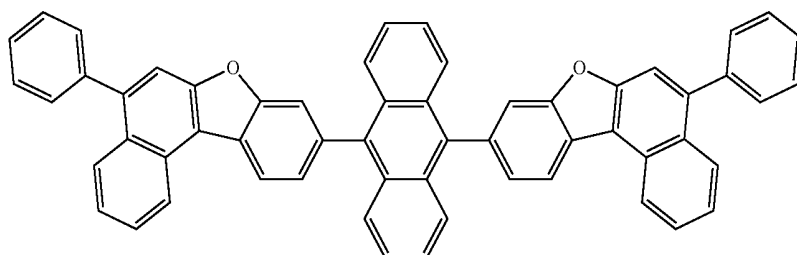
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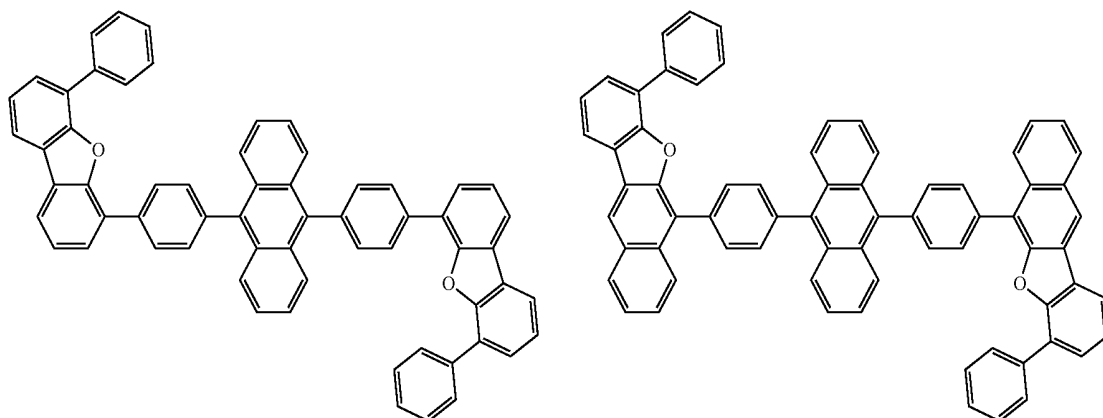


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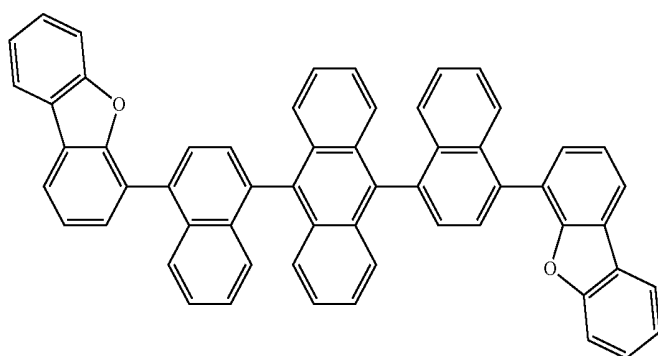


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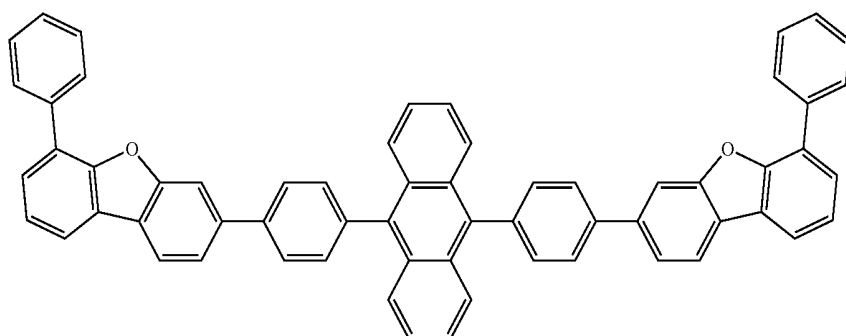
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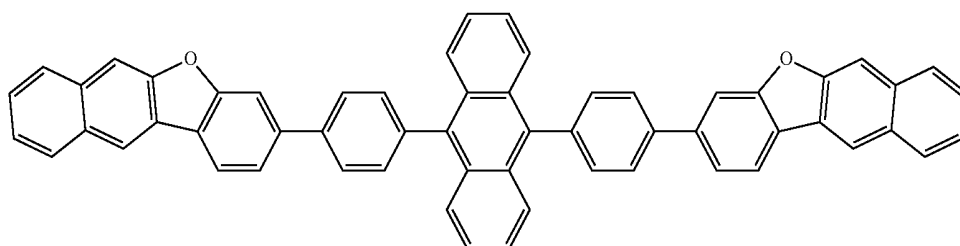
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2-87



11. The organic light-emitting device of claim 1, wherein the emission layer in the organic layer comprises the compound represented by Formula 1 and the compound represented by Formula 2.

12. The organic light-emitting device of claim 11, wherein an amount of the compound represented by Formula 2 in the emission layer is greater than that of the compound represented by Formula 1 in the emission layer.

13. The organic light-emitting device of claim 11, wherein the compound represented by Formula 1 in the emission layer is a thermally activated delayed fluorescence (TADF) emitter, and accordingly, the emission layer emits delayed fluorescence.

14. The organic light-emitting device of claim 1, wherein the emission layer comprises a host and a dopant, wherein the host comprises the compound represented by Formula 2 and the dopant comprises the compound represented by Formula 1.

15. The organic light-emitting device of claim 14, wherein an amount of the dopant is in a range of about 0.01 part to about 30 parts by weight based on 100 parts by weight of the host.

16. The organic light-emitting device of claim 1, wherein a thickness of the emission layer is in a range of about 100 Å to about 1,000 Å.

17. The organic light-emitting device of claim 1, wherein 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.

18. The organic light-emitting device of claim 17, wherein the hole transport region comprises a hole injection layer, a hole transport layer, a buffer layer, an electron blocking layer, or any combination thereof, and

the electron transport region comprises a hole blocking layer, an electron transport layer, an electron injection layer, or any combination thereof.

19. The organic light-emitting device of claim 17, wherein the hole transport region comprises an amine-based compound.

20. The organic light-emitting device of claim 17, wherein the hole transport region further comprises a p-dopant, wherein the p-dopant has a lowest unoccupied molecular orbital (LUMO) energy level of about -3.5 eV or less.

21. The organic light-emitting device of claim 17, wherein the electron transport region comprises a metal-free compound containing at least one π electron-depleted nitrogen-containing ring.

22. A flat display apparatus comprising:

a thin film transistor comprising a source electrode, a drain electrode, and an active layer; and

the organic light-emitting device of claim 1, wherein the first electrode of the organic light-emitting device is electrically coupled to at least one of the source electrode and the drain electrode of the thin film transistor.

* * * * *

专利名称(译)	有机发光装置和包括其的平板显示装置		
公开(公告)号	US20190115538A1	公开(公告)日	2019-04-18
申请号	US16/112302	申请日	2018-08-24
[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	LIM JINO KHO SAMIL YANG SEUNGGA LEE KWANHEE		
发明人	LIM, JINO KHO, SAMIL YANG, SEUNGGA LEE, KWANHEE		
IPC分类号	H01L51/00		
CPC分类号	H01L51/008 H01L51/0071 H01L51/0073 H01L51/0052 H01L51/0058 H01L51/5012 H01L51/5088 H01L51/5064 H01L51/5096 H01L51/5072 H01L51/5092 H01L51/0072		
优先权	1020170134245 2017-10-16 KR		
外部链接	Espacenet USPTO		

摘要(译)

提供一种平板显示装置，包括主体和掺杂剂，每个都具有预定的一组或预定的配方。该有机发光装置包括：第一电极，面对第一电极的第二电极，以及位于第一电极和第二电极之间并包括发光层的有机层，其中有机层包括由式1表示的化合物和由式2表示的化合物。

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220
190
150
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