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

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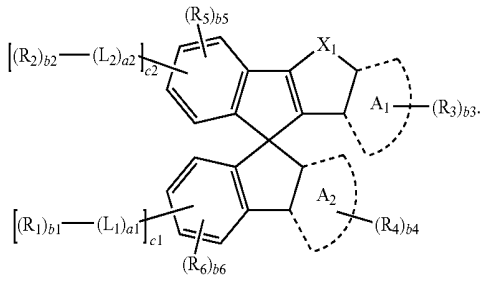
(57) **ABSTRACT**

A condensed cyclic compound and an organic light-emitting device including the same, the condensed cyclic compound being represented by the following Formula 1:

<Formula 1>



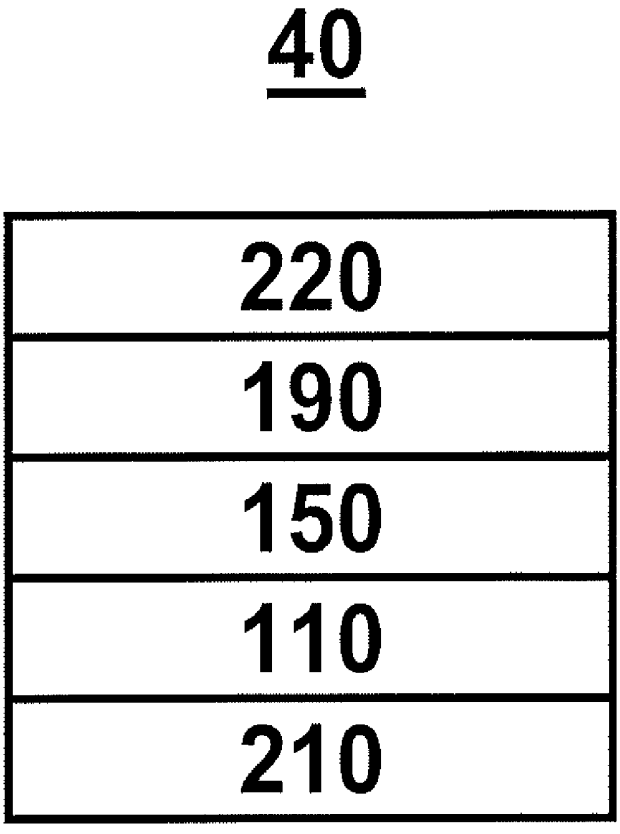


FIG. 1

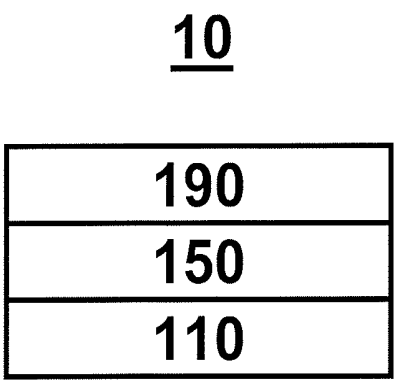


FIG. 2

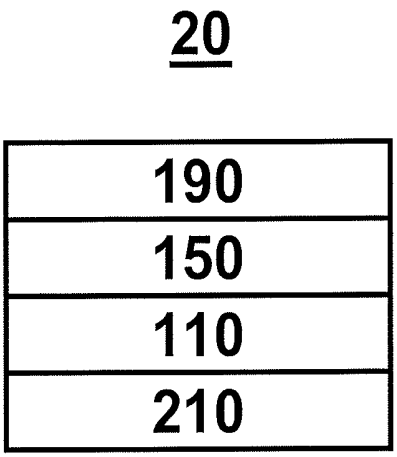


FIG. 3

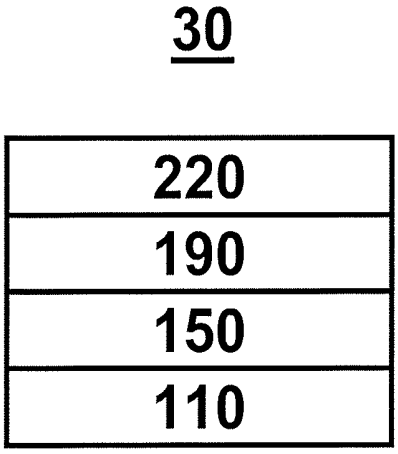
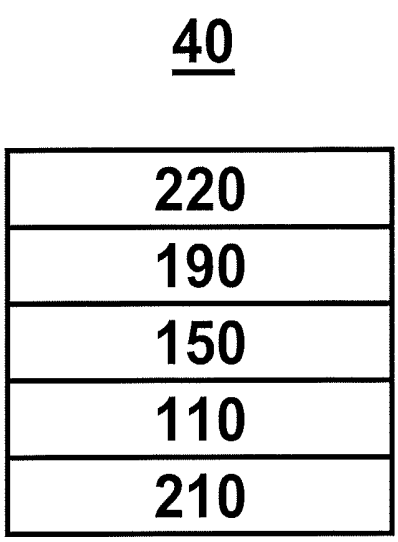


FIG. 4



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

CROSS-REFERENCE TO RELATED APPLICATION

[0001] Korean Patent Application No. 10-2015-0124940, filed on Sep. 3, 2015, in the Korean Intellectual Property Office, and entitled: "Condensed Cyclic Compound and Organic Light-Emitting Device Including the Same," is incorporated by reference herein in its entirety.

BACKGROUND

[0002] 1. Field

[0003] Embodiments relate to a condensed cyclic compound and an organic light-emitting device including the same.

[0004] 2. Description of the Related Art

[0005] Organic light-emitting devices are self-emission devices that have wide viewing angles, high contrast ratios, short response times, and excellent brightness, driving voltage, and response speed characteristics, and produce full-color images.

[0006] The organic light-emitting device may include a first electrode on a substrate, and a hole transport region, an emission layer, an electron transport region, and a second electrode, which are sequentially disposed on the first electrode. Holes provided from the first electrode may move toward the emission layer through the hole transport region, and electrons provided from the second electrode may move toward the emission layer through the electron transport region. Carriers, such as holes and electrons, recombine in the emission layer to produce excitons. These excitons change from an excited state to a ground state, thereby generating light.

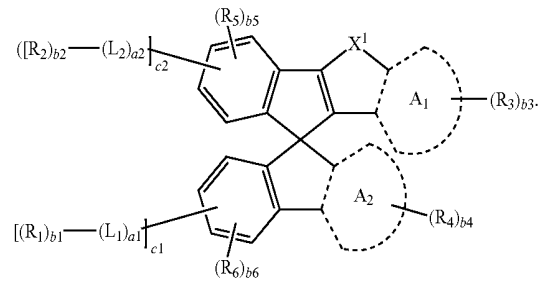
SUMMARY

[0007] Embodiments are directed to a condensed cyclic compound and an organic light-emitting device including the same.

[0008] Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

[0009] According to one or more exemplary embodiments, a condensed cyclic compound is represented by Formula 1:

<Formula 1>



[0010] In Formula 1,

[0011] ring A_1 and ring A_2 may be each independently selected from a benzene, a naphthalene, a pyridine, a pyrimidine, a pyrazine, a quinoline, an isoquinoline, a quinoxaline, a quinazoline, and a cinnoline,

[0012] X_1 may be N-$[(L_{11})_{a11}$-$(R_{11})_{b11}]$, O, or S,

[0013] L_1, L_2, and L_{11} may be each independently selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

[0014] a1 and a2 may be each independently an integer of 1 to 5, a11 may be selected from integers of 0 to 5, when a1 is 2 or more, two or more L_1(s) may be identical to or different from each other, when a2 is 2 or more, two or more L_2(s) may be identical to or different from each other, when a11 is 2 or more, two or more L_{11}(s) may be identical to or different from each other,

[0015] R_1 to R_6, and R_{11} may be each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, and —$B(Q_6)(Q_7)$,

[0016] b1, b2, b5, b6, and b11 may be each independently an integer of 0 to 4,

[0017] b3 and b4 may be each independently an integer of 0 to 6,

[0018] c1 and c2 may be each independently an integer of 0 to 4, and

[0019] at least one of substituents of the substituted C_3-C_{10} cycloalkylene group, substituted C_1-C_{10} heterocycloalkylene group, substituted C_3-C_{10} cycloalkenylene group, substituted C_1-C_{10} heterocycloalkenylene group, substituted C_6-C_{60} arylene group, substituted C_1-C_{60} heteroarylene group, substituted divalent non-aromatic condensed polycyclic group, substituted divalent non-aromatic condensed heteropolycyclic group, substituted C_1-C_{60} alkyl group, substituted C_2-C_{60} alkenyl group, substituted C_2-C_{60} alkynyl group, substituted C_1-C_{60} alkoxy group, substituted C_3-C_{10} cycloalkyl group, substituted C_1-C_{10} heterocycloalkyl group, substituted C_3-C_{10} cycloalkenyl group, substituted C_1-C_{10} heterocycloalkenyl group, substituted

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

[0020] deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an 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_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;

[0021] a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an 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_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, $—N(Q_{11})(Q_{12})$, $—Si(Q_{13})(Q_{14})(Q_{15})$, and $—B(Q_{16})(Q_{17})$;

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

[0023] a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an 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_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—N(Q_{21})(Q_{22})$, $—Si(Q_{23})(Q_{24})(Q_{25})$, and $—B(Q_{26})(Q_{27})$; and

[0024] $—N(Q_{31})(Q_{32})$, $—Si(Q_{33})(Q_{34})(Q_{35})$, and $—B(Q_{36})(Q_{37})$,

[0025] wherein Q_1 to Q_7, Q_{11} to Q_{17}, Q_{21} to Q_{27}, and Q_{31} to Q_{37} may be each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0026] According to one or more exemplary embodiments, an 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, wherein the organic layer includes at least one condensed cyclic compound as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] Features will be apparent to those of skill in the art by describing in detail exemplary embodiments with reference to the attached drawings in which:

[0028] FIGS. **1** to **4** each schematically illustrate the structure of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

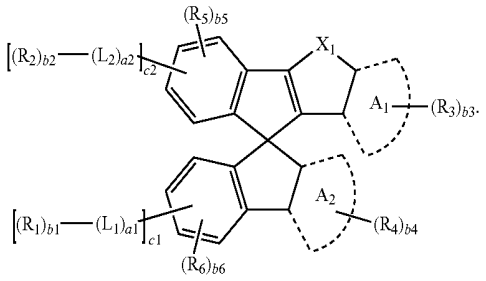
[0029] Example embodiments will now be described more fully hereinafter with reference to the accompanying drawings; however, they may be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey exemplary implementations to those skilled in the art.

[0030] In the drawing figures, the dimensions of layers and regions may be exaggerated for clarity of illustration. It will also be understood that when a layer or element is referred to as being "on" another layer or substrate, it can be directly on the other layer or substrate, or intervening layers may also be present. Further, it will be understood that when a layer is referred to as being "under" another layer, it can be directly under, and one or more intervening layers may also be present. In addition, it will also be understood that when a layer is referred to as being "between" two layers, it can be the only layer between the two layers, or one or more intervening layers may also be present. Like reference numerals refer to like elements throughout.

[0031] Reference will now be made in detail to exemplary embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present exemplary embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the exemplary embodiments are merely described below, by referring to the figures, to explain aspects of the present description. 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.

[0032] A condensed cyclic compound may be represented by Formula 1:

<Formula 1>



[0033] Each of ring A_1 and ring A_2 in Formula 1 may be fused to a neighboring five-membered ring while sharing carbons. Ring A_1 and ring A_2 in Formula 1 may each independently be selected from a benzene, a naphthalene, a pyridine, a pyrimidine, a pyrazine, a quinoline, an isoquinoline, a quinoxaline, a quinazoline, and a cinnoline.

[0034] For example, rings A_1 and A_2 in Formula 1 may each independently be selected from a benzene, a naphthalene, a pyridine, a quinoline, and an isoquinoline.

[0035] In some embodiments, in Formula 1, the A_1 ring may be a benzene, and A_2 ring may be a benzene, a naphthalene, or a pyridine; or A_1 ring may be a naphthalene, and A_2 ring may be a benzene or a pyridine.

[0036] X_1 in Formula 1 may be N-[$(L_{11})_{a11}$-$(R_{11})_{b11}$], O, or S. L_{11}, a11, R_{11}, and b11 may be understood by referring to descriptions thereof given below.

[0037] In some embodiments, X_1 in Formula 1 may be O or S.

[0038] L_1, L_2, and L_{11} in Formula 1 may each independently be selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group.

[0039] For example, L_1, L_2, and L_{11} in Formula 1 may each independently be selected from

[0040] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene 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 benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group, and an imidazopyrimidinylene group; and

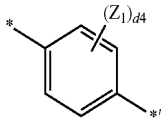
[0041] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene 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 benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group, and an imidazopyrimidinylene 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 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, 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 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 benzoimidazolyl 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, an imidazopyridinyl group, an imidazopyrimidinyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$,

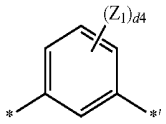
[0042] wherein Q_{33} to Q_{35} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0043] In some embodiments, L_1, L_2, and L_{11} in Formula 1 may each independently be a group represented by one of the following Formulae 3-1 to Formula 3-41.

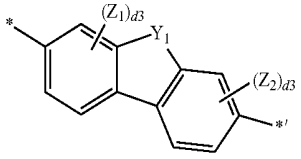
Formula 3-1



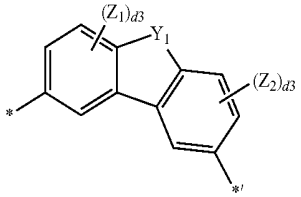
Formula 3-2



Formula 3-3



Formula 3-4



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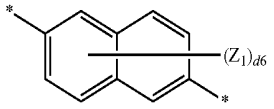

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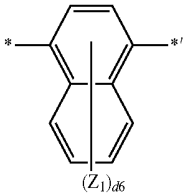

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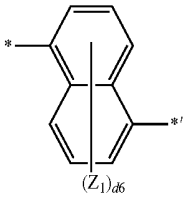

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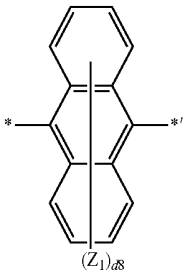

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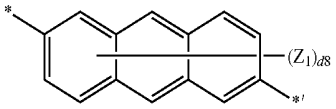

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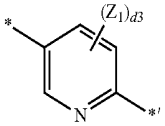

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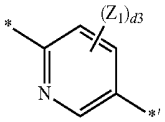

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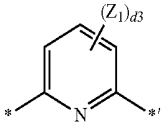

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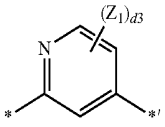

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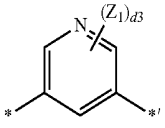

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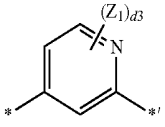

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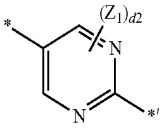

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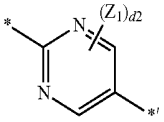

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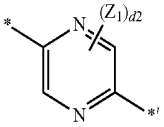

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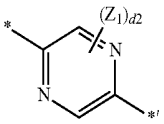
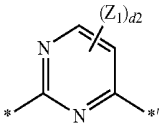


Formula 3-20



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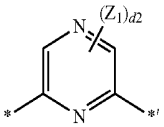

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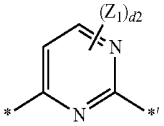

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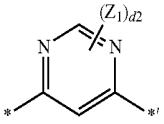

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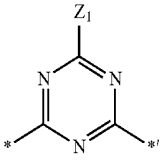

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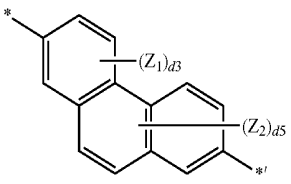

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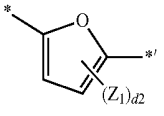

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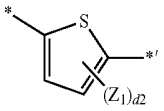

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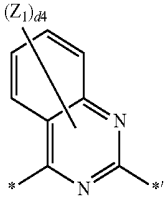

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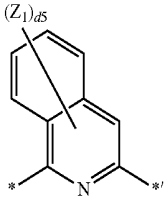

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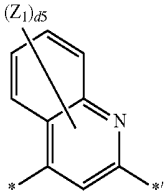

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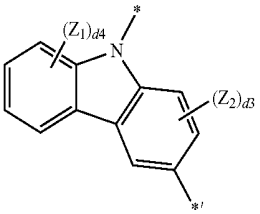

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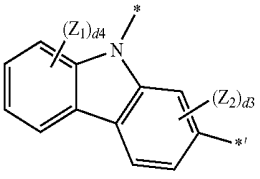

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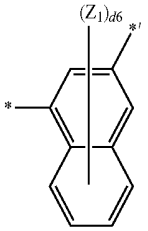
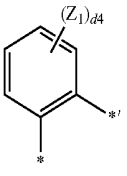


Formula 3-34



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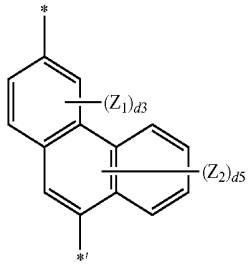
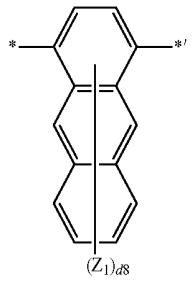
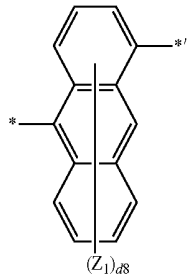
Formula 3-35



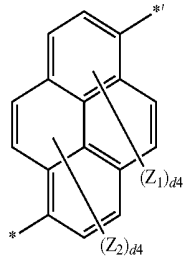
Formula 3-36



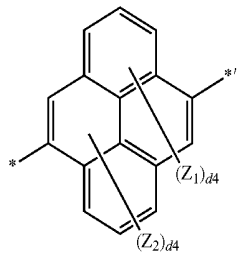
Formula 3-37



Formula 3-38



Formula 3-39



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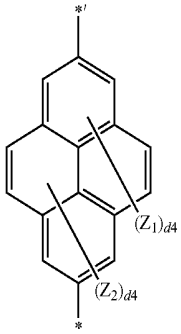
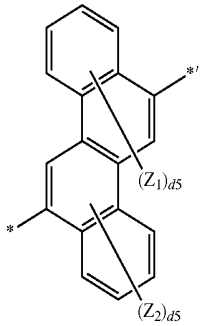
Formula 3-40



Formula 3-41



[0044] In Formulae 3-1 to 3-41,

[0045] Y_1 is O, S, $C(Z_3)(Z_4)$, $N(Z_5)$, or $Si(Z_6)(Z_7)$,

[0046] Z_1 to Z_7 may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an 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 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 pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and $—Si(Q_{33})(Q_{34})(Q_{35})$,

[0047] wherein Q_{33} to Q_{35} may be each independently selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

[0048] d2 is 1 or 2,

[0049] d3 is an integer of 1 to 3,

[0050] d4 is an integer of 1 to 4,

[0051] d5 is an integer of 1 to 5,

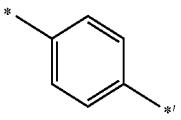
[0052] d6 is an integer of 1 to 6,

[0053] d8 is an integer of 1 to 8,

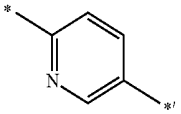
[0054] * and *' each indicate a binding site to a neighboring atom.

[0055] In some embodiments, L_1, L_2, and L_{11} in Formula 1 may each independently be a group represented by one of the following Formulae 4-1 to 4-35.

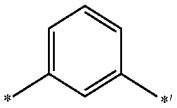
Formula 4-1



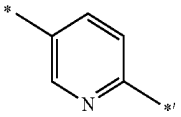
Formula 4-2



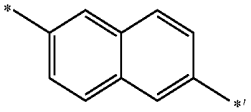
Formula 4-3



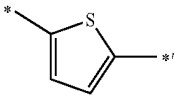
Formula 4-4



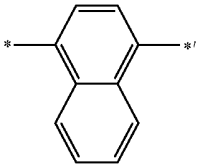
Formula 4-5



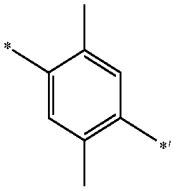
Formula 4-6



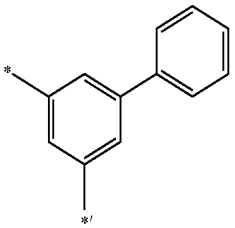
Formula 4-7



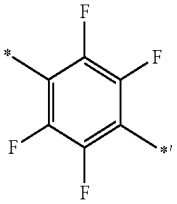
Formula 4-8



Formula 4-9



Formula 4-10



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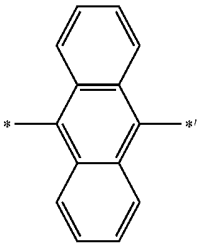
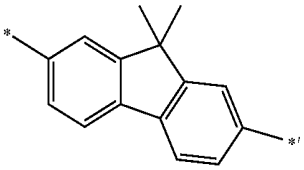
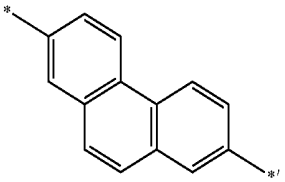
Formula 4-11



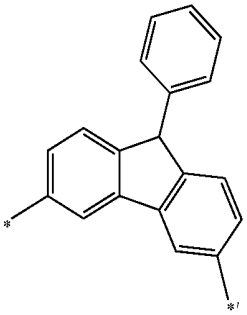
Formula 4-12



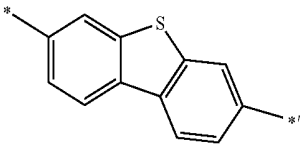
Formula 4-13



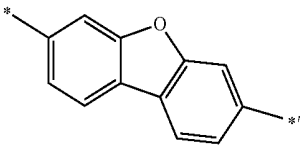
Formula 4-14



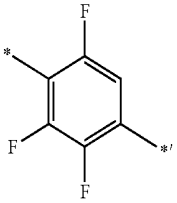
Formula 4-15



Formula 4-16



Formula 4-17



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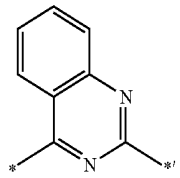
Formula 4-18



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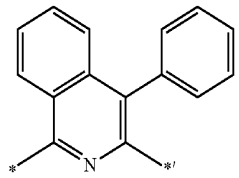
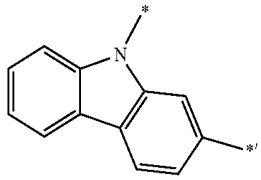


Formula 4-20



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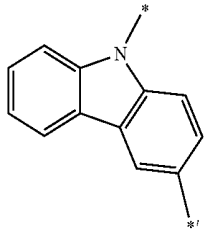

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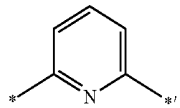

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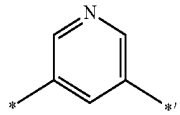
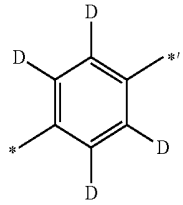


Formula 4-24



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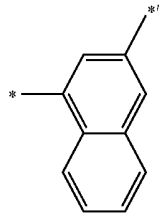

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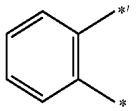
Formula 4-26



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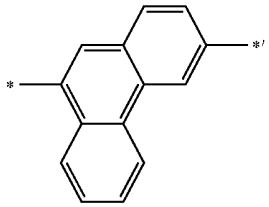

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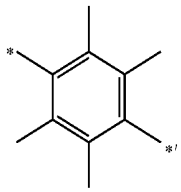

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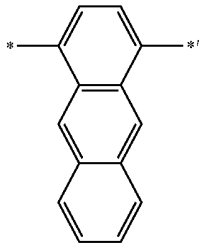

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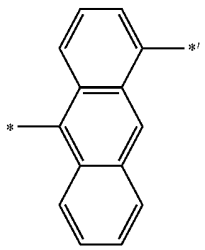
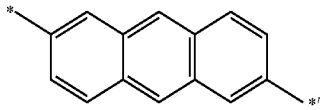
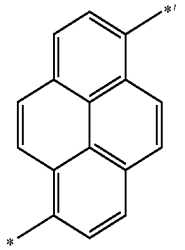


Formula 4-31



Formula 4-32



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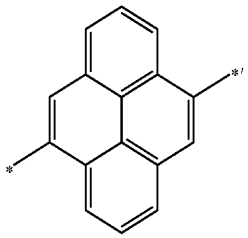
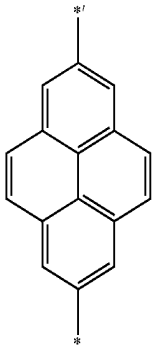
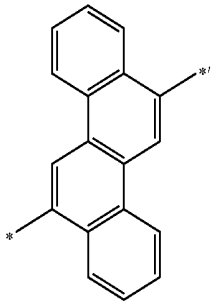
Formula 4-33



Formula 4-34



Formula 4-35



[0056] * and *' in Formulae 4-1 and 4-35 each indicate a binding site to a neighboring atom.

[0057] In some embodiments, L_1 and L_2 in Formula 1 may each independently be selected from or include substituted or unsubstituted condensed polycyclic groups having 3 or more carbocyclic groups condensed to each other.

[0058] In an implementation, at least one substituent of the substituted condensed polycyclic groups having 3 or more carbocyclic groups condensed to each other may be selected from:

[0059] 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_{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;

[0060] 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 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_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, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$B(Q_{16})(Q_{17})$;

[0061] 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;

[0062] 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 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_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_{21})(Q_{22})$, —$Si(Q_{23})(Q_{24})(Q_{25})$, and —$B(Q_{26})(Q_{27})$; and

[0063] —$N(Q_{31})(Q_{32})$, —$Si(Q_{33})(Q_{34})(Q_{35})$, and —$B(Q_{36})(Q_{37})$,

[0064] wherein Q_1 to Q_7, Q_{11} to Q_{17}, Q_{21} to Q_{27}, and Q_{31} to Q_{37} may be each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0065] The substituted or unsubstituted condensed polycyclic groups having 3 or more carbocyclic groups condensed to each other may include a carbon atom as a ring-forming atom and may not include a heteroatom (e.g., N, O, S, Si, and P). Accordingly, for example, a naphthylene group may not belong to the substituted or unsubstituted condensed polycyclic group having 3 or more carbocyclic groups condensed to each other, because the naphthylene group is a condensed polycyclic group having only two carbocyclic groups condensed to each other. A pyridinylene group may not belong to the substituted or unsubstituted condensed polycyclic group having 3 or more carbocyclic groups condensed to each other, because the pyridinylene group includes N as a ring-forming atom (and only has one ring).

[0066] For example, L_1 and L_2 in Formula 1 may each independently be selected from

[0067] an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, and an ovalenylene group; and

[0068] an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, and an ovalenylene 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 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, 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 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 benzoimidazolyl 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, an imidazopyridinyl group, an imidazopyrimidinyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$,

[0069] wherein Q_{33} to Q_{35} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0070] In some embodiments, L_1 and L_2 in Formula 1 may each independently be selected from

[0071] a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, and a perylenylene group; and

[0072] a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, and a perylenylene 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 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, 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 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 benzoimidazolyl 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, an imidazopyridinyl group, an imidazopyrimidinyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$,

[0073] wherein Q_{33} to Q_{35} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0074] In some embodiments, in Formula 1, L_1 and L_2 may each independently be a group represented by one of Formulae 4-11, 4-13, 4-27, and 4-29 to 4-35, and L_{11} may be a group represented by one of Formulae 4-1 to 4-35.

[0075] In Formula 1, a1 and a2 may each independently be an integer of 1 to 5, and a11 may be selected from integers of 0 to 5. When a1 is 0, *-$(L_1)_{a1}$-*' is a single bond, and when a1 is 2 or more, two or more L_1s may be identical to or different from each other. When a2 is 0, *-$(L_2)_{a2}$-*' is a single bond, and when a2 is 2 or more, two or more L_es may be identical to or different from each other. When a11 is 0, *-$(L_{11})_{a11}$-*' is a single bond, and when a11 is 2 or more, two or more L_{11}s may be identical to or different from each other.

[0076] Neither of a1 and a2 may be 0, and therefore, in Formula 1, "L_1" in a group represented by *-[$(L_1)_{a1}$-$(R_1)_{b1}$] and "L_2" in a group represented by *-[$(L_2)_{a2}$-$(R_2)_{b2}$] certainly exist.

[0077] For example, a1 and a2 in Formula 1 may be each independently 1 or 2. In some embodiments, a1 and a2 in Formula 1 may be 1.

[0078] For example, a11 in Formula 1 may be 0, 1, or 2.

[0079] R_1 to R_6 and R_{11} in Formula 1 may each independently be selected from or include, e.g., hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, and —$B(Q_6)(Q_7)$.

[0080] For example, R_1 to R_6 and R_{11} in Formula 1 may each independently be selected from

[0081] hydrogen, deuterium, —F, —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, and a C_1-C_{20} alkoxy group;

[0082] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an 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, and a phosphoric acid group or a salt thereof;

[0083] 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, 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 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 benzoimidazolyl 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 dibenzosilolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[0084] 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, 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 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 benzoimidazolyl 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 dibenzosilolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl 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 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, 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

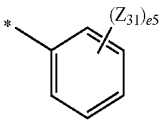
purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl 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, an imidazopyridinyl group, an imidazopyrimidinyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$; and

[0085] —$Si(Q_3)(Q_4)(Q_5)$,

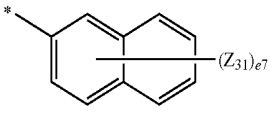
[0086] wherein Q_3 to Q_5 and Q_{33} to Q_{35} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0087] In some embodiments, R_1 to R_6 and R_{11} in Formula 1 may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a group represented by one of Formulae 5-1 to 5-75, and —$Si(Q_3)(Q_4)(Q_5)$, wherein Q_3 to Q_5 may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group:

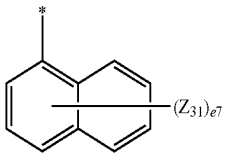
Formula 5-1



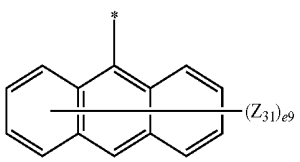
Formula 5-2



Formula 5-3



Formula 5-4



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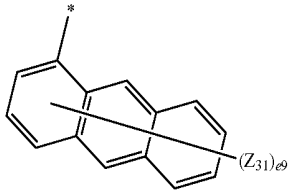

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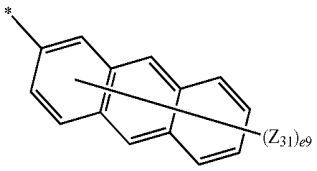

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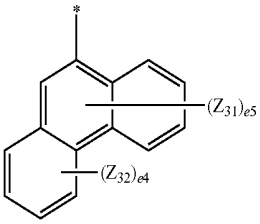
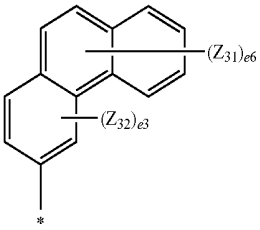


Formula 5-8



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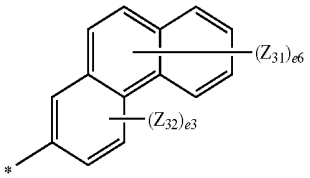

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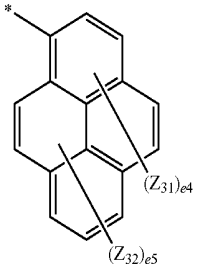

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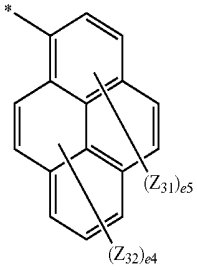
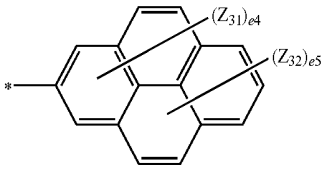


Formula 5-12



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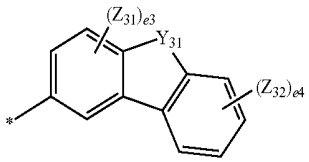

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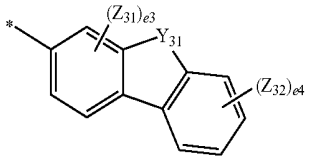

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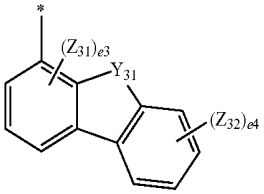
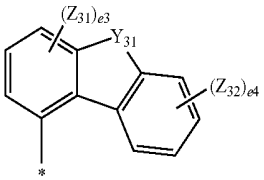


Formula 5-16



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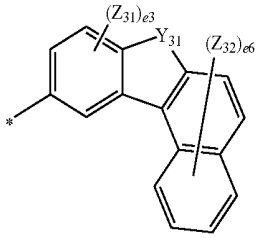

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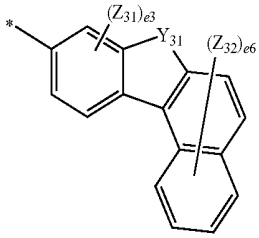

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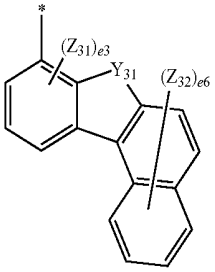

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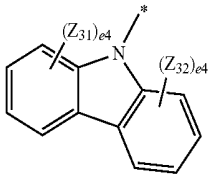

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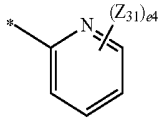

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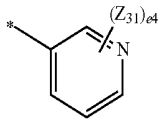
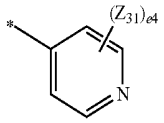


Formula 5-23



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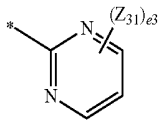

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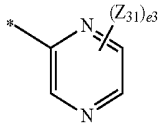

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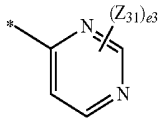

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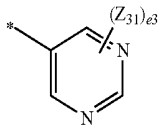

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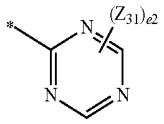

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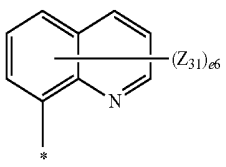

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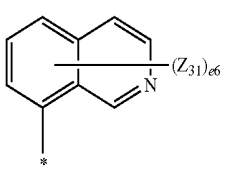

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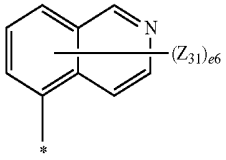
Formula 5-31



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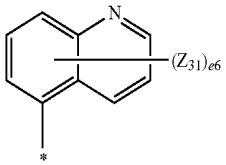
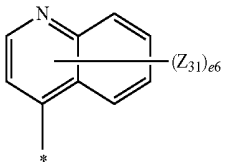
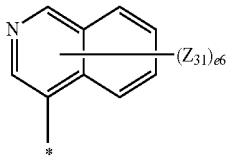


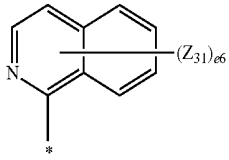
Formula 5-33



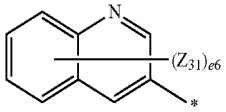
Formula 5-34



Formula 5-35



Formula 5-36



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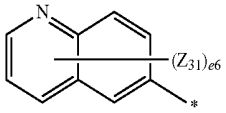
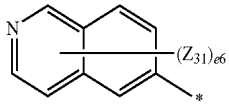
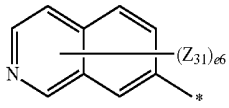


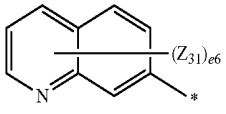
Formula 5-38



Formula 5-39



Formula 5-40



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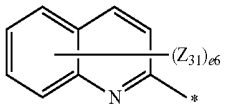
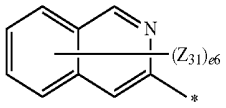
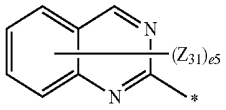
Formula 5-41



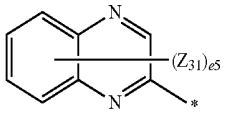
Formula 5-42



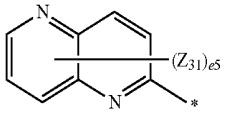
Formula 5-43



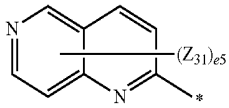
Formula 5-44



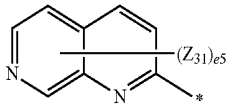
Formula 5-45



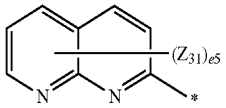
Formula 5-46



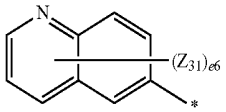
Formula 5-47



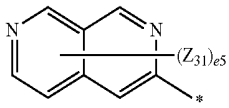
Formula 5-48



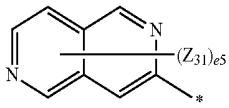
Formula 5-49



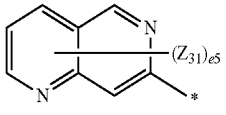
Formula 5-50



Formula 5-51



Formula 5-52



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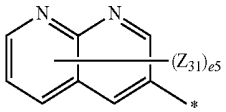
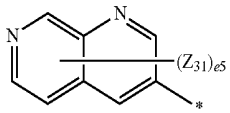
Formula 5-53



Formula 5-54



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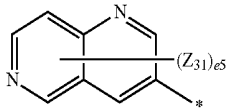
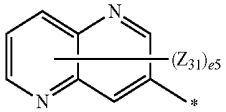
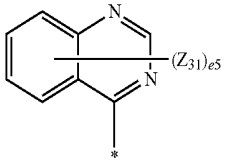


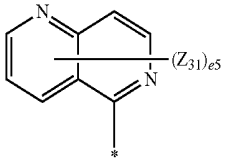
Formula 5-56



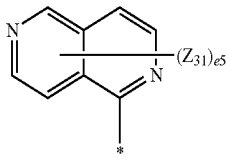
Formula 5-57



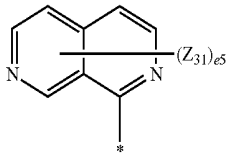
Formula 5-58



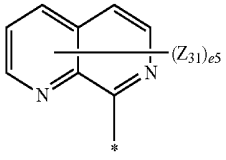
Formula 5-59



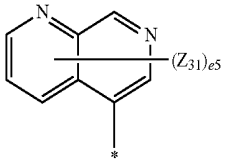
Formula 5-60



Formula 5-61



Formula 5-62



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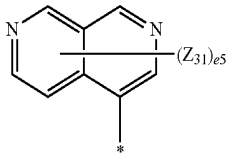
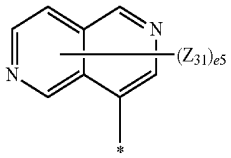
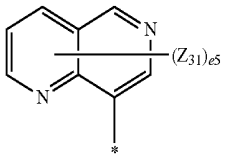
Formula 5-63



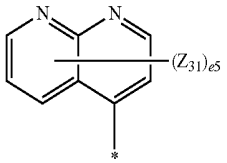
Formula 5-64



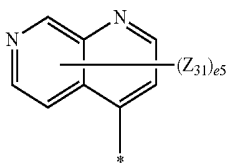
Formula 5-65



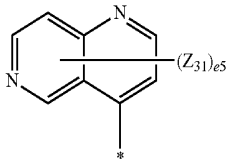
Formula 5-66



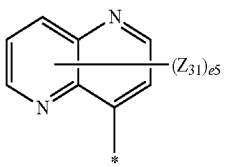
Formula 5-67



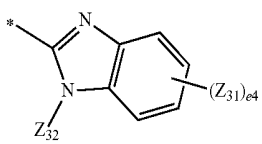
Formula 5-68



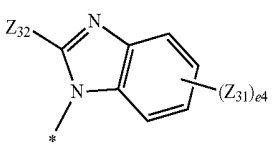
Formula 5-69



Formula 5-70



Formula 5-71



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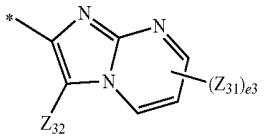
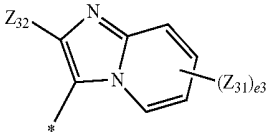
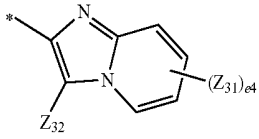
Formula 5-72



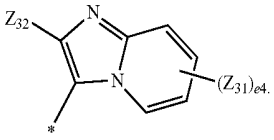
Formula 5-73



Formula 5-74



Formula 5-75



[0088] In Formulae 5-1 to 5-75,

[0089] Y_{31} is O, S, $C(Z_{33})(Z_{34})$, $N(Z_{35})$, or $Si(Z_{36})(Z_{37})$,

[0090] Z_{31} to Z_{37} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and $—Si(Q_{33})(Q_{34})(Q_{35})$,

[0091] wherein Q_{33} to Q_{35} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

[0092] e2 is 1 or 2,

[0093] e3 is an integer of 1 to 3,

[0094] e4 is an integer of 1 to 4,

[0095] e5 is an integer of 1 to 5,

[0096] e6 is an integer of 1 to 6,

[0097] e7 is an integer of 1 to 7,

[0098] e8 is an integer of 1 to 8,

[0099] e9 is an integer of 1 to 9, and

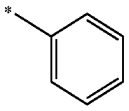
[0100] * indicates a binding site to a neighboring atom.

[0101] In some embodiments, in Formula 1,

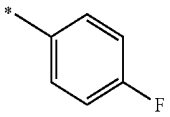
[0102] R_3 to R_6 may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a 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, and $—Si(Q_3)(Q_4)(Q_5)$, and

[0103] R_1, R_2, and R_{11} may each independently be a group represented by Formulae 6-1 to 6-43 or a group represented by Formulae 10-1 to 10-117, wherein Q_3 to Q_5 may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group:

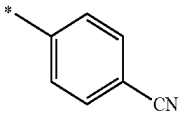
Formula 6-1



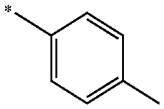
Formula 6-2



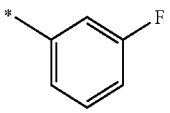
Formula 6-3



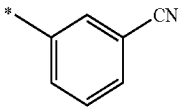
Formula 6-4



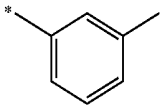
Formula 6-5



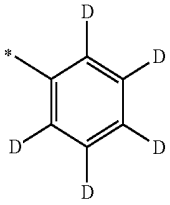
Formula 6-6



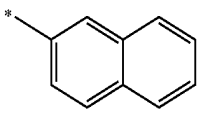
Formula 6-7



Formula 6-8



Formula 6-9



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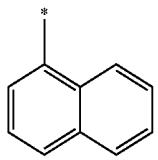
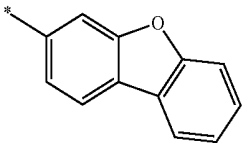
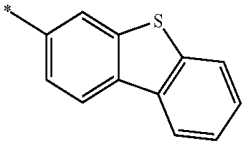
Formula 6-10



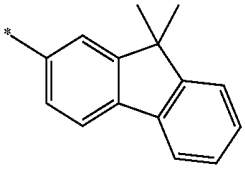
Formula 6-11



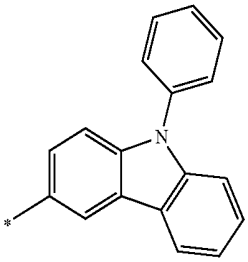
Formula 6-12



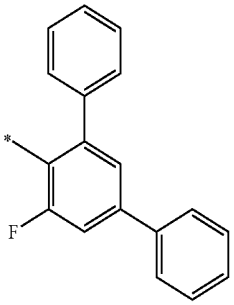
Formula 6-13



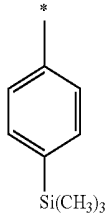
Formula 6-14



Formula 6-15



Formula 6-16



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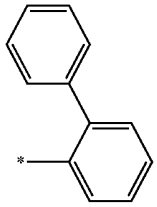
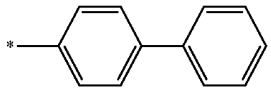
Formula 6-17



Formula 6-18



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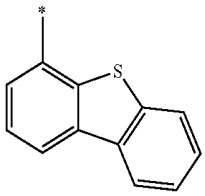

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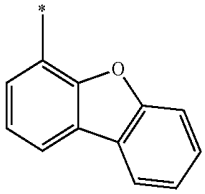

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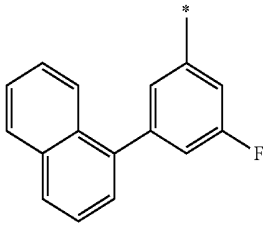

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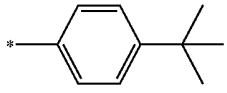

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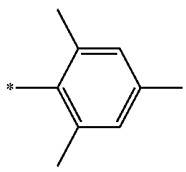

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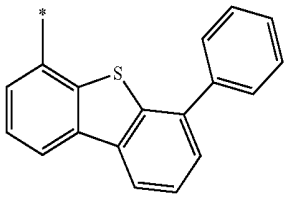

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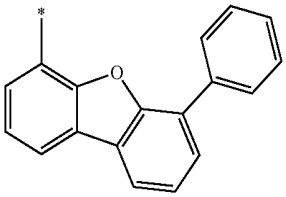

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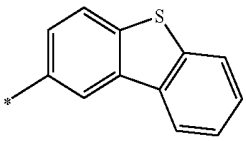

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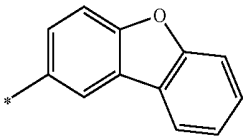

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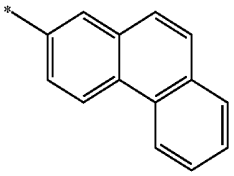

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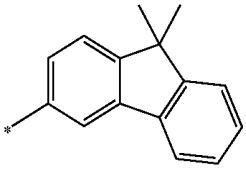

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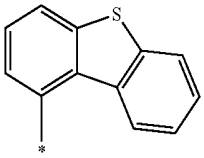

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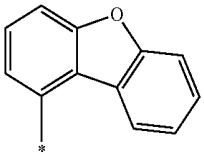

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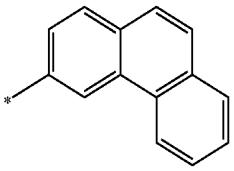

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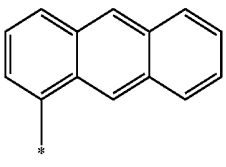

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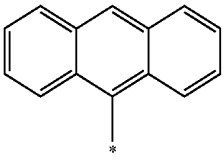

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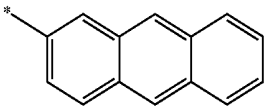

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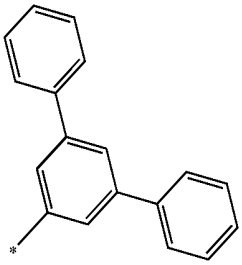

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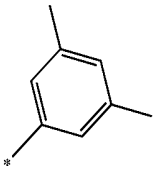

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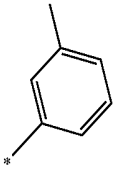

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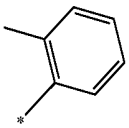

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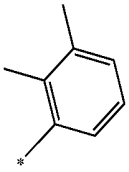

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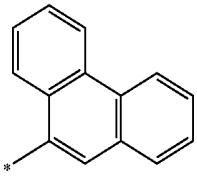

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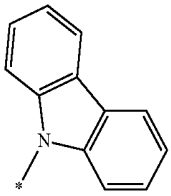

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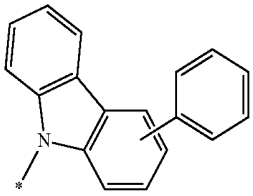

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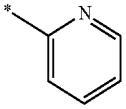

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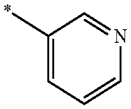

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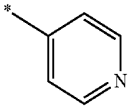

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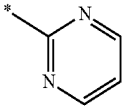

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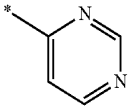

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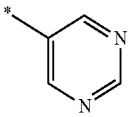

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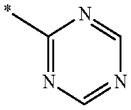

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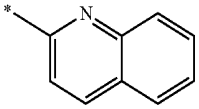

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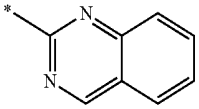

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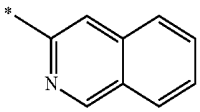

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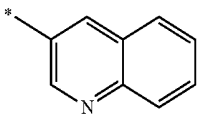

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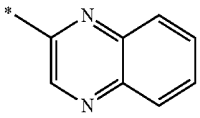

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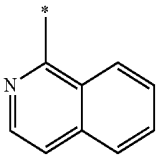

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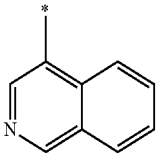

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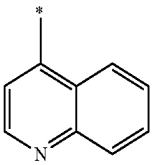

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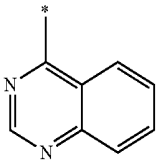

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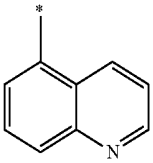

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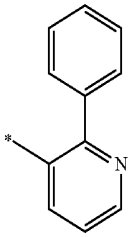

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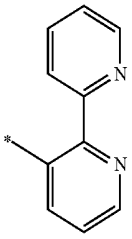

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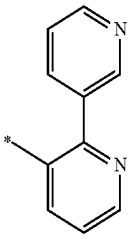

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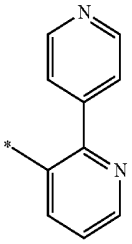

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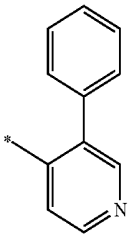

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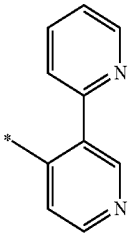

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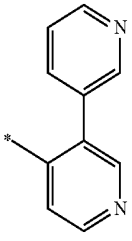

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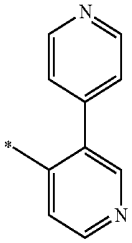

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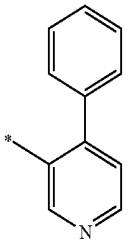

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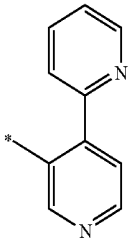

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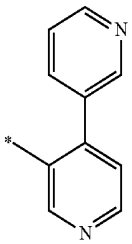

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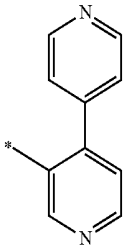

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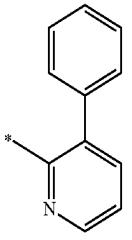

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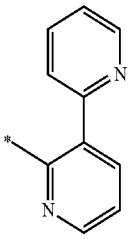

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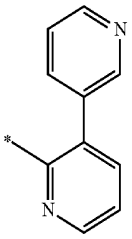

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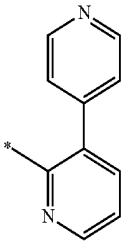

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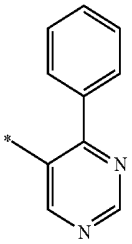

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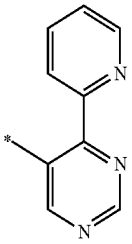

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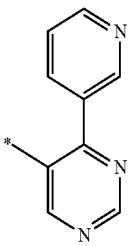

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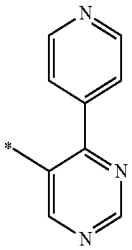

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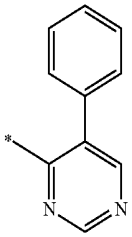

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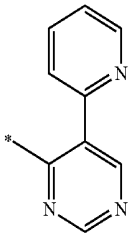

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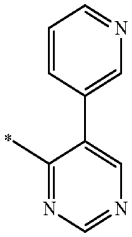

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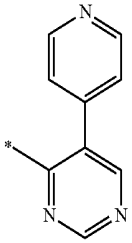

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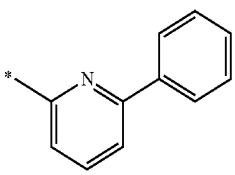

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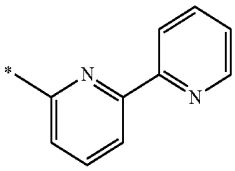

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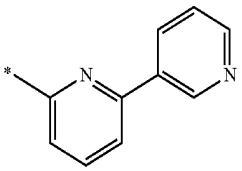

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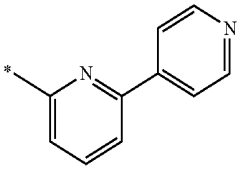

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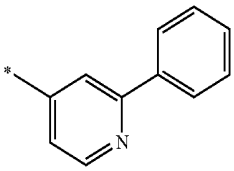

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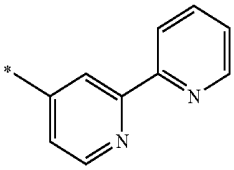

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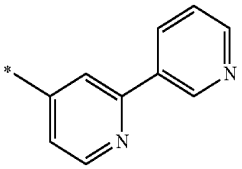

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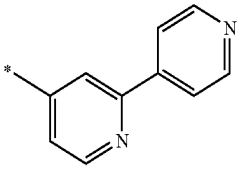

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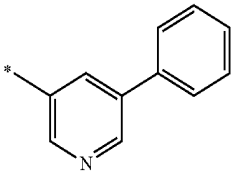

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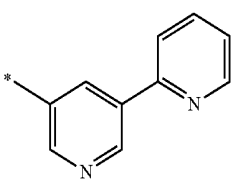

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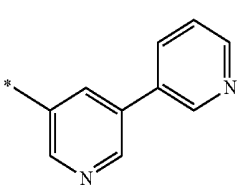

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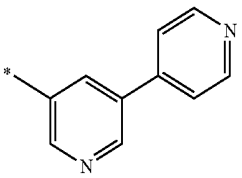

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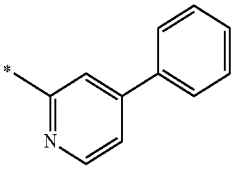

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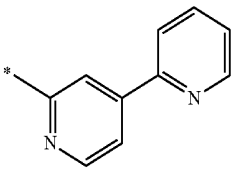

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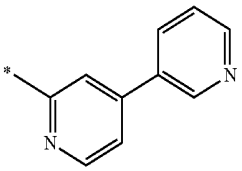

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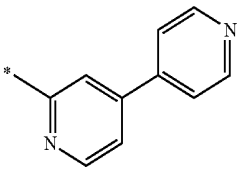

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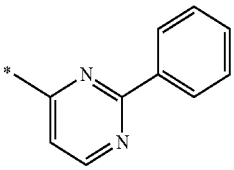

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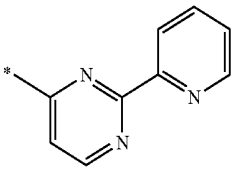

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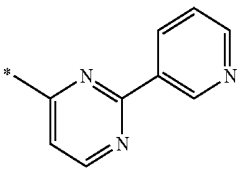

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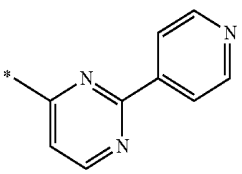

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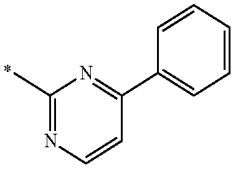

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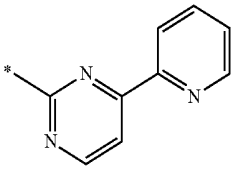

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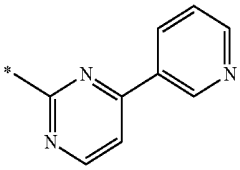

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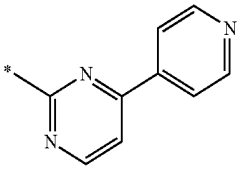

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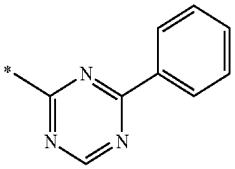

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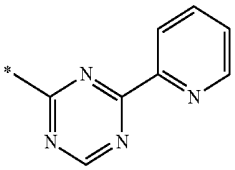

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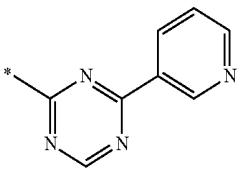

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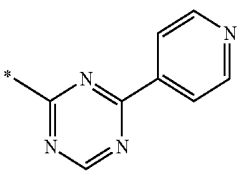

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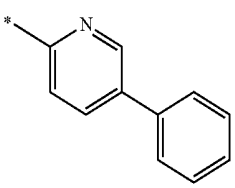

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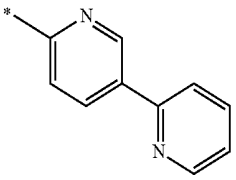

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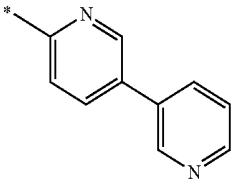

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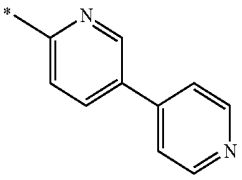

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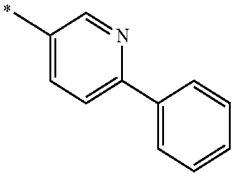

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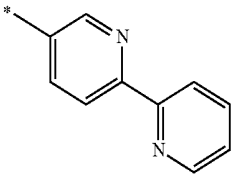

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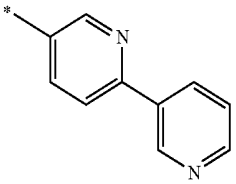

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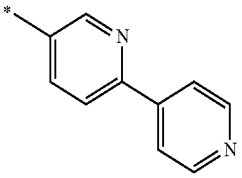

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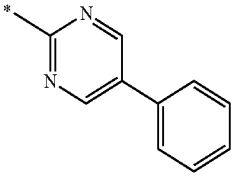

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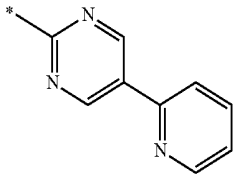

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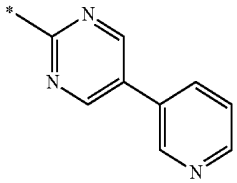

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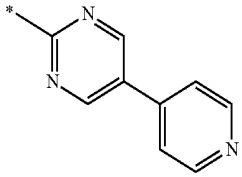

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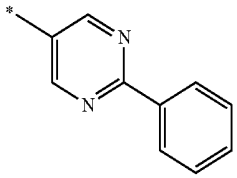

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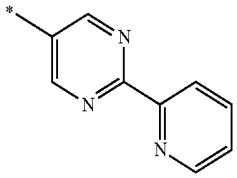

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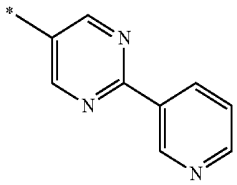

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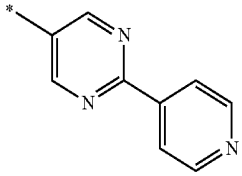

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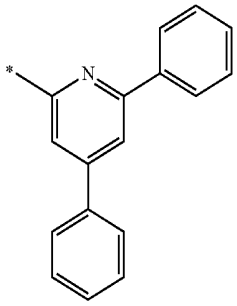

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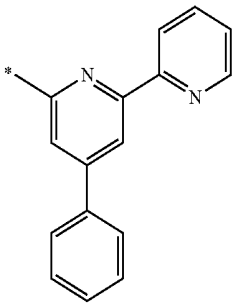

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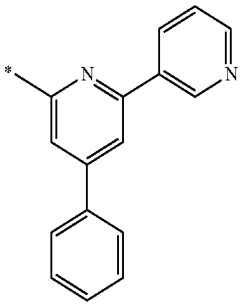
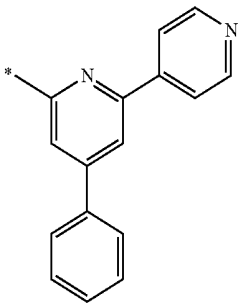


Formula 10-89



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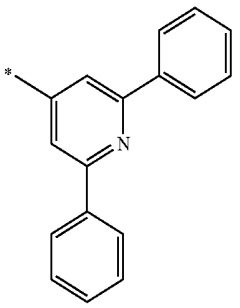
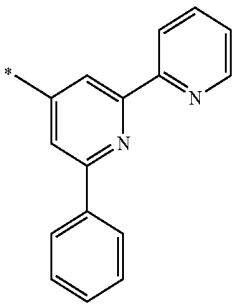


Formula 10-91



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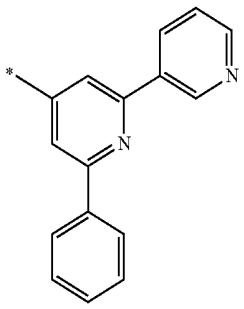

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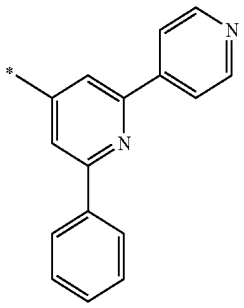

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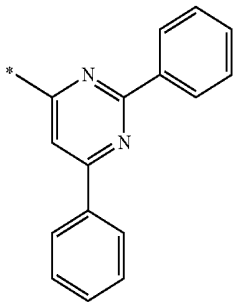

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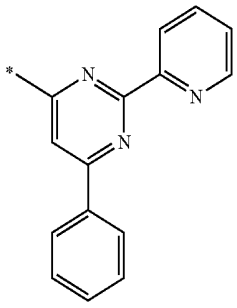

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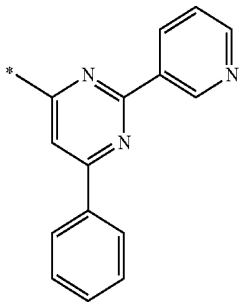

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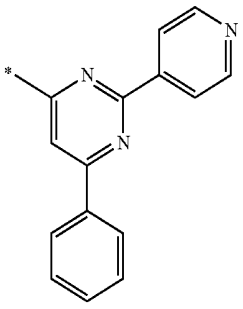
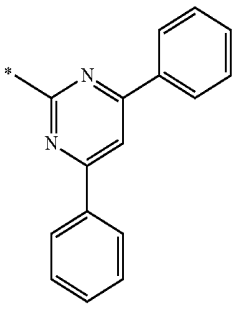
Formula 10-97



Formula 10-98



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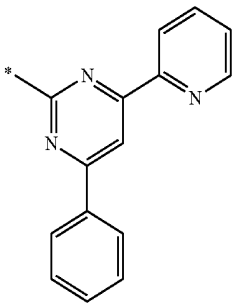

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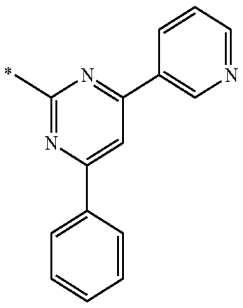

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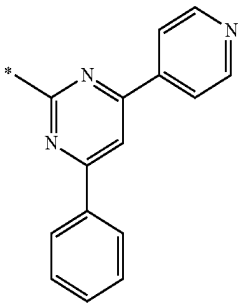

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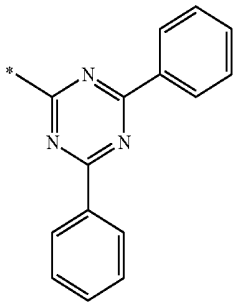

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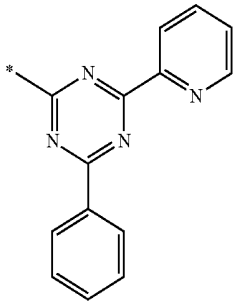

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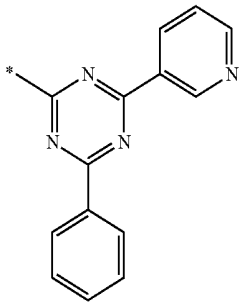

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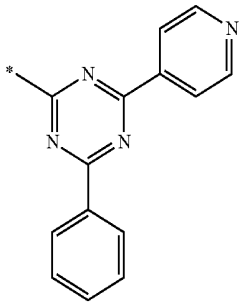

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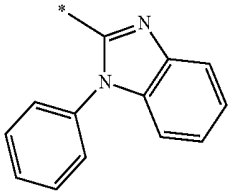

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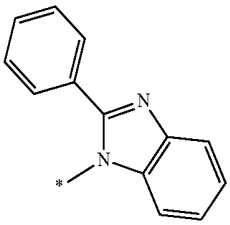
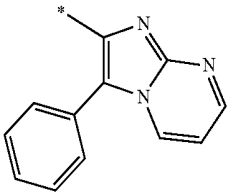


Formula 10-108



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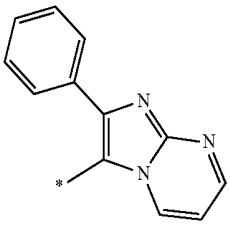

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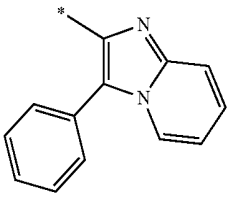

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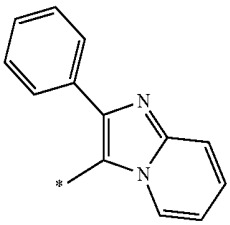
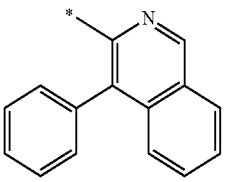
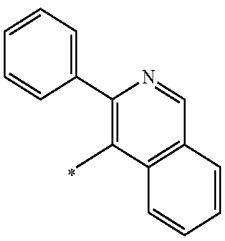


Formula 10-112



Formula 10-113



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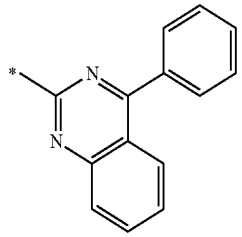
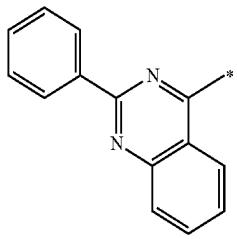
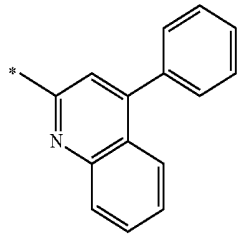
Formula 10-114



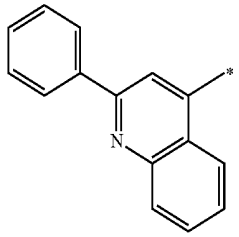
Formula 10-115



Formula 10-116



Formula 10-117



[0104] * in Formulae 6-1 to 6-41 and 10-1 to 10-117 indicates a binding site to a neighboring atom.

[0105] In some embodiments, in Formula 1,

[0106] R_3 to R_6 may be hydrogen, and

[0107] R_1, R_2, and R_{11} may each independently be a group represented by one of Formulae 5-1 to 5-75 (e.g., a group represented by Formulae 6-1 to 6-43 and/or 10-1 to 10-117).

[0108] In Formula 1, b1, b2, b5, b6, and b11 may each independently be an integer of 0 to 4, and b3 and b4 may each independently be an integer of 0 to 6. When b1 is 2 or more, R_1 may be identical to or different from each other, when b2 is 2 or more, R_2 may be identical to or different from each other, when b3 is 2 or more, R_3 may be identical to or different from each other, when b4 is 2 or more, R_4 may be identical to or different from each other, when b5 is 2 or more, R_5 may be identical to or different from each other, and when b6 is 2 or more, R_6 may be identical to or different from each other.

[0109] For example, b1 to b6 in Formula 1 may each independently be 1 or 2.

[0110] c1 and c2 in Formula 1 may each independently be an integer of 0 to 4. For example, c1 and c2 may each independently be 0, 1, or 2.

[0111] In some embodiments, c1+c2 (a sum of c1 and c2) in Formula 1 may be 1 or greater. When the sum of c1 and c2 is 1 or greater, at least one of the group represented by $*-[(L_1)_{a1}-(R_1)_{b1}]$ and the group represented by $*-[(L_2)_{a2}-(R_2)_{b2}]$ in Formula 1 is present.

[0112] For example, in Formula 1,

[0113] c1 may be 1, and c2 may be 0;

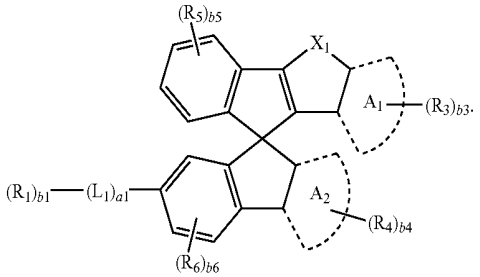
[0114] c1 may be 1, and c2 may be 1; or

[0115] c1 may be 0, and c2 may be 1.

[0116] In some embodiments, in Formula 1, L_1 and L_2 may each independently be a group represented by Formulae 3-8, 3-9, 3-25, and 3-35 to 3-41, L_{11} may be a group represented by Formulae 3-1 to 3-41, and c1+c2 may be 1 or greater.

[0117] In some embodiments, the condensed cyclic compound represented by Formula 1 may be represented by Formula 1A:

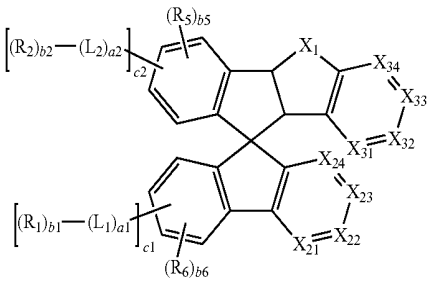
<Formula 1A>



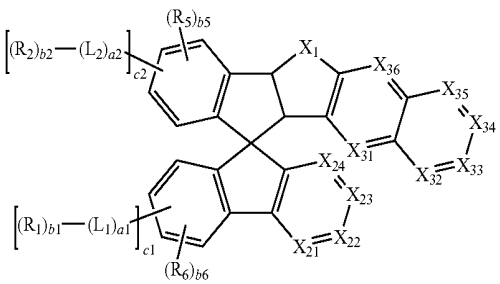
[0118] A_1 ring, A_2 ring, X_1, L_1, a1, R_1, R_3 to R_6, b1, and b3 to b6 in Formula 1A may be understood by referring to descriptions thereof with respect to Formula 1.

[0119] In some embodiments, the condensed cyclic compound represented by Formula 1 may be represented by one of Formulae 1-1 to 1-7.

Formula 1-1



Formula 1-2



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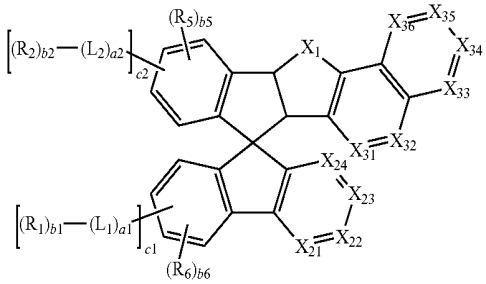
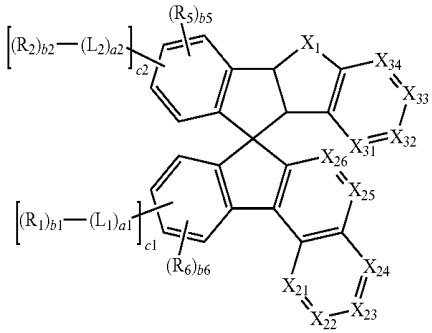
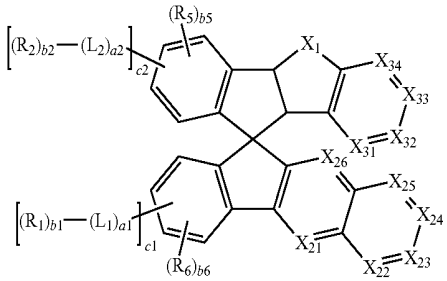
Formula 1-3



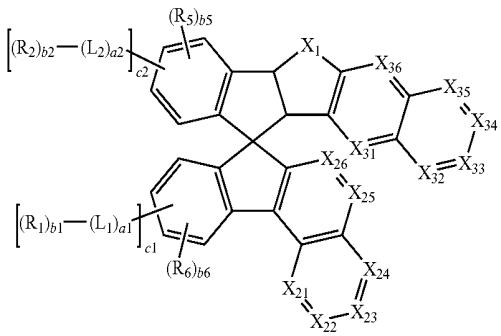
Formula 1-4



Formula 1-5



Formula 1-6



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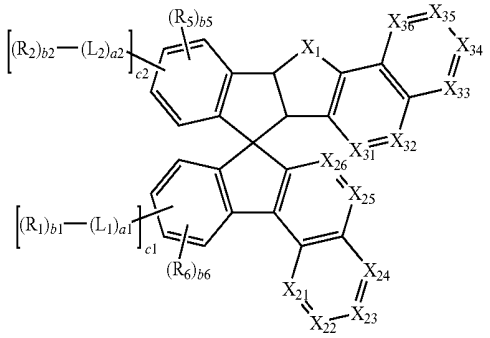
Formula 1-7



[0120] In Formulae 1-1 to 1-7,

[0121] X_1, L_1, L_2, a1, a2, R_1, R_2, R_5, R_6, b1, b2, b5, b6, c1, and c2 may be understood by referring to descriptions thereof provided herein with respect to Formula 1,

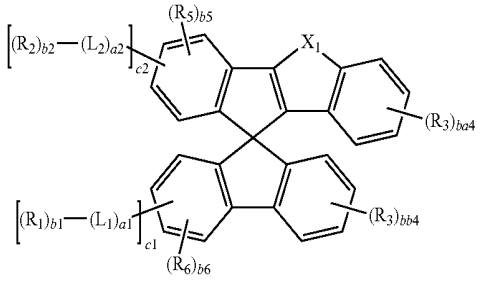
[0122] X_{21} is N or C(R_{21}), X_{22} is N or C(R_{22}), X_{23} is N or C(R_{23}), X_{24} is N or C(R_{24}), X_{25} is N or C(R_{25}), X_{26} is N or C(R_{26}), X_{31} is N or C(R_{31}), X_{32} is N or C(R_{32}), X_{33} is N or C(R_{33}), X_{34} is N or C(R_{34}), X_{35} is N or C(R_{35}), and X_{36} is N or C(R_{36}),

[0123] each description of R_{21} to R_{26} may be the same as the description of R_3 provided herein with respect to Formula 1, and

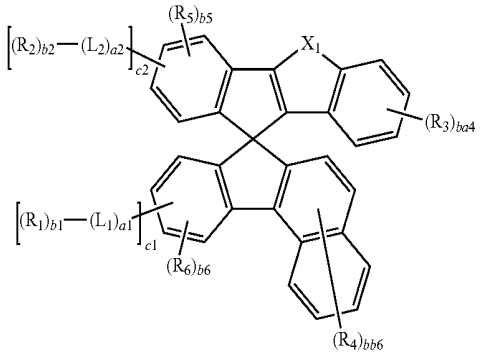
[0124] each description of R_{31} to R_{36} may be the same as the description of R_4 provided herein with respect to Formula 1.

[0125] In some embodiments, the condensed cyclic compound represented by Formula 1 may be represented by one of Formulae 1(1) to 1(19):

Formula 1(1)



Formula 1(2)



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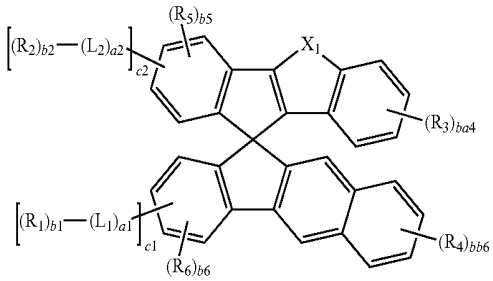
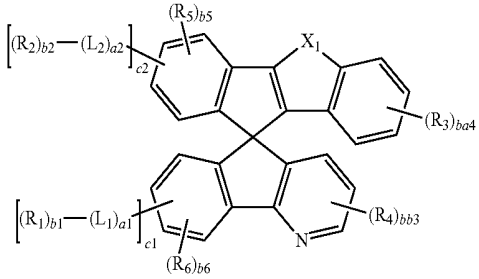
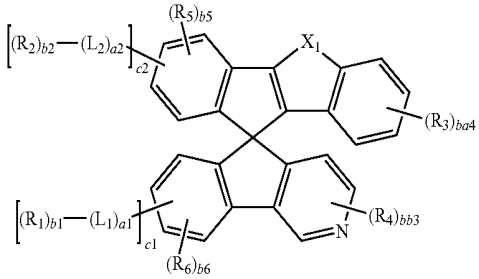
Formula 1(3)



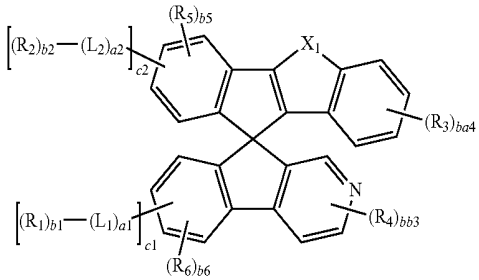
Formula 1(4)



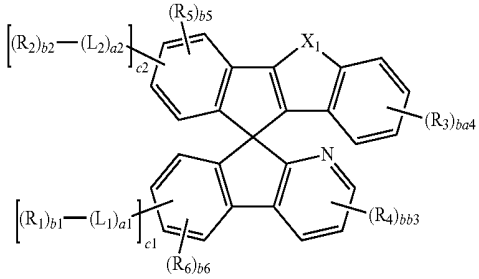
Formula 1(5)



Formula 1(6)



Formula 1(7)



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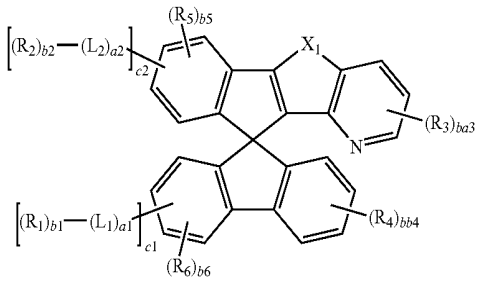
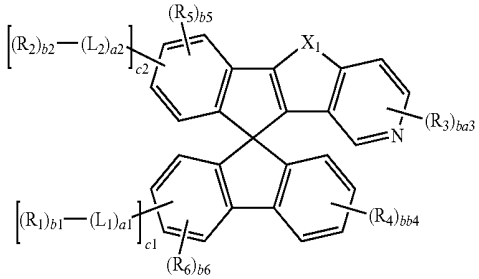
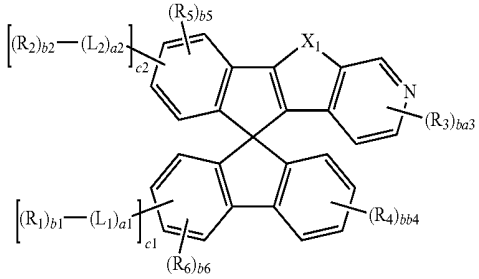
Formula 1(8)



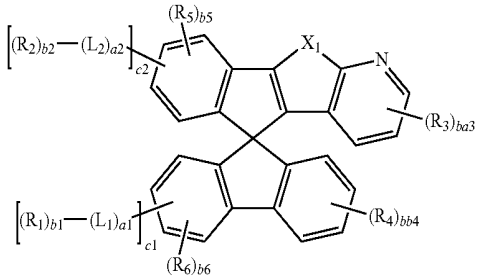
Formula 1(9)



Formula 1(10)



Formula 1(11)



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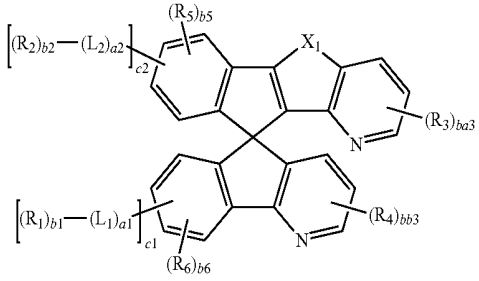

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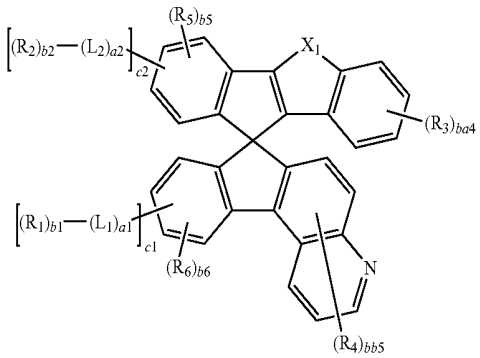
Formula 1(13)



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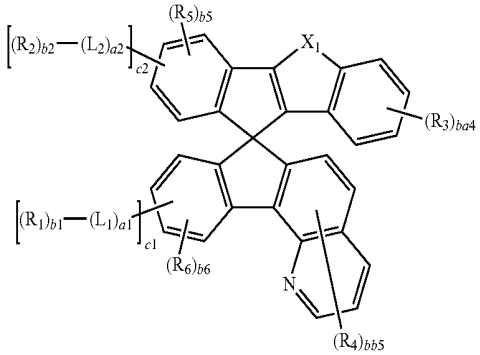

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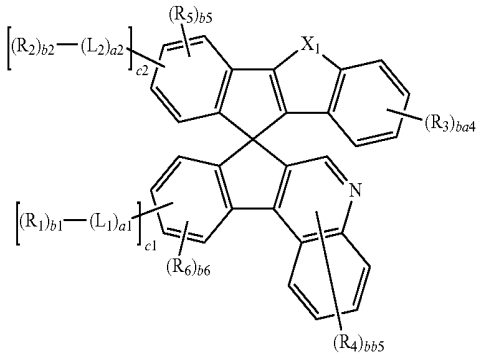

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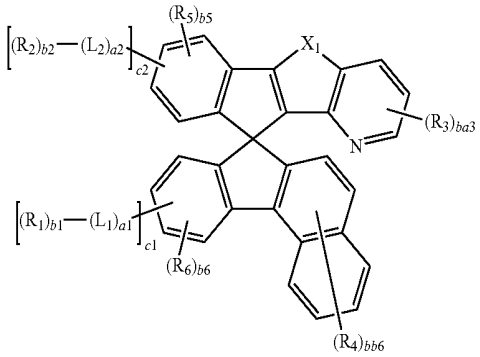

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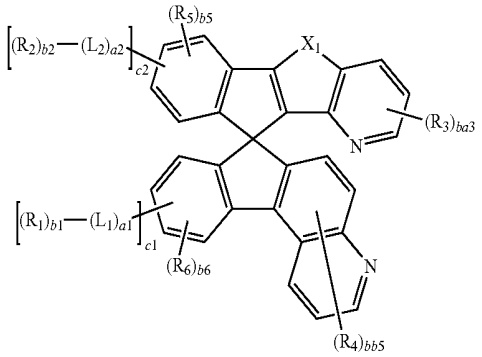

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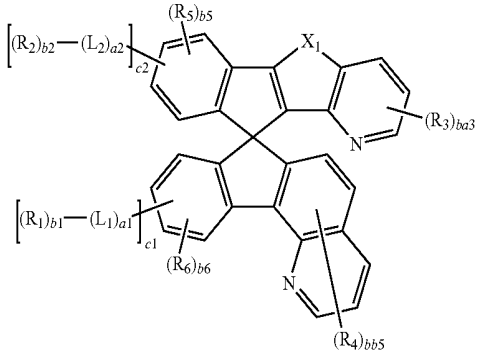

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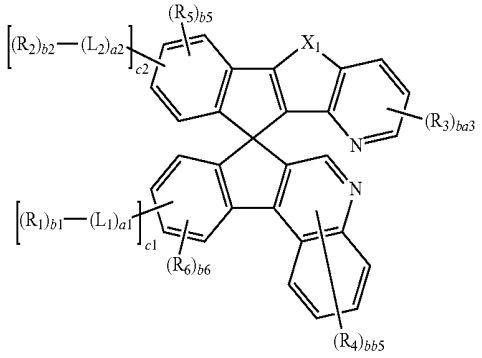


[0126] In Formulae 1(1) to 1(19),

[0127] descriptions of X_1, L_1, L_2, a1, a2, R_1 to R_6, b1 to b6, c1, and c2 are the same as provided herein with respect to Formula 1,

[0128] ba3 and bb3 may be each independently an integer of 0 to 3,

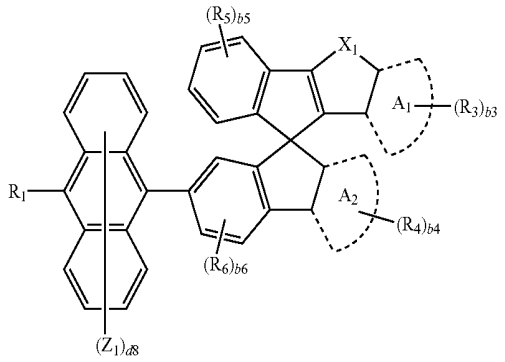
[0129] ba4 and bb4 may be each independently an integer of 0 to 4,

[0130] ba5 and bb5 may be each independently an integer of 0 to 5, and

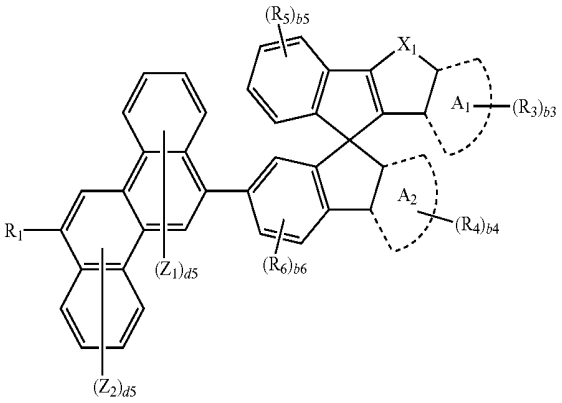
[0131] ba6 and bb6 may be each independently an integer of 0 to 6.

[0132] In some embodiments, the condensed cyclic compound represented by Formula 1 may be represented by one of Formulae 1A-1 to 1A-4:

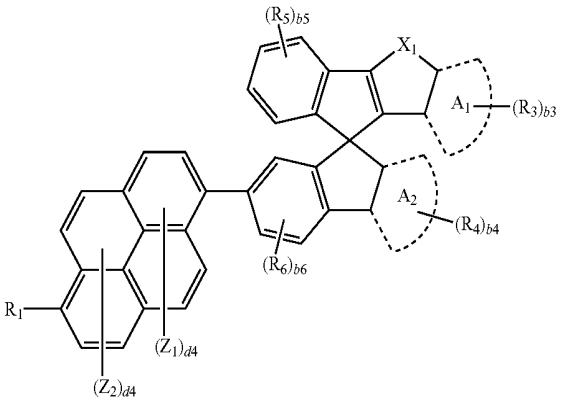
Formula 1A-1



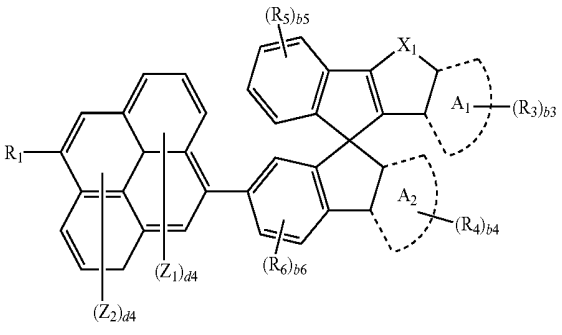
Formula 1A-2



Formula 1A-3



Formula 1A-4



[0133] Descriptions of A_1 ring, A_2 ring, X_1, R_1, R_3 to R_6, b1, and b3 to b6 in Formulae 1A-1 to 1A-4 are the same as provided herein with respect to Formula 1.

[0134] For example, in Formulae 1A-1 to 1A-4,

[0135] A_1 ring and A_2 ring with respect to Formula 1, selected from a benzene, a naphthalene, a pyridine, a quinoline, and an isoquinoline,

[0136] X_1 may be O or S,

[0137] R_1 may be a group represented by one of Formulae 5-1 to 5-75,

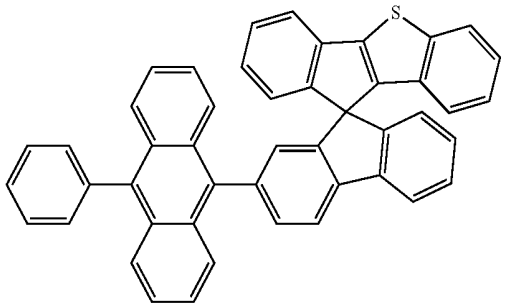
[0138] R_3 to R_6 with respect to Formula 1, selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and —$Si(Q_3)(Q_4)(Q_5)$,

[0139] Z_1 and Z_2 may each be understood by referring to the description of Z_{31}, and

[0140] b3 to b6, d4, d5, and d8 with respect to Formula 1,0, 1, or 2.

[0141] In some embodiments, the condensed cyclic compound represented by Formula 1 may be one of Compounds 1 to 64:

1



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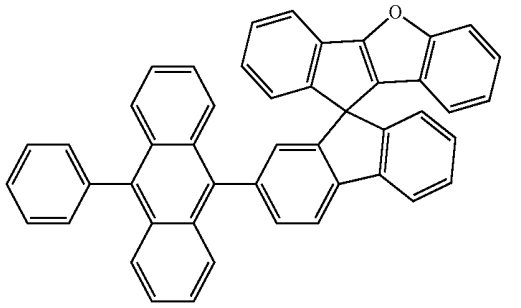

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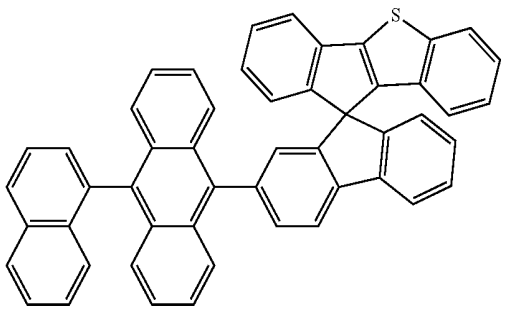

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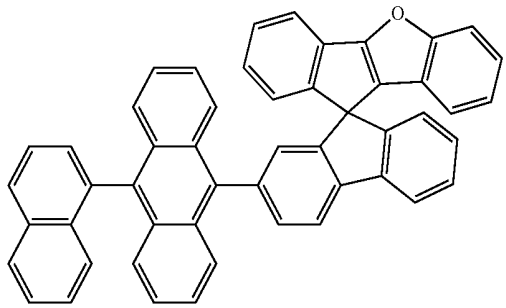

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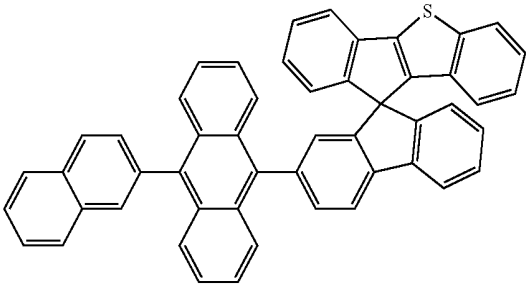

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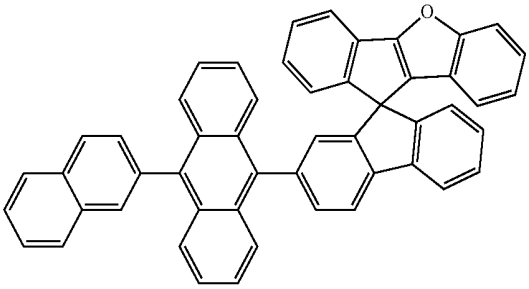

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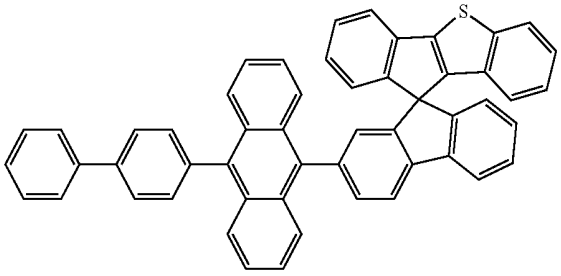

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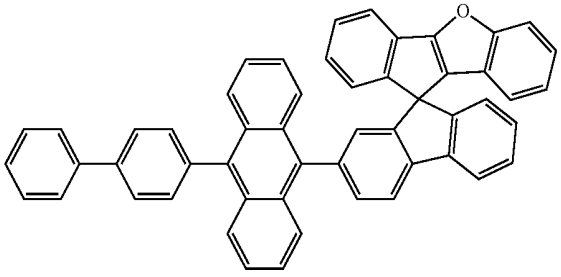

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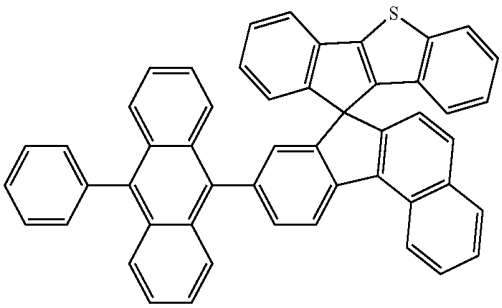

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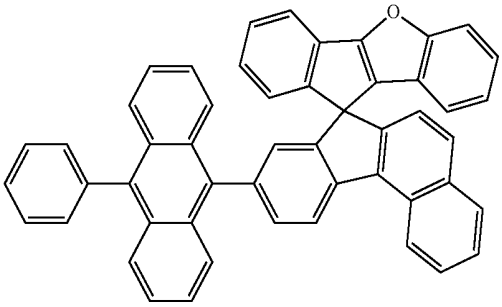

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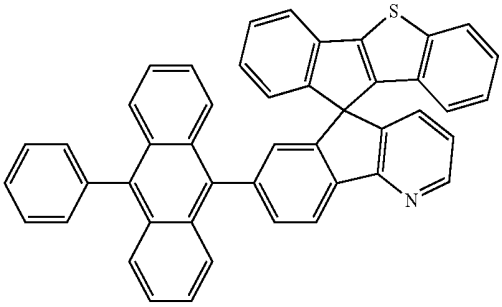

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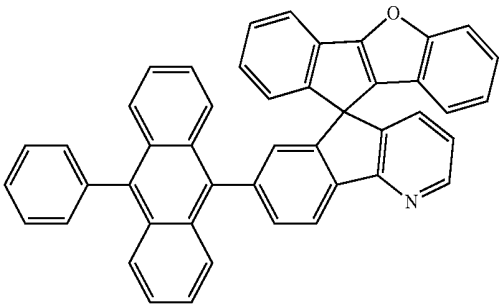

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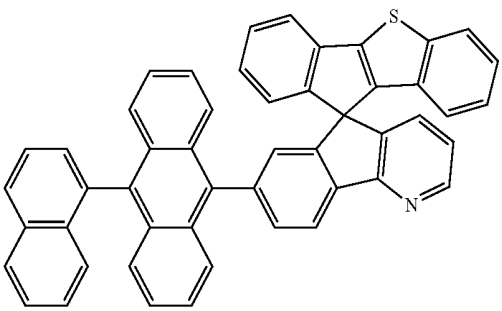

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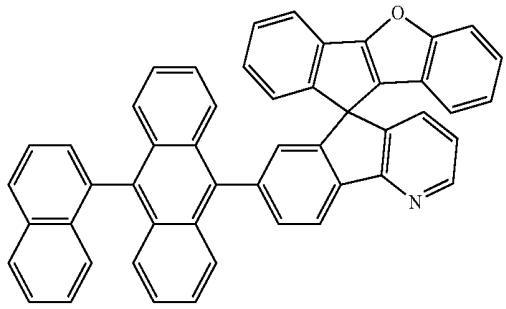

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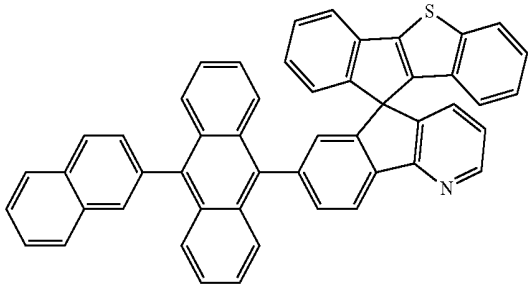

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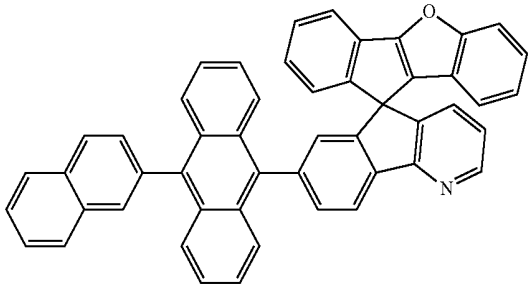

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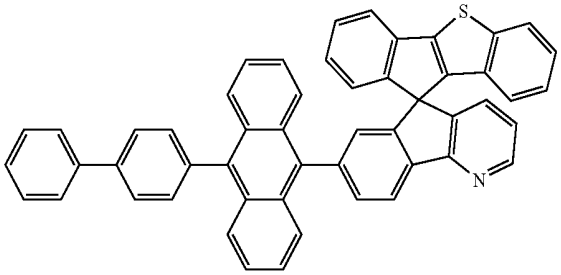

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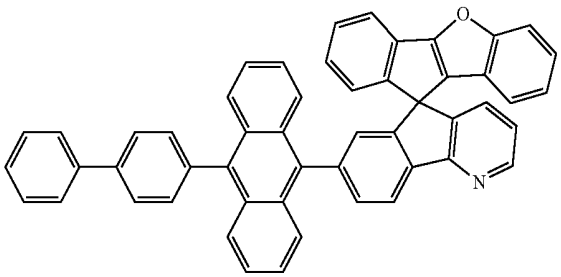

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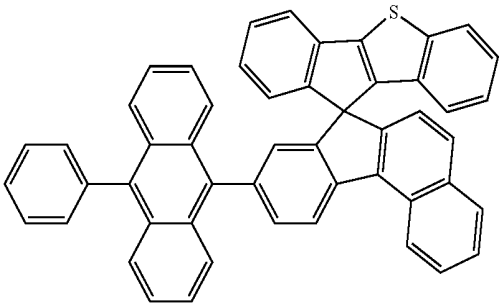

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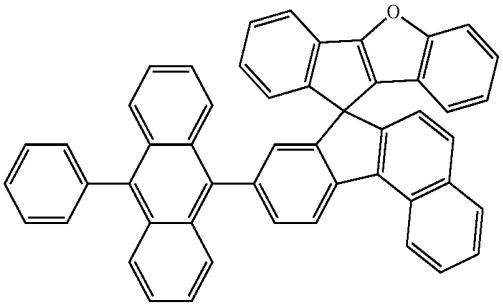

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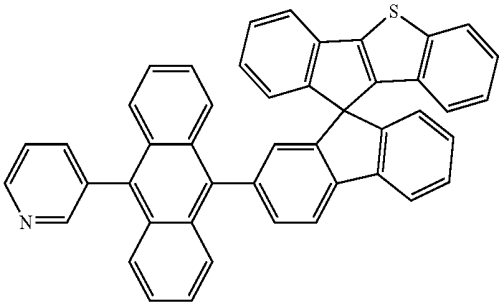

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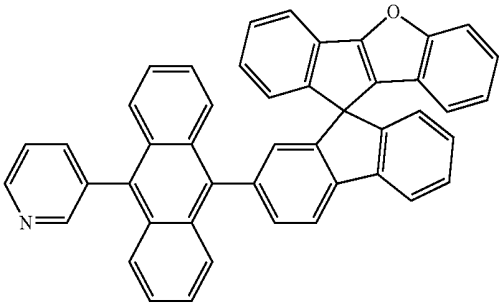

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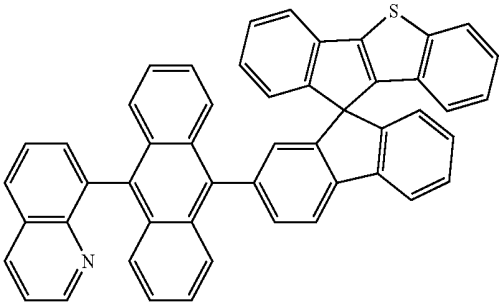

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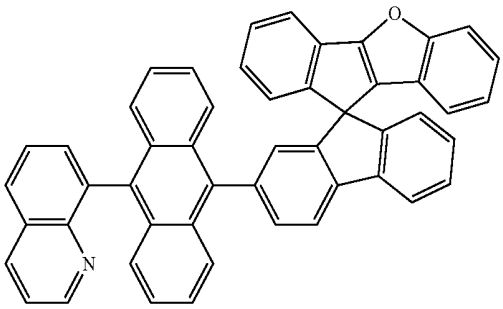

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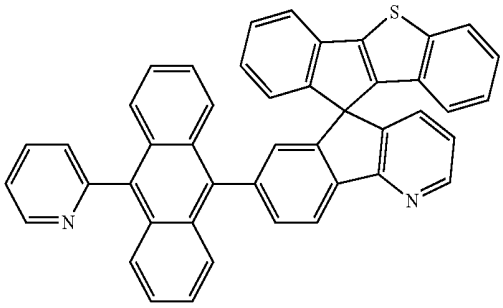

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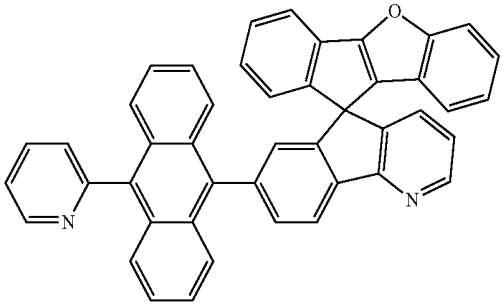

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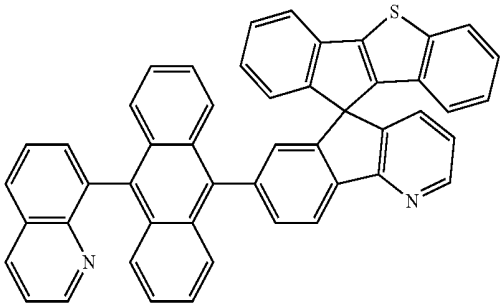

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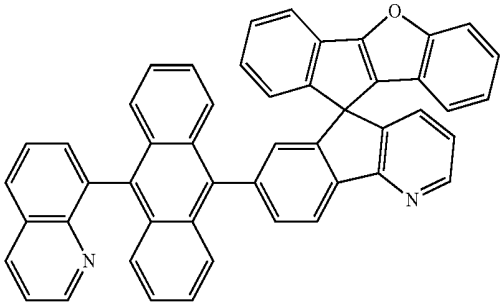

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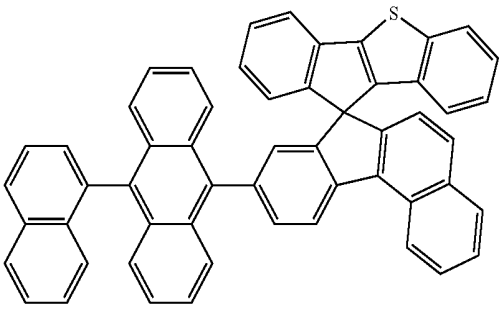

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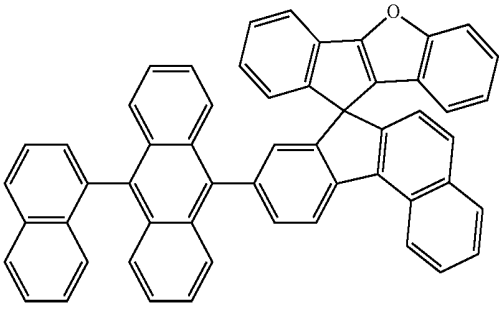

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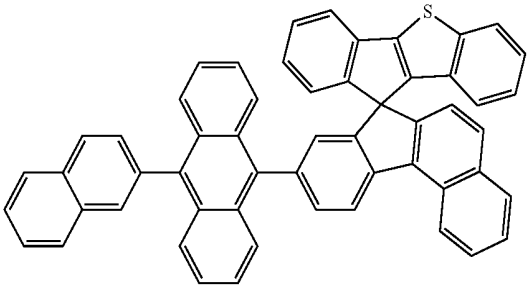

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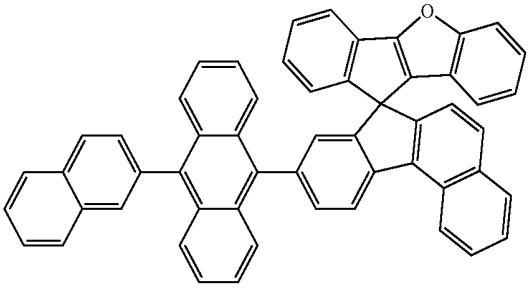

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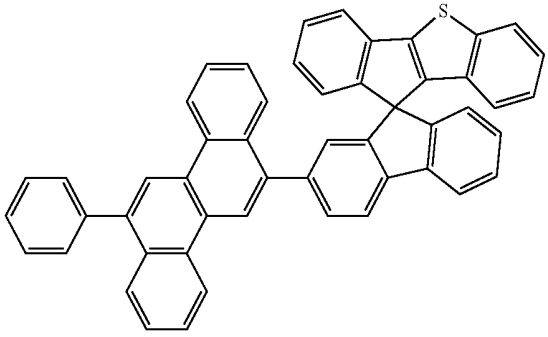

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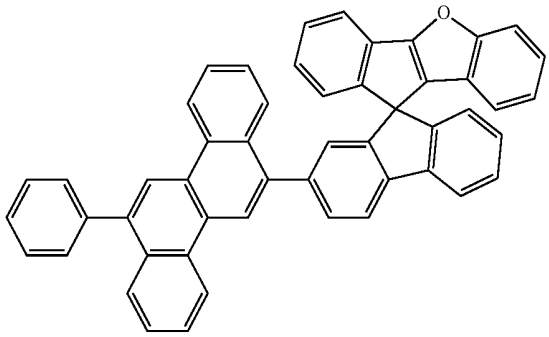

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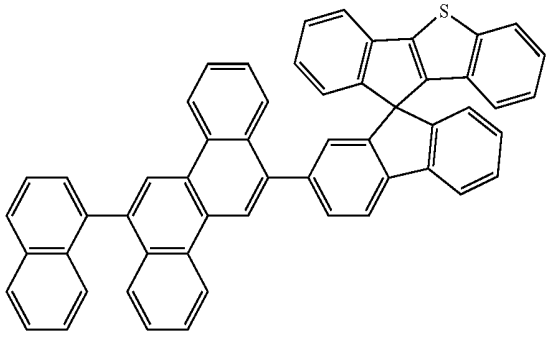

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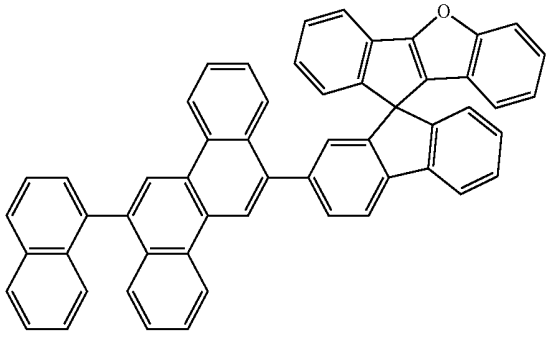

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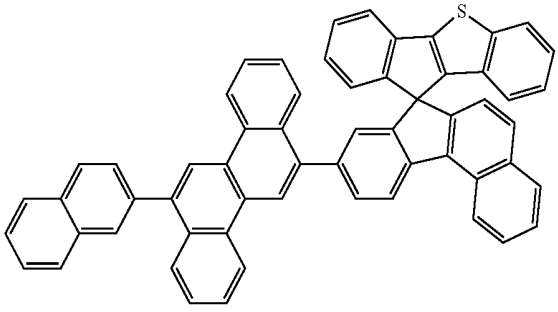

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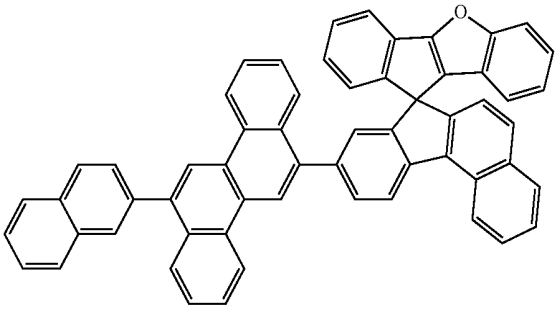

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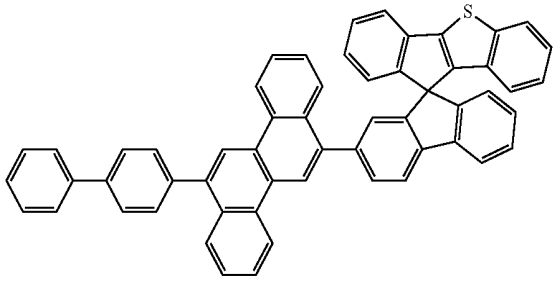

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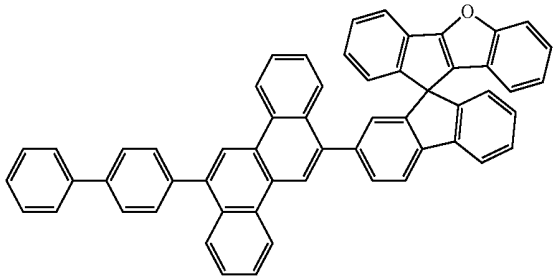

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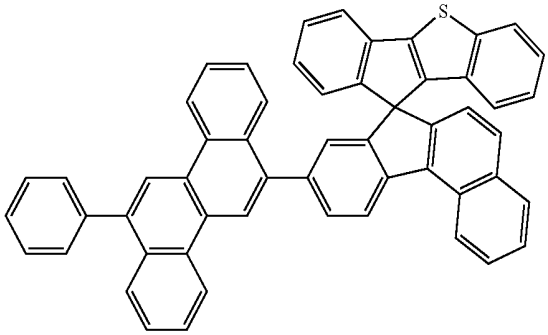

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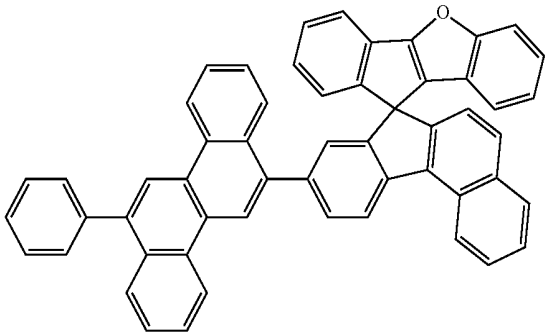

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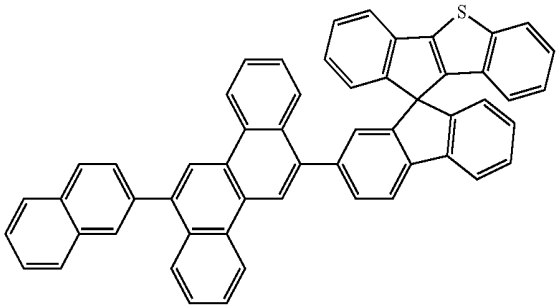

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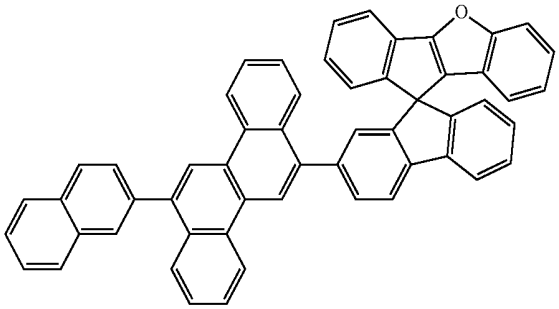

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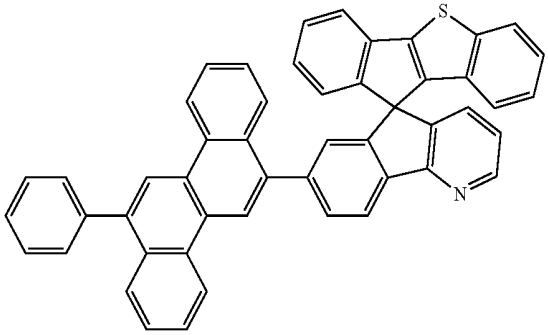

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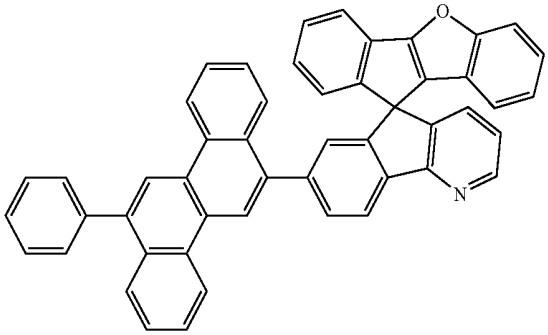

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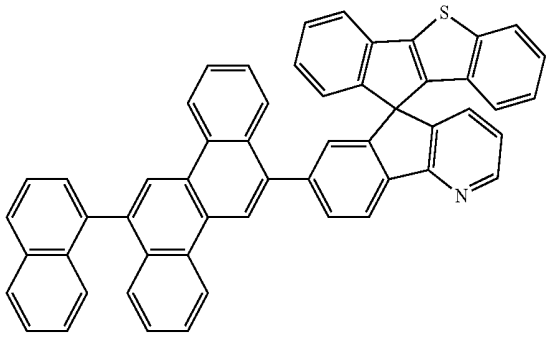

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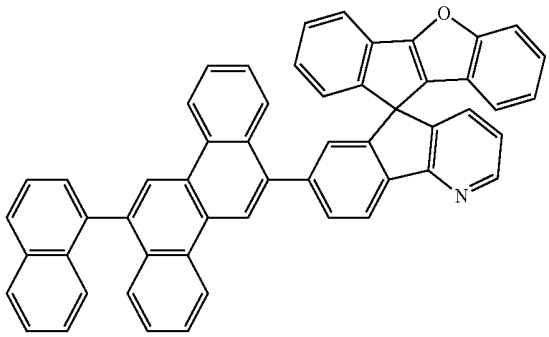

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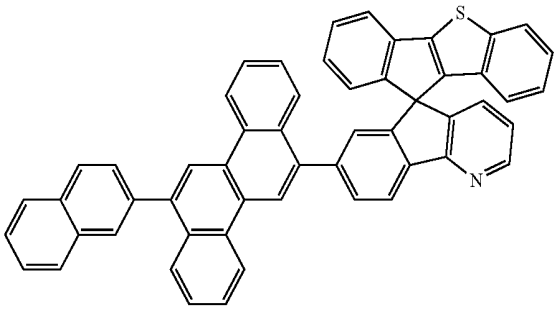

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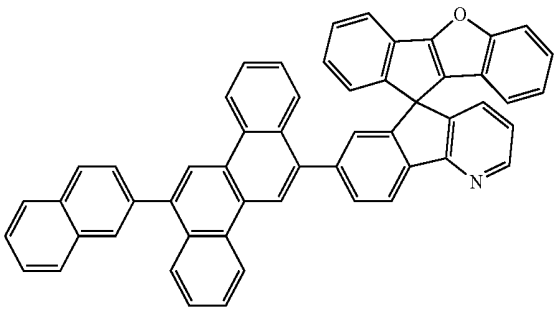

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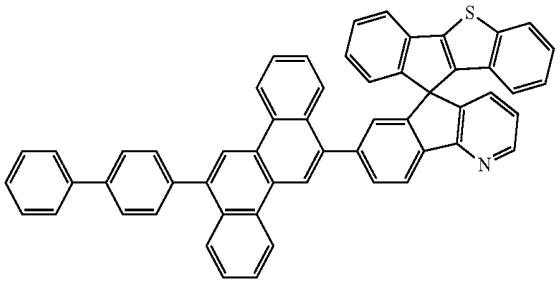

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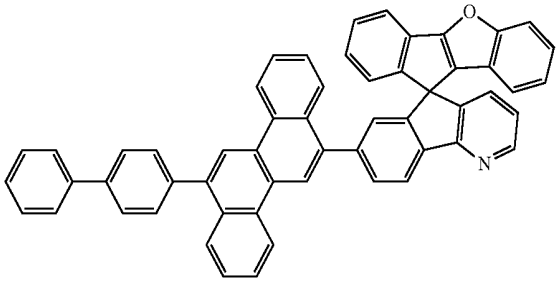

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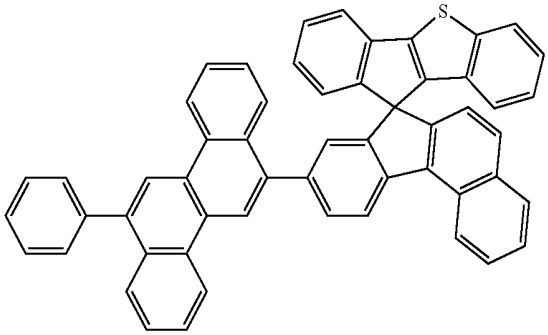

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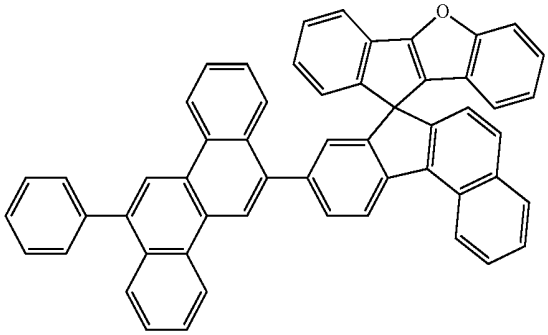

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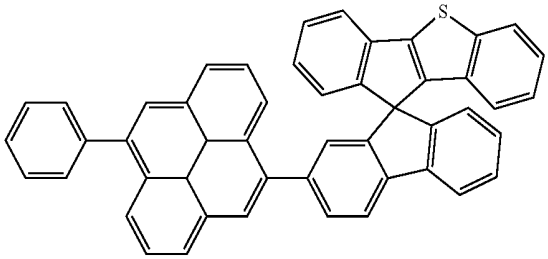

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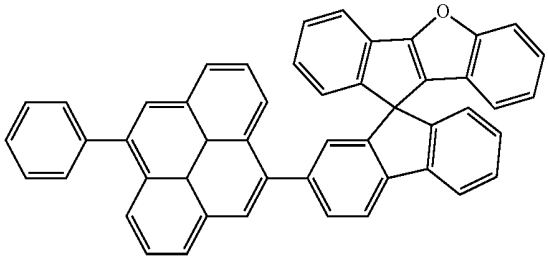

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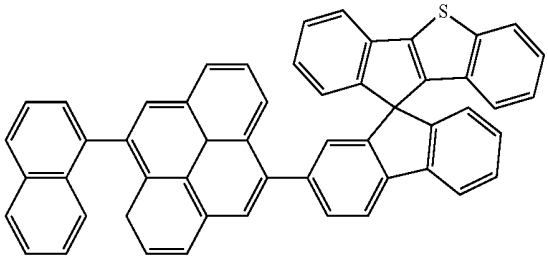

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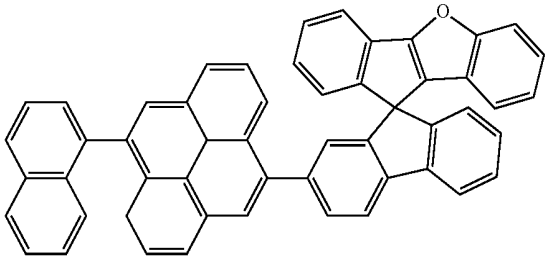

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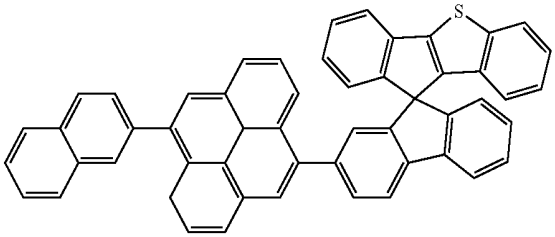

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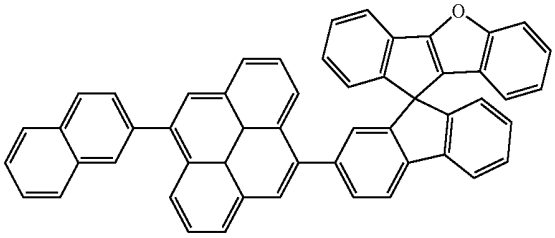

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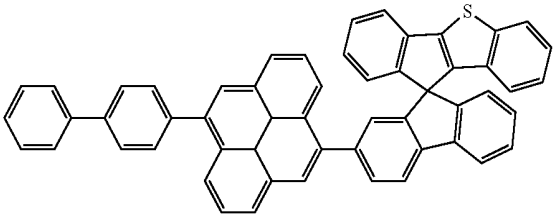

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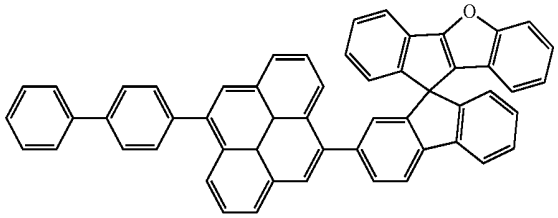

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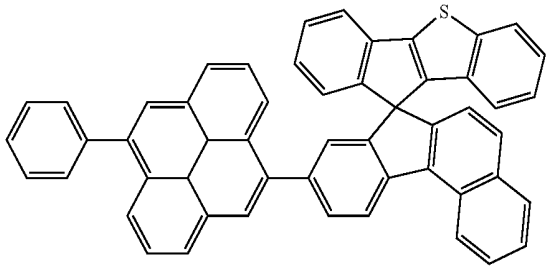

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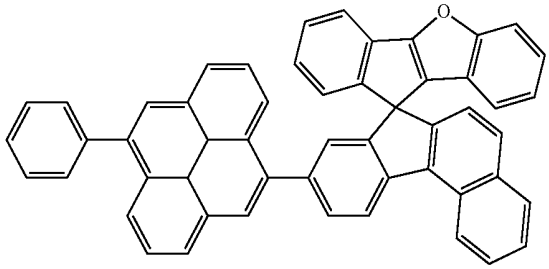


[0142] The condensed cyclic compound represented by Formula 1 may have a condensed cyclic core based on spiro-bifluorene. Accordingly, deterioration of the condensed cyclic compound represented by Formula 1 due to electrons may be reduced and/or prevented. Thus, an electron device, e.g., an organic light-emitting device, including the condensed cyclic compound represented by Formula 1 may have a long lifespan.

[0143] In an implementation, the condensed cyclic compound represented by Formula 1 may have a relatively high charge transport capability (holes or electrons), and accordingly, in an emission layer in an organic light-emitting device using the condensed cyclic compound represented by Formula 1, an exciton formation ratio may be increased, providing an organic light-emitting device with high efficiency and low driving voltage.

[0144] Regarding the condensed cyclic compound represented by Formula 1, in the case in which: the sum of c1 and c2 is 1 or more, and L_1 and L_2 are each independently selected from or include substituted or unsubstituted condensed polycyclic groups in which "3 or more carbocyclic groups" are condensed with each other; and a ring-forming atom is not a heteroatom [e.g., regarding Formula 1, "L_1" in a group represented by *-[$(L_1)_{a1}$-$(R_1)_{b1}$] and "L_2" in a group represented by *-[$(L_2)_{a2}$-$(R_2)_{b2}$] are present or essentially exist (each of a1 and a2 is not 0), and L_1 and L_2 are each independently selected from or include substituted or unsubstituted condensed polycyclic groups in which "3 or more carbocyclic groups" are condensed with each other; and a ring-forming atom is not a heteroatom], when the condensed cyclic compound represented by Formula 1 is used as a host in an emission layer of an organic light-emitting device, an energy level between a host and a dopant may be efficiently adjusted, enabling an efficient energy transition between the host and the dopant. Accordingly, an electron device, e.g., an organic light-emitting device, including the condensed cyclic compound represented by Formula 1 may have a long lifespan.

[0145] The condensed cyclic compound represented by Formula 1 may be synthesized by using a suitable organic synthetic method.

[0146] At least one of the condensed cyclic compounds represented by Formula 1 may be used or included between a pair of electrodes of an organic light-emitting device. For example, the condensed cyclic compound may be included in an emission layer. In some embodiments, the condensed cyclic compound represented by Formula 1 may be used as a material for a capping layer on the outside of a pair of electrodes of an organic light-emitting device.

[0147] Accordingly, an organic light-emitting device according to an embodiment may include 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. The organic layer may include at least one condensed cyclic compound represented by Formula 1.

[0148] The expression, "(for example, the organic layer) includes at least one condensed cyclic compound" used herein may be construed as "(the organic layer) includes one of the condensed cyclic compounds of Formula 1 or at least two different condensed cyclic compounds of Formula 1."

[0149] For example, the organic layer may include only Compound 1 as the condensed cyclic compound. In this regard, Compound 1 may be in the emission layer of the organic light-emitting device. Alternatively, the organic layer may include Compound 1 and Compound 2 as the condensed cyclic compounds. In this regard, Compound 1 and Compound 2 may be in the same layer (e.g., Compound 1 and Compound 2 may both be in the emission layer) or may be in different layers from each other (e.g., Compound 1 may be in a hole transport layer, and Compound 2 may be in the emission layer).

[0150] The organic layer may include a hole transport region between the first electrode (anode) and the emission layer, and an electron transport region between the emission layer and the second electrode (cathode). The hole transport region may include a hole injection layer, a hole transport layer, a buffer layer, an electron blocking layer, or any combination thereof and the electron transport region may include a hole blocking layer, an electron transport layer, an electron injection layer, or any combination thereof. For example, the emission layer of the organic light-emitting device may include at least one of condensed cyclic compounds represented by Formula 1. The condensed cyclic compound represented by Formula 1 included in the emission layer may serve as a host, and in this regard, the emission layer may further include a dopant. The dopant may be a phosphorescent dopant or a fluorescent dopant. In some embodiments, the dopant may be a fluorescent dopant.

[0151] The organic light-emitting device may further include at least one of a first capping layer disposed in a path along which light generated in the emission layer is extracted toward the outside through the first electrode, and a second capping layer disposed in a path along which light

generated in the emission layer is extracted toward the outside through the second electrode, wherein at least one of the first capping layer and the second capping layer may include at least one of the condensed cyclic compounds described above

[0152] For example, the organic light-emitting device may have i) a structure including a first electrode, an organic layer, a second electrode, and a second capping layer, which are sequentially stacked in this stated order, ii) a structure including a first capping layer, a first electrode, an organic layer, and a second electrode, which are sequentially stacked in this stated order, or iii) a structure including a first capping layer, a first electrode, an organic layer, a second electrode, and a second capping layer, which are sequentially stacked in this stated order, wherein the condensed cyclic compound may be included in at least one of the first capping layer and the second capping layer.

[0153] The term "organic layer" used herein refers to a single layer and/or a plurality of layers between the first electrode and the second electrode of the organic light-emitting device. A material included in the "organic layer" is not limited to an organic compound.

[0154] FIG. **1** illustrates a schematic cross-sectional 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**.

[0155] Hereinafter, the structure of an organic light-emitting device according to an embodiment and a method of manufacturing an organic light-emitting device according to an embodiment will be described in connection with FIG. **1**.

[0156] In an implementation, 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 transparent plastic substrate, each with excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water-resistance.

[0157] 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. The first electrode **110** may be a reflective electrode or a transmissive electrode. The material for the first electrode **110** may be a transparent and highly conductive material, and examples of such a material are indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO_2), and zinc oxide (ZnO). When the first electrode **110** is a semi-transmissive electrode or a reflective electrode, as a material for forming the first electrode **110**, at least one of magnesium (Mg), aluminum(Al), aluminum-lithium(Al—Li), calcium (Ca), magnesium-indium(Mg—In), magnesium-silver (Mg—Ag) may be used.

[0158] The first electrode **110** may have a single-layer structure, or a multi-layer structure including two or more layers. For example, the first electrode **110** may have a three-layered structure of ITO/Ag/ITO.

[0159] An organic layer **150** is disposed on the first electrode **110**. The organic layer **150** may include an emission layer.

[0160] The organic layer **150** may further include a hole transport region disposed between the first electrode and the emission layer, and an electron transport region disposed between the emission layer and the second electrode.

[0161] The hole transport region may include at least one selected from a hole injection layer (HIL), a hole transport layer (HTL), a buffer layer, and an electron blocking layer (EBL), and the electron transport region may include at least one selected from a hole blocking layer (HBL), an electron transport layer (ETL), and an electron injection layer (EIL).

[0162] The hole transport region may have a single-layered structure formed of a single material, a single-layered structure formed of a plurality of different materials, or a multi-layered structure having a plurality of layers formed of a plurality of different materials.

[0163] For example, the hole transport region may have a single-layered structure formed of a plurality of different materials, or a structure of hole injection layer/hole transport layer, a structure of hole injection layer/hole transport layer/buffer layer, a structure of hole injection layer/buffer layer, a structure of hole transport layer/buffer layer, or a structure of hole injection layer/hole transport layer/electron blocking layer, wherein layers of each structure are sequentially stacked from the first electrode **110** in this stated order.

[0164] When the hole transport region includes a hole injection layer, the hole injection layer may be formed on the first electrode **110** by using one or more methods selected from vacuum deposition, spin coating, casting, a Langmuir-Blodgett (LB) method, ink-jet printing, laser-printing, and laser-induced thermal imaging.

[0165] When a hole injection layer is formed by vacuum deposition, for example, the vacuum deposition may be performed at a temperature of a deposition temperature of about 100 to about 500° C., at a vacuum degree of about 10^{-8} to about 10^{-3} torr, and at a deposition rate of about 0.01 to about 100 Å/sec by taking into account a compound for a hole injection layer to be deposited, and the structure of a hole injection layer to be formed.

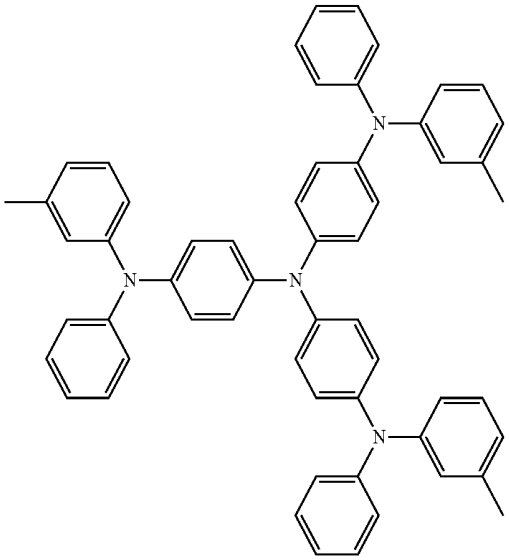
[0166] When a hole injection layer is formed by spin coating, the spin coating may be performed at a coating rate of about 2000 rpm to about 5000 rpm, and at a temperature of about 80° C. to 200° C. by taking into account a compound for a hole injection layer to be deposited, and the structure of a hole injection layer to be formed.

[0167] When the hole transport region includes a hole transport layer, the hole transport layer may be formed on the first electrode **110** or the hole injection layer by using one or more methods selected from vacuum deposition, spin coating, casting, a LB method, ink-jet printing, laser-printing, and laser-induced thermal imaging. When the hole transport layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the hole transport layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

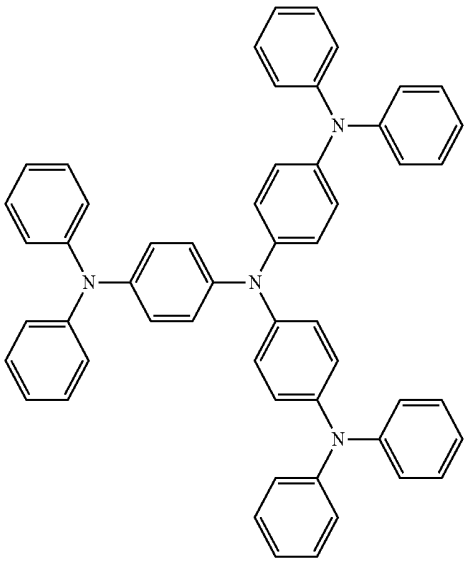
[0168] The hole transport region may include the condensed cyclic compound represented by Formula 1. For example, the hole transport region may include the hole transport layer, and the hole transport layer may include the condensed cyclic compound represented by Formula 1.

[0169] In some embodiments, the hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB, 13-NPB, TPD, Spiro-TPD, Spiro-NPB, α-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 sulfonicacid (Pani/CSA), (polyaniline)/poly(4-

styrenesulfonate) (PANI/PSS), a compound represented by Formula 201 below, and a compound represented by Formula 202 below:



m-MTDATA



TDATA

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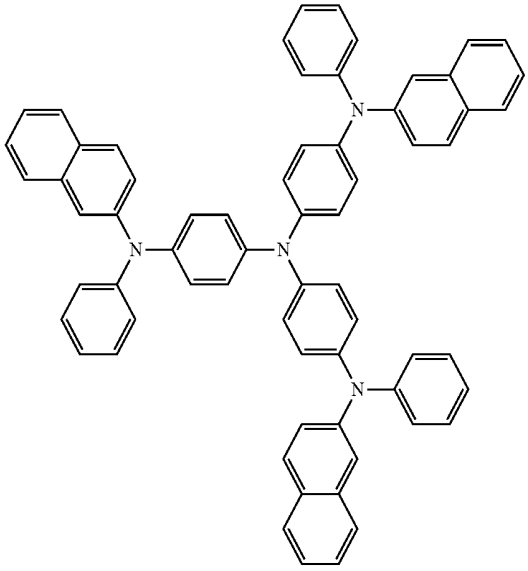
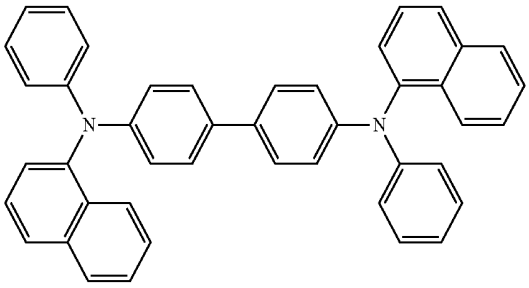
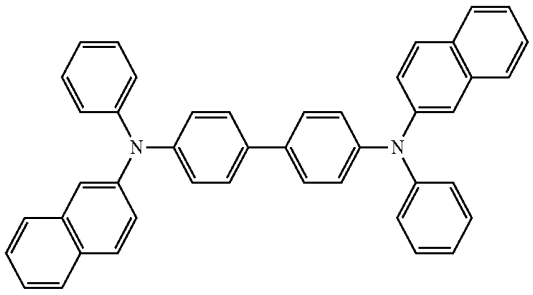


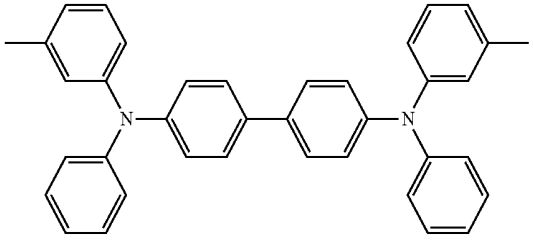
2-TNATA



NPB



β-NPB



TPD

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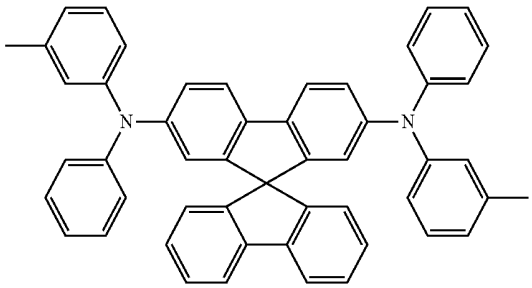
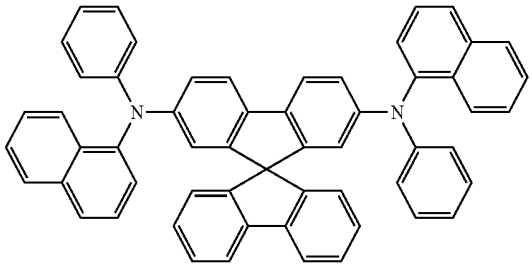


Spiro-TPD



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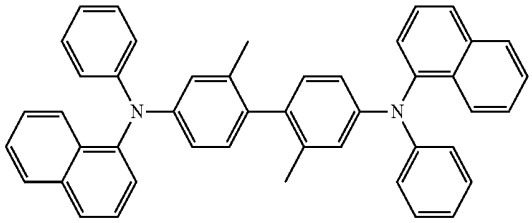
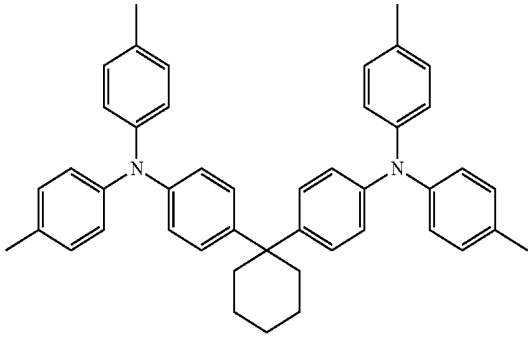


methylated NPB



TAPC

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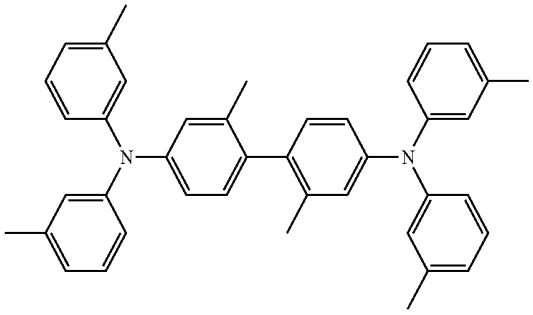
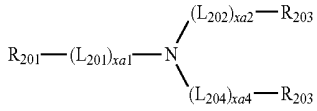
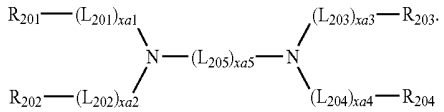


HMTPD

<Formula 201>



<Formula 202>



[0170] In Formulae 201 and 202,

[0171] L_{201} to L_{205} may be each independently understood by referring to the description of L_1 provided herein,

[0172] xa1 to xa4 may be each independently selected from 0, 1, 2, and 3,

[0173] xa5 may be selected from 1, 2, 3, 4, and 5, and

[0174] R_{201} to R_{204} may be each independently selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0175] For example, in Formulae 201 and 202,

[0176] L_{201} to L_{205} may be each independently selected from

[0177] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorene group, a dibenzofluorene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene group; and

[0178] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluore-

nylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a pyrenylene group, a chrysenylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylene group, a quinazolinylene group, a carbazolylene group, and a triazinylene 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 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 pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group,

[0179] xa1 to xa4 may be each independently 0, 1, or 2,

[0180] xa5 may be 1, 2, or 3, and

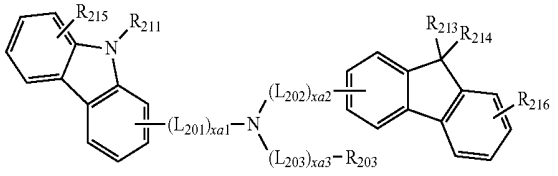
[0181] R_{201} to R_{204} may be each independently selected from

[0182] 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 pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

[0183] 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 pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl 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 phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, an azulenyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group.

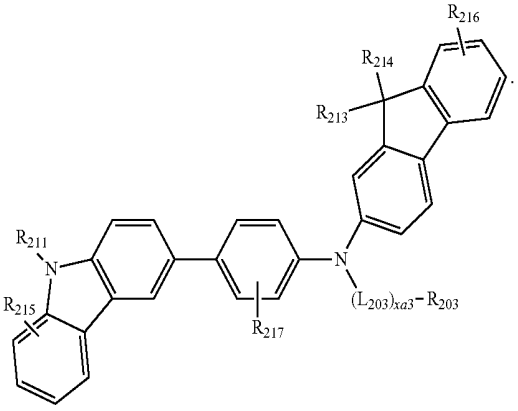
[0184] The compound represented by Formula 201 may be represented by Formula 201A:

<Formula 201A>



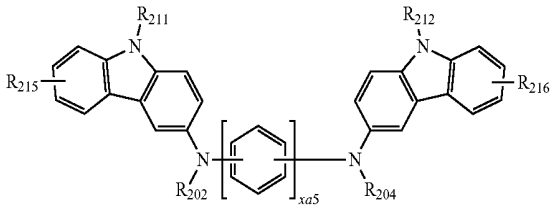
[0185] For example, the compound represented by Formula 201 may be represented by Formula 201A-1:

<Formula 201A-1>



[0186] The compound represented by Formula 202 may be represented by Formula 202A:

<Formula 202A>

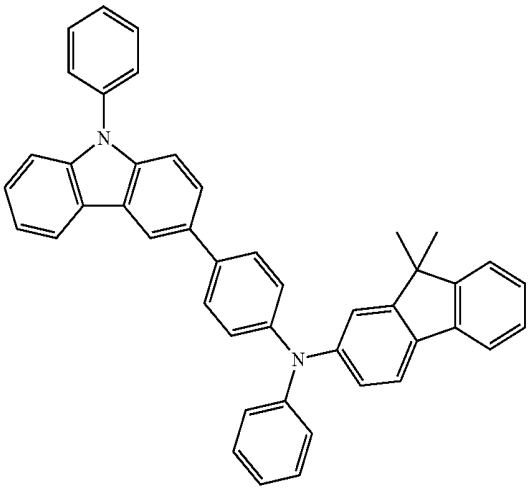


[0187] In Formulae 201A, 201A-1, and 202A, L_{201} to L_{203}, xa1 to xa3, xa5, and R_{202} to R_{204} may be understood by referring to descriptions thereof provided herein, R_{211} and R_{212} may be understood by referring to the description of R_{203}, and R_{213} to R_{217} may be each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone

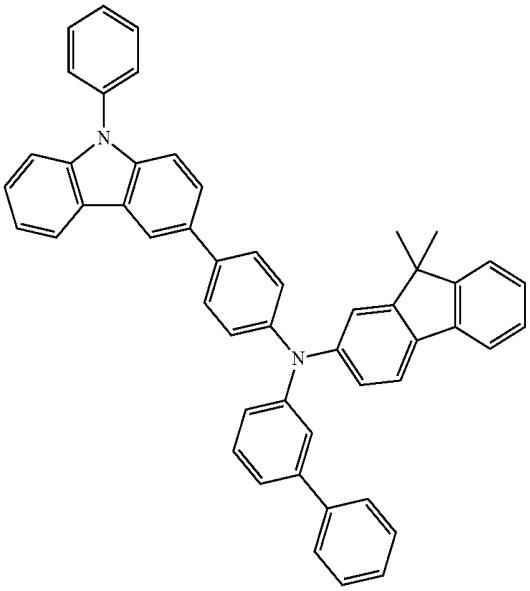
group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0188] The compound represented by Formula 201 and the compound represented by Formula 202 may each include Compounds HT1 to HT20.

HT1

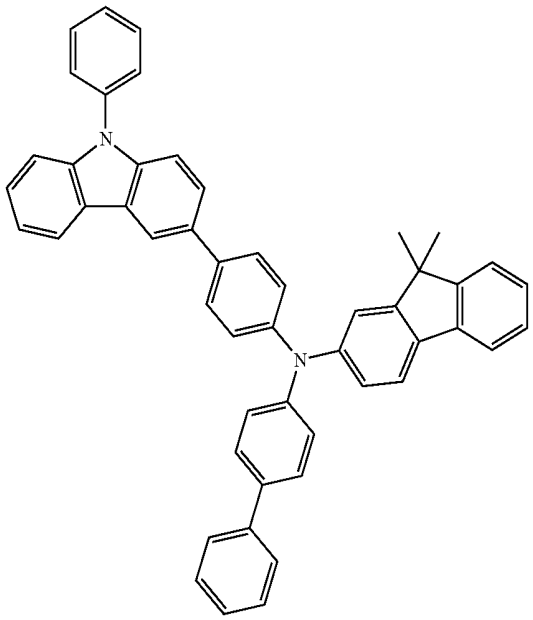


HT2

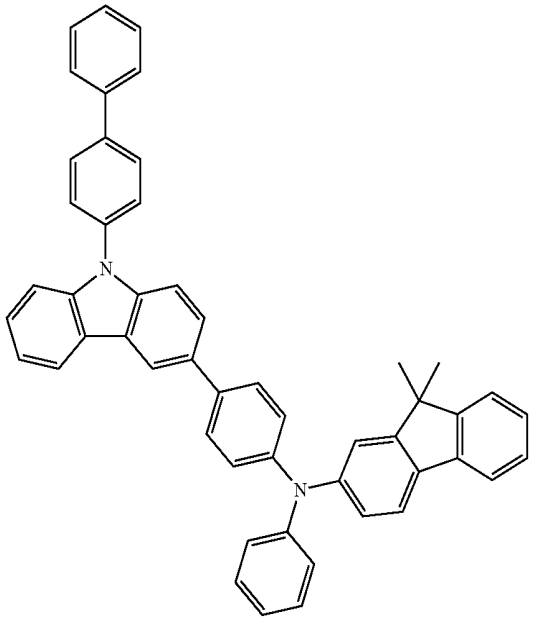


-continued

HT3

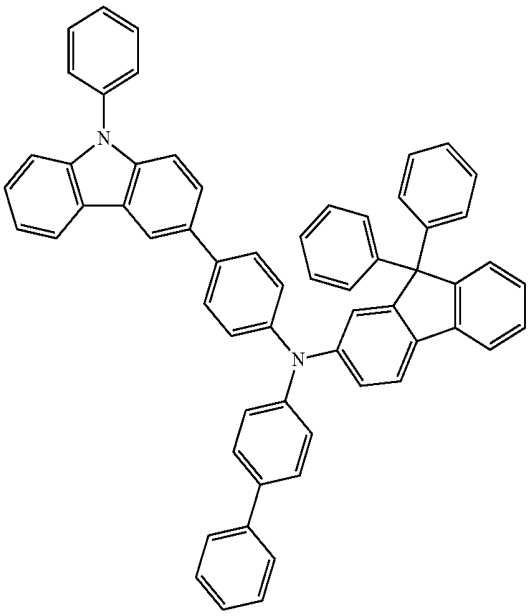


HT4

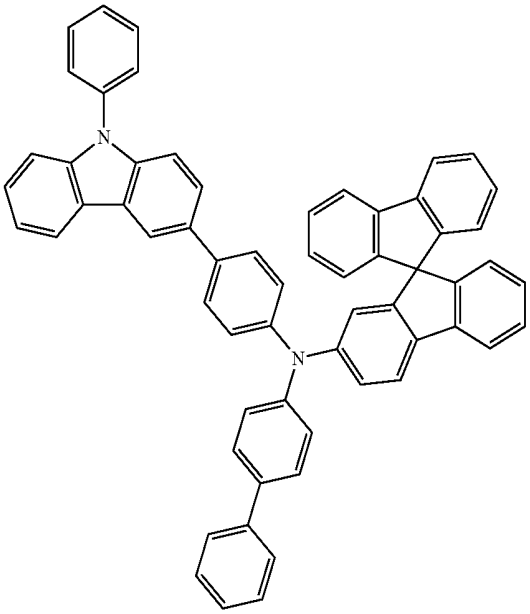


-continued

HT5

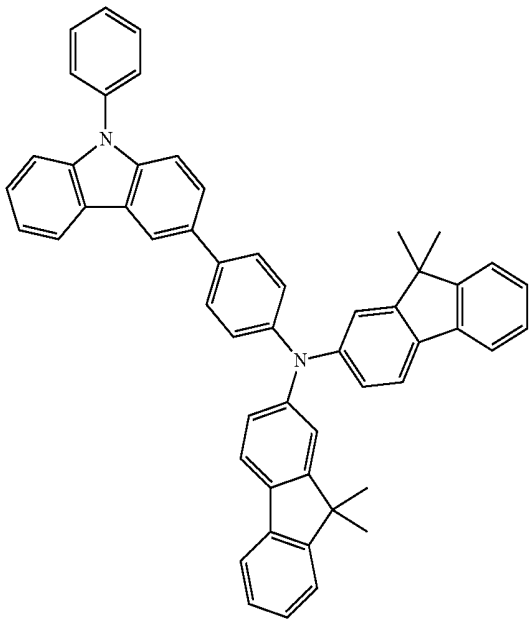


HT6

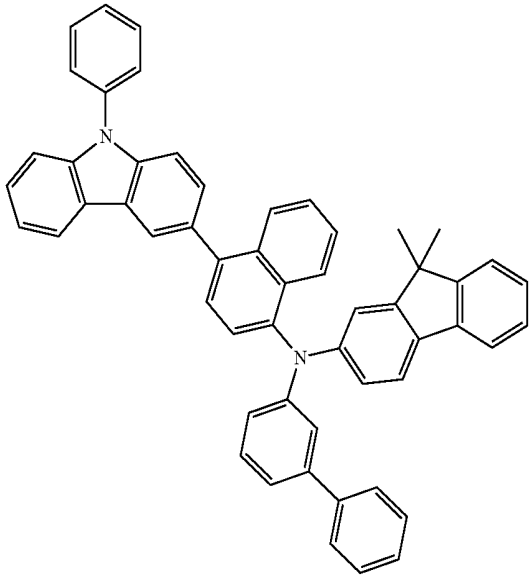


-continued

HT7

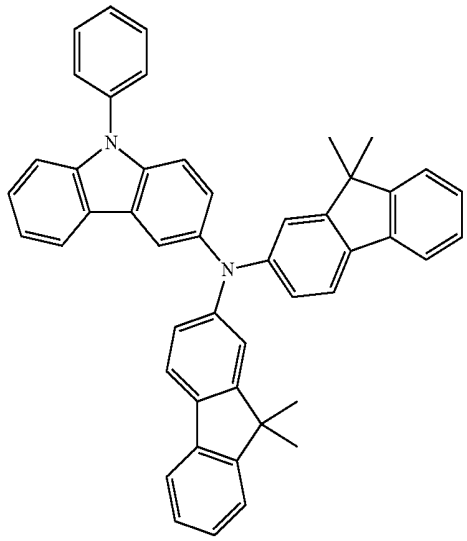


HT8



-continued

HT9



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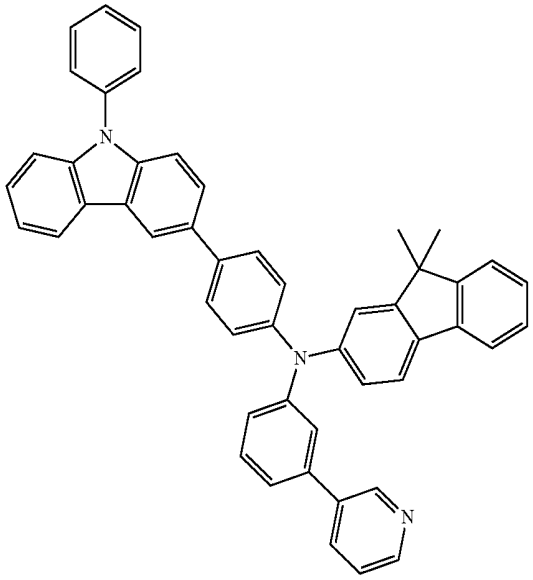
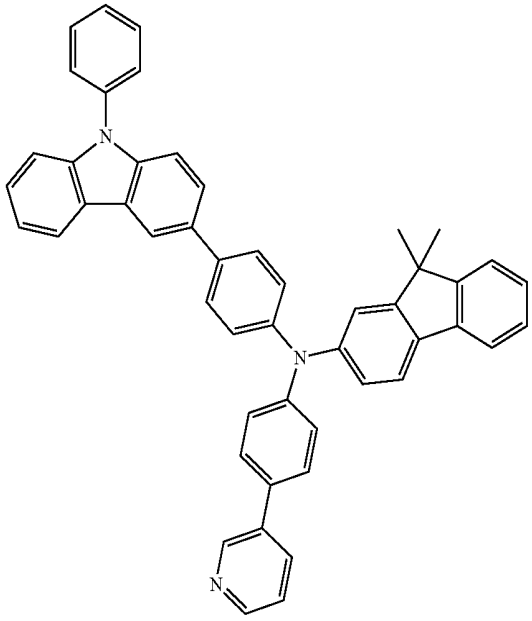
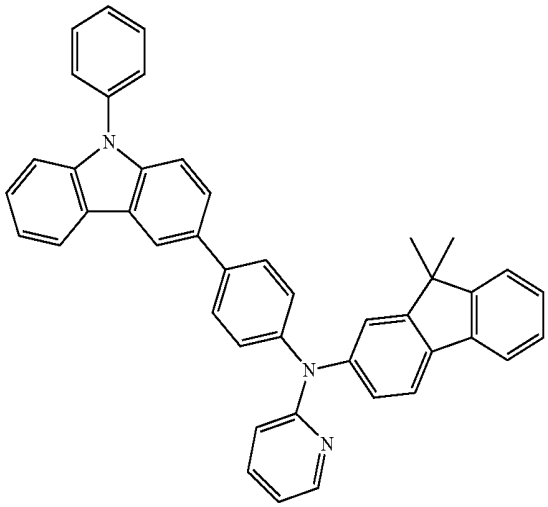
HT11



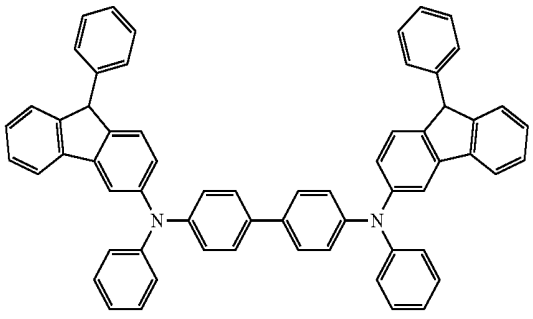
HT10



HT12

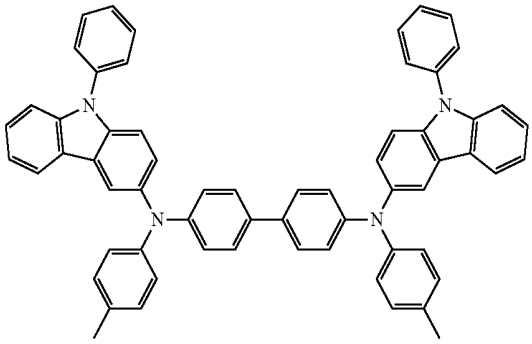


HT13

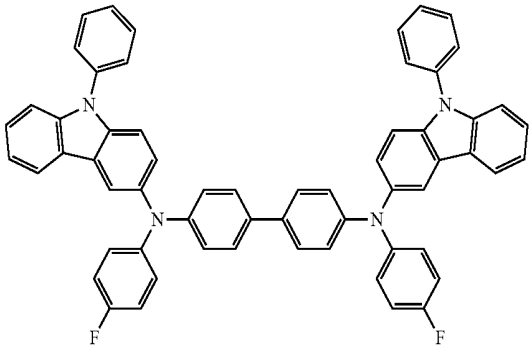


-continued

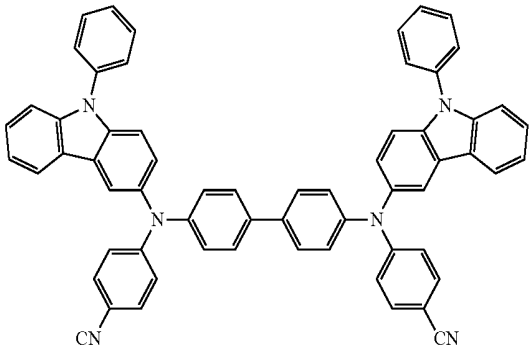
HT14



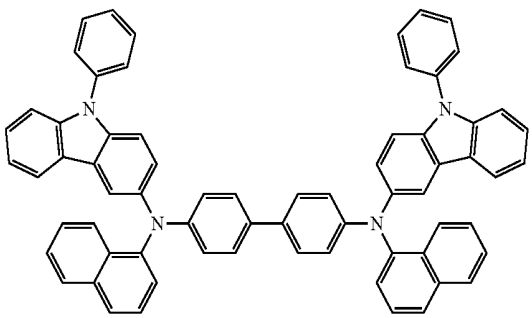
HT15



HT16

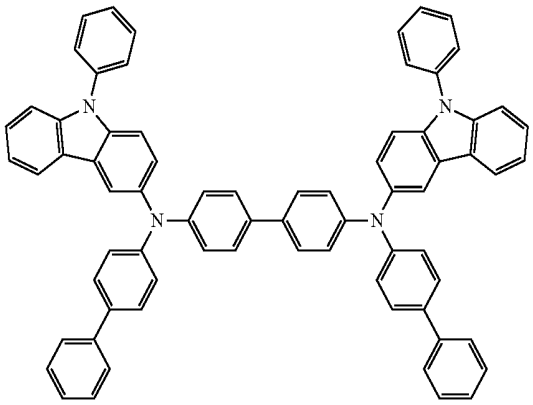


HT17

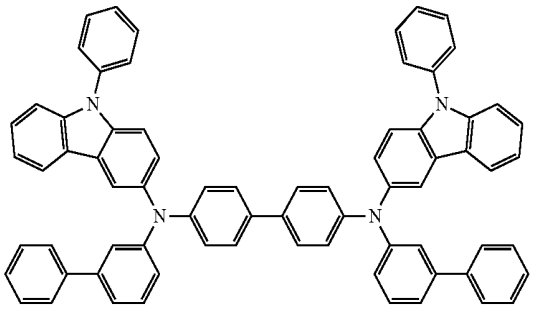


-continued

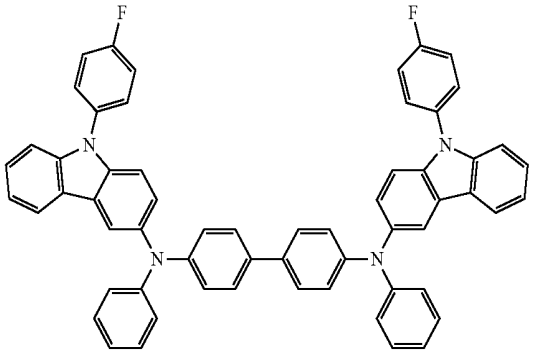
HT18



HT19



HT20

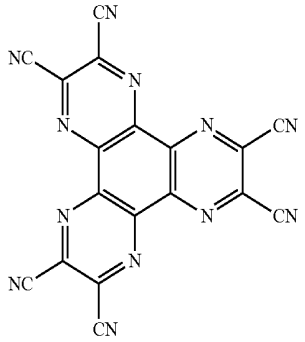


[0189] A thickness of the hole transport region may be in a range of about 100 Å to about 10000 Å, for example, about 100 Å to about 1000 Å. When the hole transport region includes at least one of a hole injection layer and a hole transport layer, the thickness of the hole injection layer may be in a range of about 100 Å to about 10,000 Å, and for example, about 100 Å to about 1,000 Å, and the thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, and for example, about 100 Å to about 1500 Å. When the thicknesses of the hole transport region, the hole injection layer and the hole transport layer are within these ranges, satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

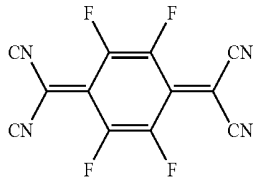
[0190] The hole transport region may further include, in addition to these materials, a charge-generation material for the improvement of conductive properties. The charge-generation material may be homogeneously or unhomogeneously dispersed in the hole transport region.

[0191] The charge-generation material may be, e.g., a p-dopant. The p-dopant may be one selected from a quinone derivative, a metal oxide, and a cyano group-containing compound. For example, non-limiting examples of the p-dopant are a quinone derivative, such as tetracyanoquinonedimethane (TCNQ) or 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonedimethane (F4-TCNQ); a metal oxide, such as a tungsten oxide or a molybdenum oxide, and Compound HT-D1 illustrated below.

<Compound HT-D1>



<F4-TCNQ>



[0192] The hole transport region may further include, in addition to the hole injection layer and the hole transport layer, at least one of a buffer layer and an electron blocking layer. Since the buffer layer may compensate for an optical resonance distance according to a wavelength of light emitted from the emission layer, light-emission efficiency of a formed organic light-emitting device may be improved. For use as a material included in the buffer layer, materials that are included in the hole transport region may be used. The electron blocking layer prevents injection of electrons from the electron transport region.

[0193] An emission layer is formed on the first electrode **110** or the hole transport region by using one or more methods selected from vacuum deposition, spin coating, casting, a LB method, ink-jet printing, laser-printing, and laser-induced thermal imaging. When the emission layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the emission layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

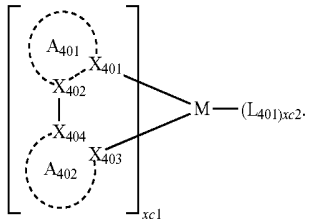
[0194] When the organic light-emitting device **10** is a full color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, or a blue emission layer, according to a sub pixel. In some embodiments, the emission layer may have a stacked structure of a red emission layer, a green emission layer, and a blue emission layer, or may include a red-light emission material, a green-light emission material, and a blue-light emission material, which are mixed with each other in a single layer, to emit white light.

[0195] The emission layer may include the host and dopant. The host may include the condensed cyclic compound represented by Formula 1.

[0196] The dopant may include a phosphorescent dopant or a fluorescent dopant.

[0197] The phosphorescent dopant may include an organometallic complex represented by Formula 401:

<Formula 401>



[0198] In Formula 401,

[0199] M may be selected from iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), and thulium (TM),

[0200] X_{401} to X_{404} may be each independently nitrogen or carbon,

[0201] A_{401} and A_{402} rings may be each independently selected from a substituted or unsubstituted benzene, a substituted or unsubstituted naphthalene, a substituted or unsubstituted fluorene, a substituted or unsubstituted spiro-bifluorene, a substituted or unsubstituted indene, a substituted or unsubstituted pyrrole, a substituted or unsubstituted thiophene, a substituted or unsubstituted furan, a substituted or unsubstituted imidazole, a substituted or unsubstituted pyrazole, a substituted or unsubstituted thiazole, a substituted or unsubstituted isothiazole, a substituted or unsubstituted oxazole, a substituted or unsubstituted isoxazole, a substituted or unsubstituted pyridine, a substituted or unsubstituted pyrazine, a substituted or unsubstituted pyrimidine, a substituted or unsubstituted pyridazine, a substituted or unsubstituted quinoline, a substituted or unsubstituted isoquinoline, a substituted or unsubstituted benzoquinoline, a substituted or unsubstituted quinoxaline, a substituted or unsubstituted quinazoline, a substituted or unsubstituted carbazole, a substituted or unsubstituted benzoimidazole, a substituted or unsubstituted benzofuran, a substituted or unsubstituted benzothiophene, a substituted or unsubstituted isobenzothiophene, a substituted or unsubstituted benzoxazole, a substituted or unsubstituted isobenzoxazole, a substituted or unsubstituted triazole, a substituted or unsubstituted oxadiazole, a substituted or unsubstituted triazine, a substituted or unsubstituted dibenzofuran, and a substituted or unsubstituted dibenzothiophene,

[0202] at least one of substituents of the substituted benzene, substituted naphthalene, substituted fluorene, substituted spiro-bifluorene, substituted indene, substituted pyrrole, substituted thiophene, substituted furan, substituted imidazole, substituted pyrazole, substituted thiazole, substituted isothiazole, substituted oxazole, substituted isoxazole, substituted pyridine, substituted pyrazine, substituted pyrimidine, substituted pyridazine, substituted quinoline, substituted isoquinoline, substituted benzoquinoline, substituted quinoxaline, substituted quinazoline, substituted carbazole, substituted benzoimidazole, substituted benzofuran, substituted benzothiophene, substituted isobenzothiophene,

substituted benzoxazole, substituted isobenzoxazole, substituted triazole, substituted oxadiazole, substituted triazine, substituted dibenzofuran, and substituted dibenzothiophene may be selected from

[0203] 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_{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;

[0204] 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 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_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} 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, —$N(Q_{401})(Q_{402})$, —$Si(Q_{403})(Q_{404})(Q_{405})$, and —$B(Q_{406})(Q_{407})$;

[0205] a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} 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, and a monovalent non-aromatic condensed heteropolycyclic group;

[0206] a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} 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, 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 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_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} 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, —$N(Q_{411})(Q_{412})$, —$Si(Q_{413})(Q_{414})(Q_{415})$, and —$B(Q_{416})(Q_{417})$; and

[0207] —$N(Q_{421})(Q_{422})$, —$Si(Q_{423})(Q_{424})(Q_{425})$, and —$B(Q_{426})(Q_{427})$,

[0208] L_{401} is an organic ligand,

[0209] xc1 is 1, 2, or 3, and

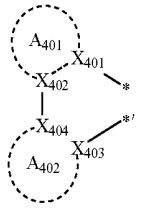
[0210] xc2 is 0, 1, 2, or 3.

[0211] L_{401} may be a monovalent, divalent, or trivalent organic ligand. For example, L_{401} may be selected from a halogen ligand (for example, Cl or F), a diketone ligand (for example, acetylacetonate, 1,3-diphenyl-1,3-propandionate, 2,2,6,6-tetramethyl-3,5-heptandionate, or hexafluoroacetonate), a carboxylic acid ligand (for example, picolinate, dimethyl-3-pyrazolecarboxylate, or benzoate), a carbon monooxide ligand, an isonitrile ligand, a cyano ligand, and a phosphorous ligand (for example, phosphine, and phosphite).

[0212] Q_{401} to Q_{407}, Q_{411} to Q_{417}, and Q_{421} to Q_{427} may be each independently selected from hydrogen, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_6-C_{60} aryl group, and a C_2-C_{60} heteroaryl group.

[0213] When A_{401} in Formula 401 has two or more substituents, the substituents of A_{402} may be linked to each other to form a saturated or unsaturated ring.

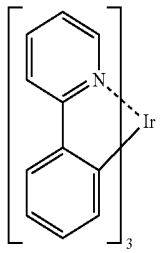
[0214] When A_{402} in Formula 402 has two or more substituents, the substituents of A_{402} may be linked to each other to form a saturated or unsaturated ring.



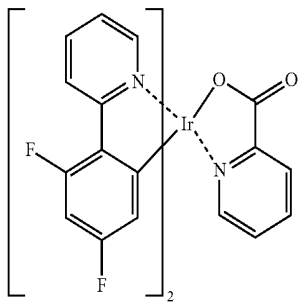
[0215] When xc1 in Formula 401 is two or more, a plurality of ligands in Formula 401 may be identical or different. When xc1 in Formula 401 is two or more, A_{401} and A_{402} may be respectively directly connected to A_{401} and A_{402} of other neighboring ligands with or without a linker (for example, a C_1-C_5 alkylene, or —N(R')— (wherein R' may be a C_1-C_{10} alkyl group or a C_6-C_{20} aryl group) or —C(═O)—) therebetween.

[0216] The phosphorescent dopant may be, for example, selected from Compounds PD1 to PD75:

PD1



PD2



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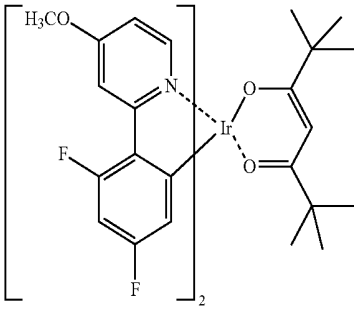
PD3



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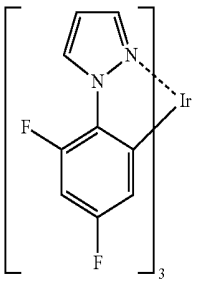

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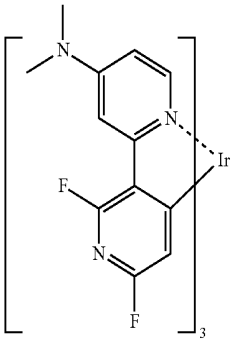

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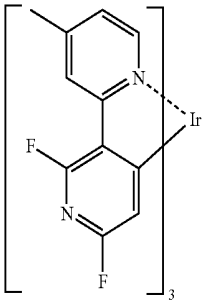

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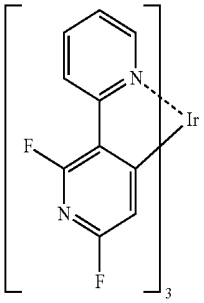

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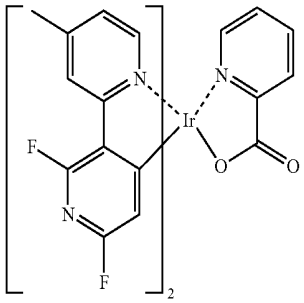

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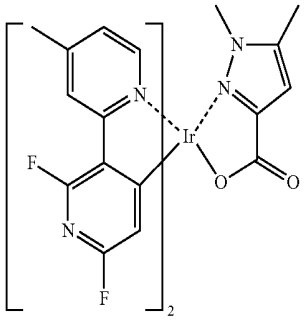

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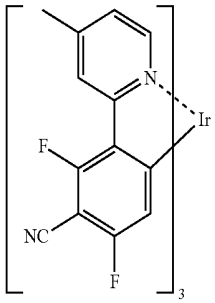

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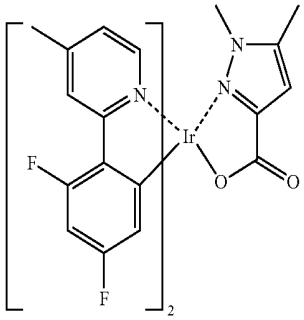

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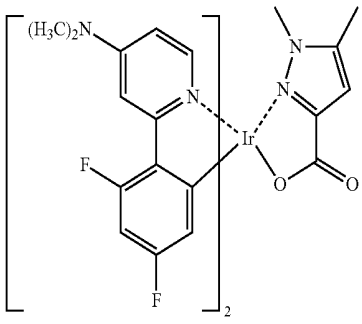

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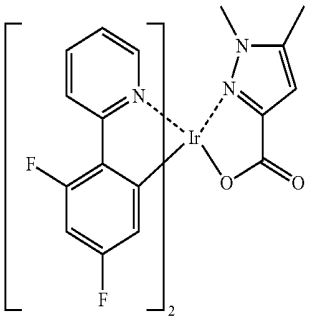

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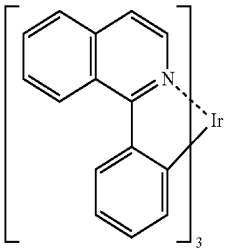

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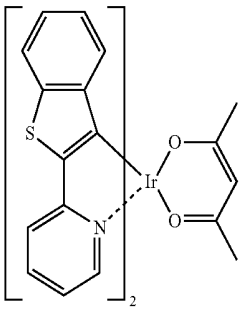

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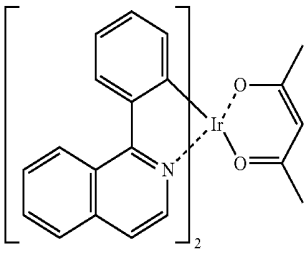

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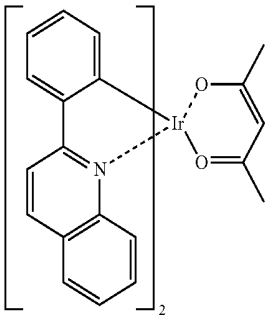

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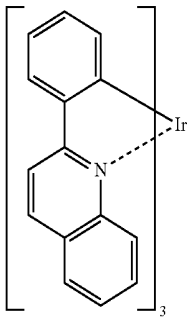

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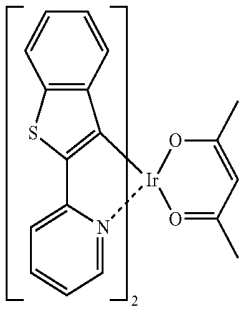

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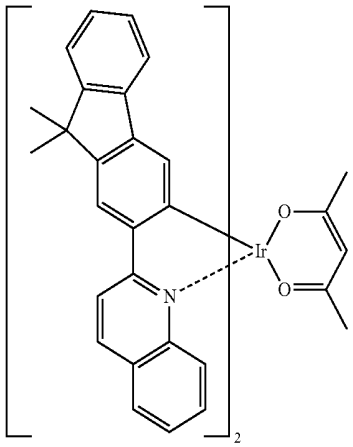

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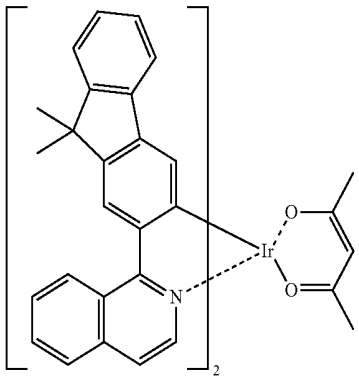

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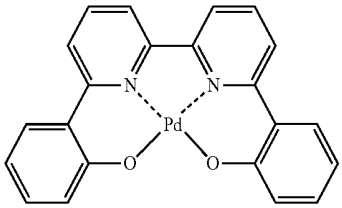

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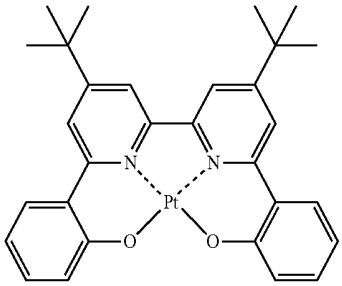

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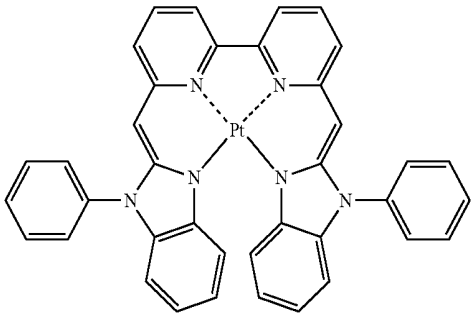

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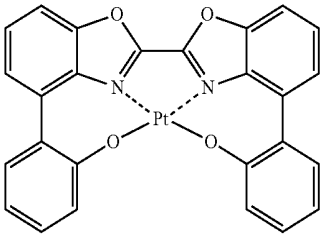

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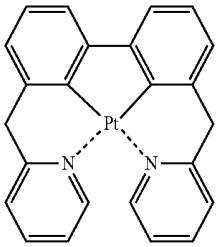

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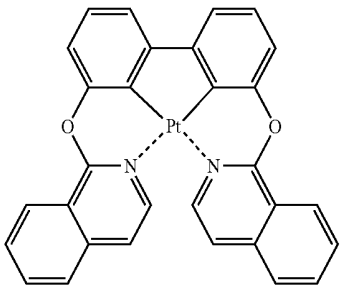

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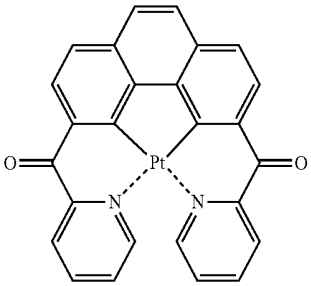

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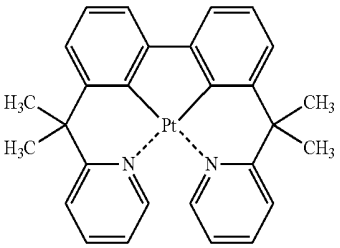

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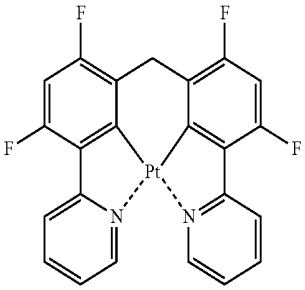

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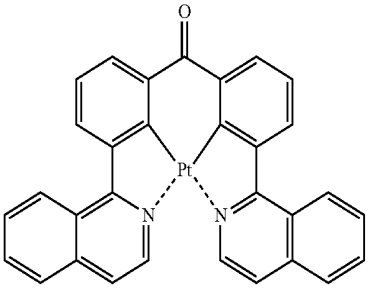

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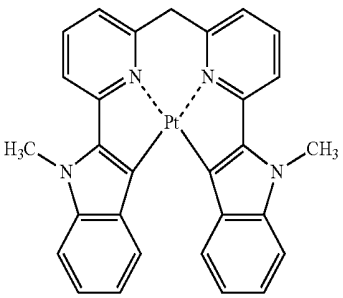

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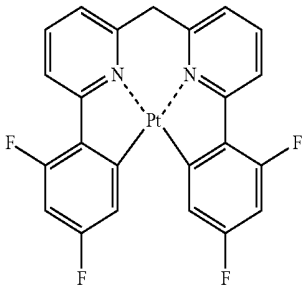

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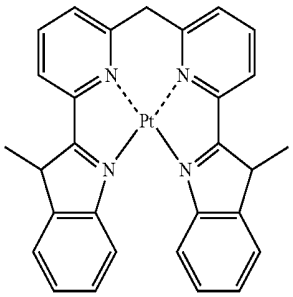

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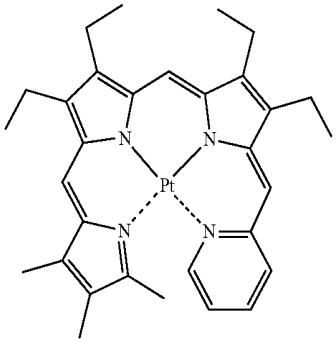

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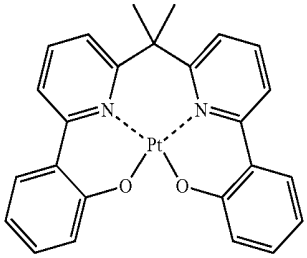

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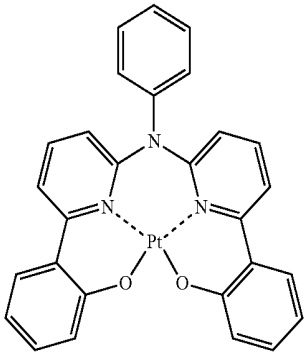

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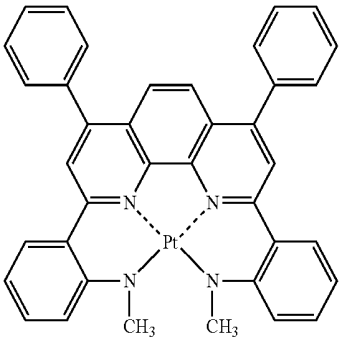

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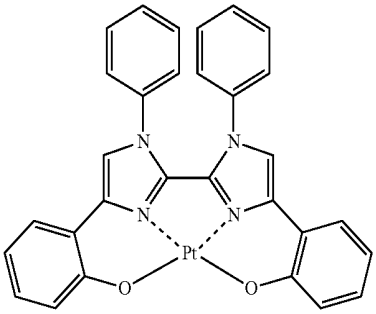

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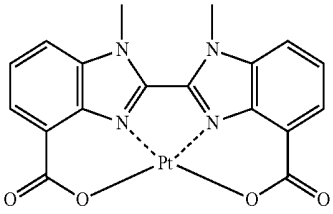

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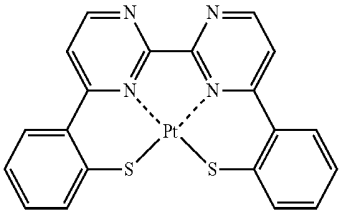

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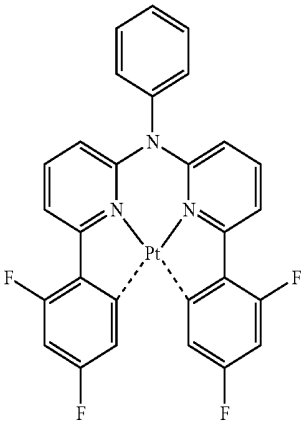

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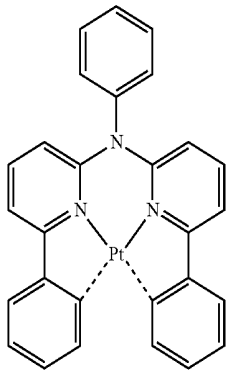

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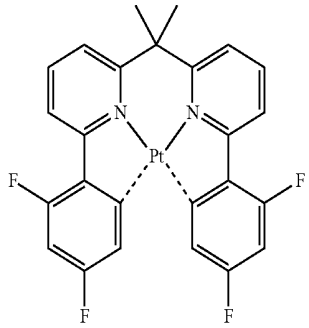

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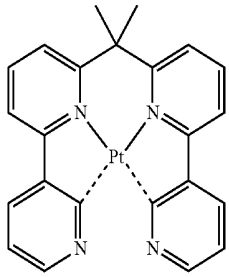

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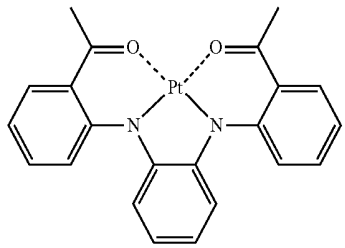

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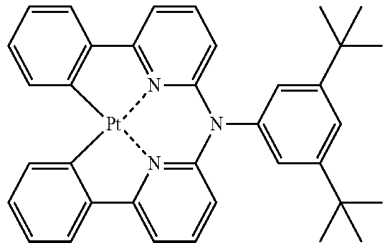

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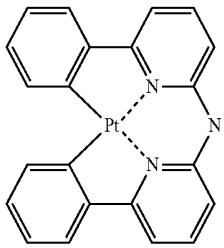

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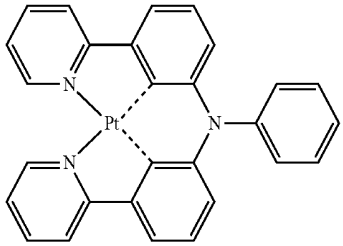

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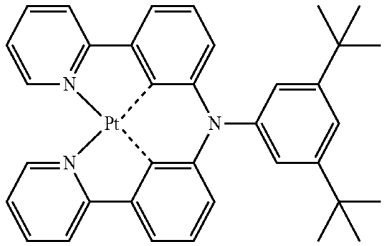

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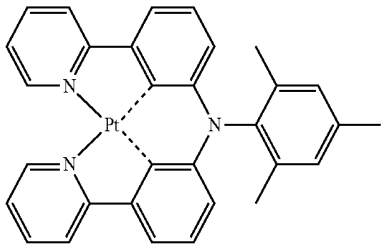

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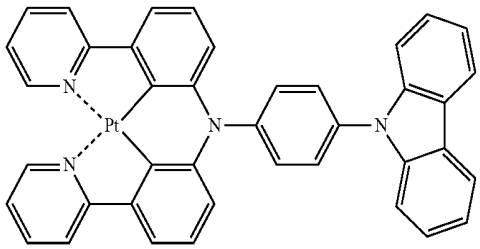

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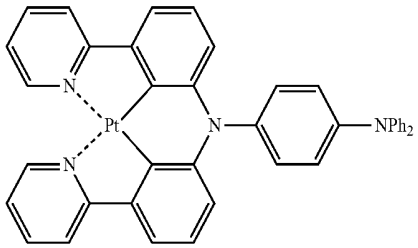

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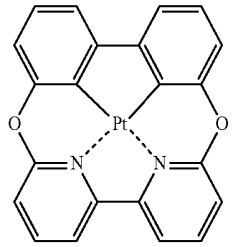

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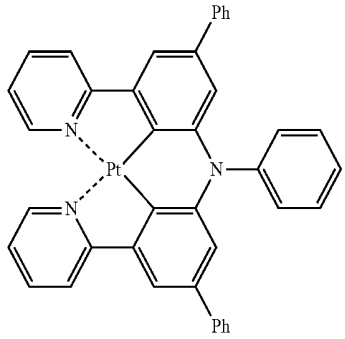

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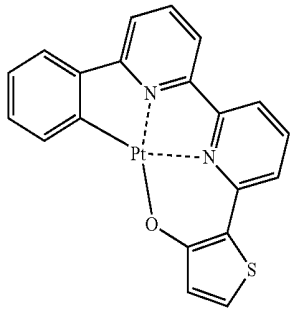

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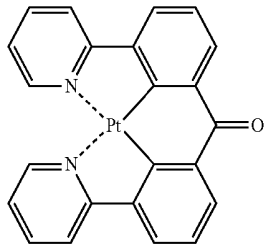
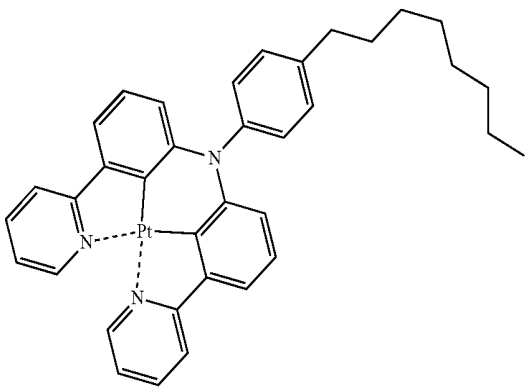


PD58



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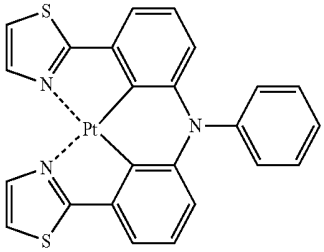

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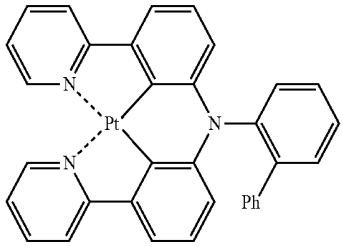

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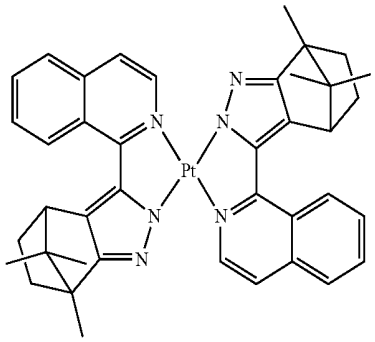

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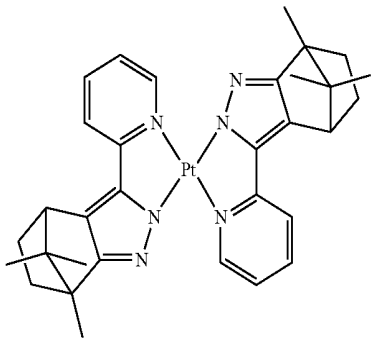

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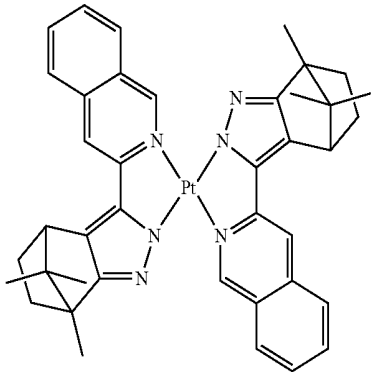

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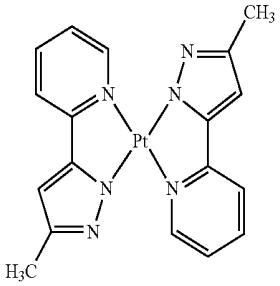

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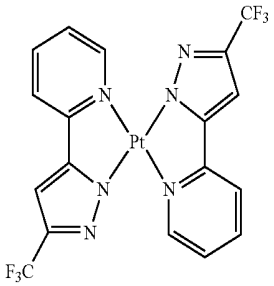

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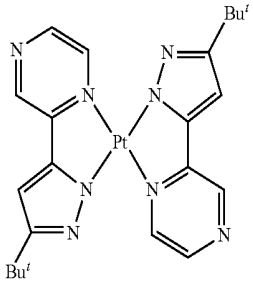

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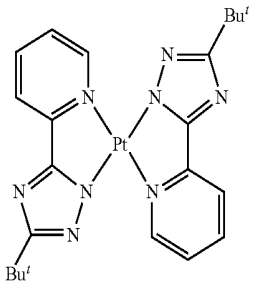

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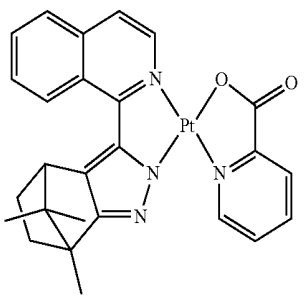

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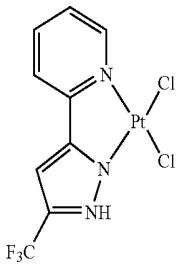
PD69



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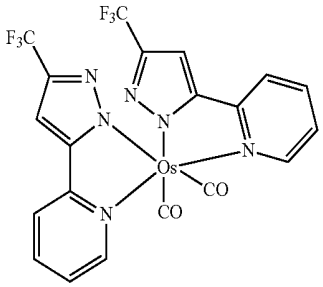

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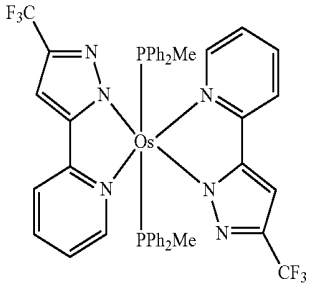

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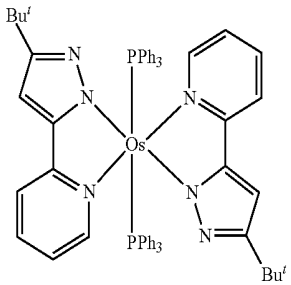

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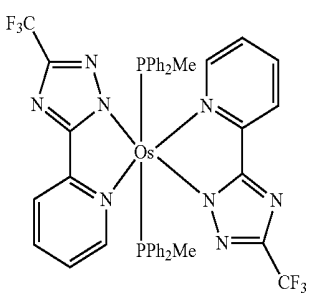

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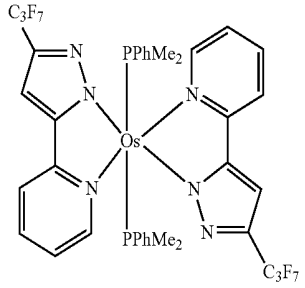
PD74



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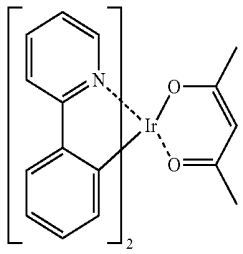
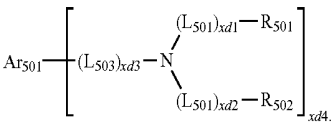


[0217] The fluorescent dopant may include a compound represented by Formula 501:

<Formula 501>



[0218] In Formula 501,

[0219] Ar_{501} may be selected from

[0220] a naphthalene, a heptalene, a fluorene, spiro-bifluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene; and

[0221] a naphthalene, a heptalene, a fluorene, spiro-bifluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene, 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_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_2-C_{10} heterocycloalkyl group, a C_3-C_{10} 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, and —$Si(Q_{501})(Q_{502})(Q_{503})$ (wherein Q_{501} to Q_{503} may be each independently selected from hydrogen, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_6-C_{60} aryl group, and a C_2-C_{60} heteroaryl group),

[0222] L_{501} to L_{503} may each be understood by referring to the description of L_1 provided herein,

[0223] R_{501} and R_{502} may be each independently selected from a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazole group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and

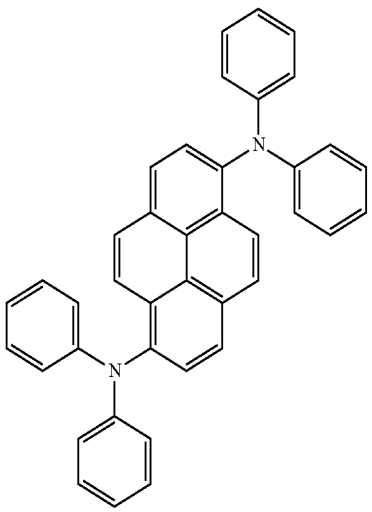
[0224] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl 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 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 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 pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a dibenzofuranyl group, and a dibenzothiophenyl group,

[0225] xd1 to xd3 may be each independently selected from 0, 1, 2, and 3, and

[0226] xd4 may be selected from 1, 2, 3, and 4.

[0227] In an implementation, the fluorescent host may include at least one of Compounds FD1 to FD9:

FD1



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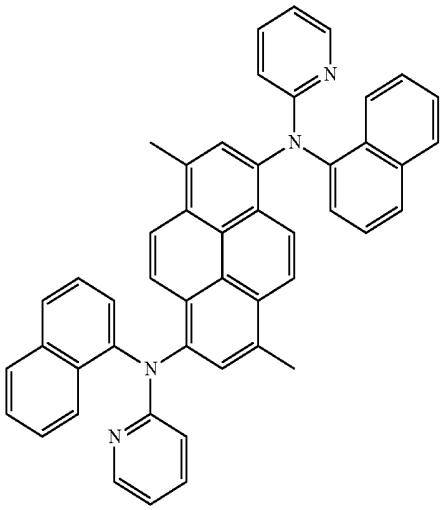
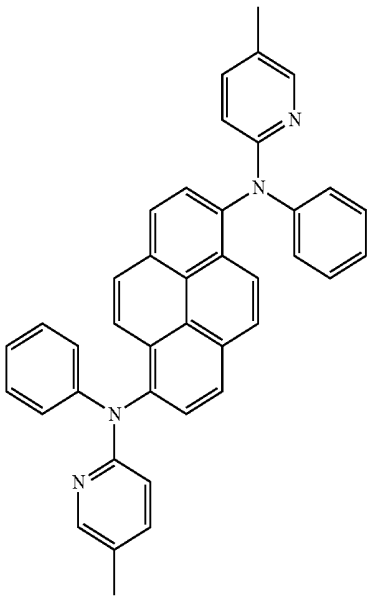
FD2



FD3



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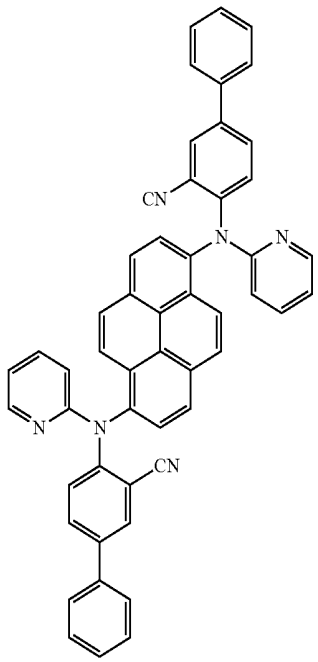
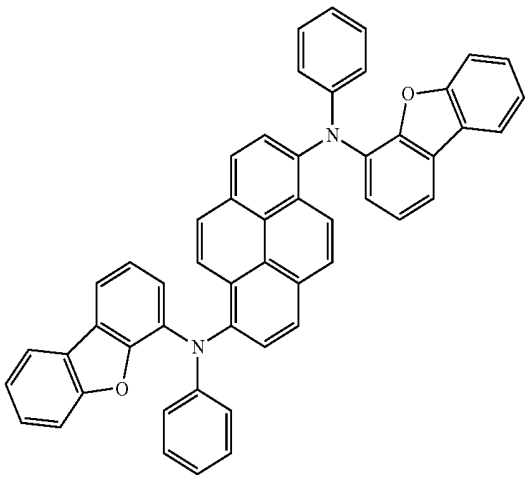
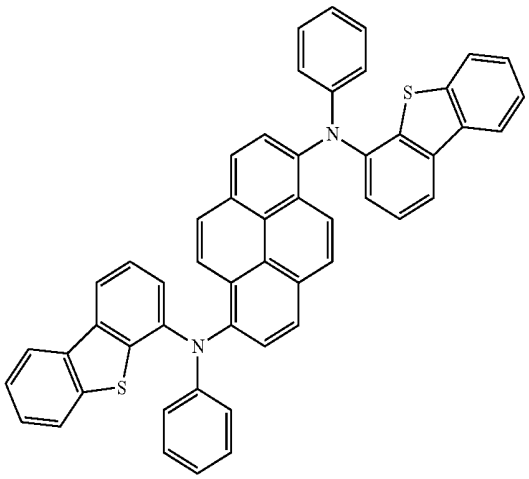
FD4



FD5



FD6



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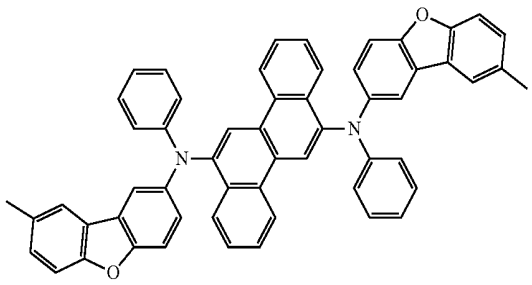
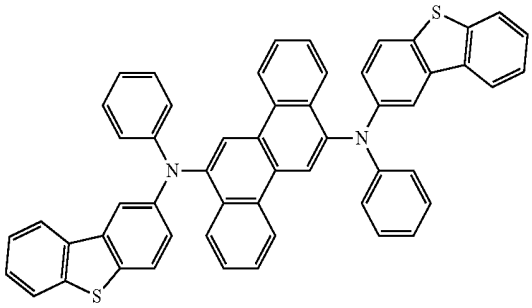
FD7



FD8



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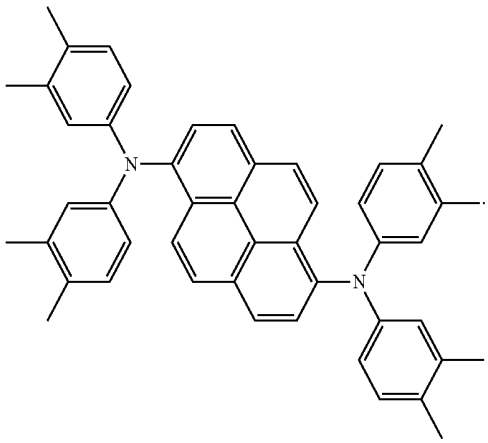
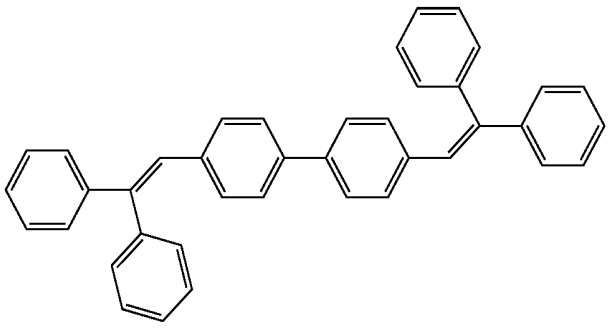
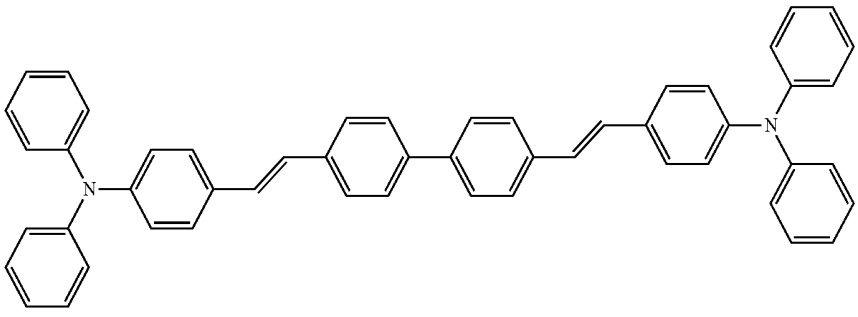
<Compound FD9>



[0228] Alternatively, the fluorescent dopant may be selected from compounds below.



DPVBi



DPAVBi

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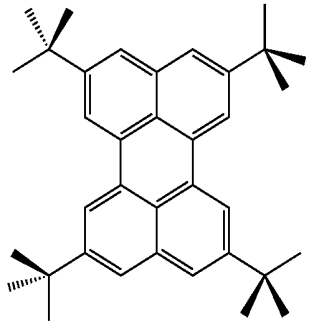
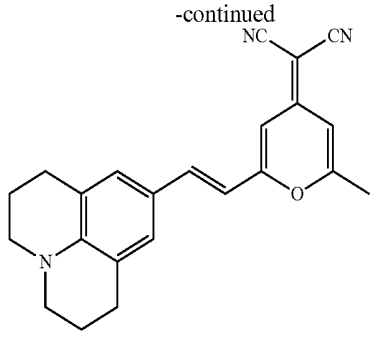
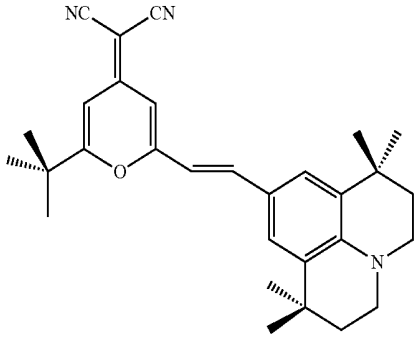


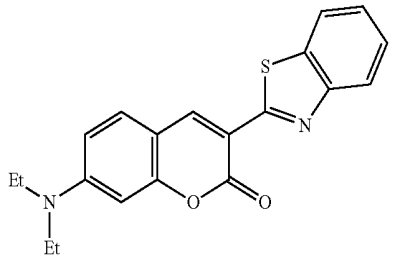
TBPe



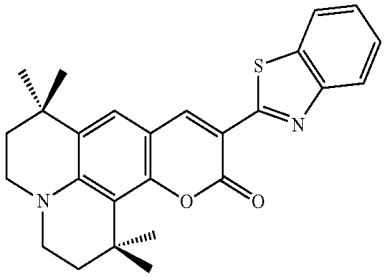
DCM



DCJTB



Coumarin 6



C545T

[0229] An amount of the dopant in the emission layer may be, e.g., in a range of about 0.01 to about 15 parts by weight based on 100 parts by weight of the host.

[0230] A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, for example, about 200 Å to about 600 Å. When the thickness of the emission layer is within this range, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

[0231] Then, an electron transport region may be disposed on the emission layer.

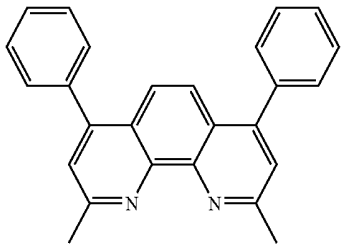
[0232] The electron transport region may include at least one selected from a hole blocking layer, an electron transport layer (ETL), and an electron injection layer.

[0233] For example, the electron transport region may have a structure of electron transport layer/electron injection layer or a structure of hole blocking layer/electron transport layer/electron injection layer, wherein layers of each structure are sequentially stacked in a direction out of the emission layer in the stated order.

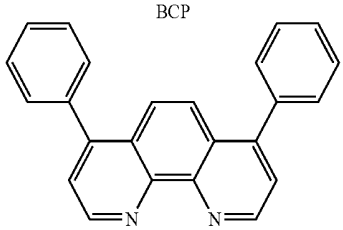
[0234] According to an embodiment, the organic layer **150** of the organic light-emitting device may include an electron transport region disposed between the emission layer and the second electrode **190**.

[0235] When the electron transport region includes a hole blocking layer, the hole blocking layer may be formed on the emission layer by using one or more methods selected from vacuum deposition, spin coating, casting, a LB method, ink-jet printing, laser-printing, and laser-induced thermal imaging. When the hole blocking layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the hole blocking layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

[0236] The hole blocking layer may include, for example, at least one of BCP and Bphen.



BCP



Bphen

[0237] A thickness of the hole blocking layer may be in a range of about 20 Å to about 1000 Å, for example, about 30 Å to about 300 Å. When the thickness of the hole blocking layer is within these ranges, the hole blocking layer may have improved hole blocking ability without a substantial increase in driving voltage.

[0238] The electron transport region may include an electron transport layer. The electron transport layer may be formed on the emission layer or the hole blocking layer by using one or more methods selected from vacuum deposition, spin coating, casting, a LB method, ink-jet printing,

laser-printing, and laser-induced thermal imaging. When an electron transport layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the electron transport layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

[0239] In some embodiments, the electron transport layer may include at least one compound selected from a compound represented by Formula 601 and a compound represented by Formula 602 illustrated below:

$$Ar_{601}\text{-}[(L_{601})_{xe1}\text{-}E_{601}]_{xe2} \quad \text{<Formula 601>}$$

[0240] In Formula 601,

[0241] Ar_{601} may be selected from

[0242] a naphthalene, a heptalene, a fluorene, a spirobifluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene; and

[0243] a naphthalene, a heptalene, a fluorene, a spirobifluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and an indenoanthracene, 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_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —$Si(Q_{301})(Q_{302})(Q_{303})$(wherein Q_{301} to Q_{303} may be each independently hydrogen, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_6-C_{60} aryl group, or a C_1-C_{60} heteroaryl group),

[0244] L_{601} may be understood by referring to the description of L_1 provided herein,

[0245] E_{601} may be selected from

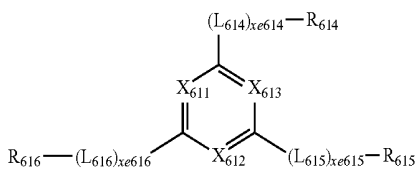
[0246] a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a 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 benzoimidazolyl 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

[0247] 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 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 benzoimidazolyl 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, 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 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, 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 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 benzoimidazolyl 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,

[0248] xe1 may be selected from 0, 1, 2, and 3, and

[0249] xe2 may be selected from 1, 2, 3, and 4.

<Formula 602>



[0250] In Formula 602,

[0251] X_{611} is N or C-$(L_{611})_{xe611}$-R_{611}, X_{612} is N or C-$(L_{612})_{xe612}$-R_{612}, X_{613} is N or C-$(L_{613})_{xe613}$—R_{613}, and at least one of X_{611} to X_{613} is N,

[0252] L_{611} to L_{616} may each be understood by referring to the description of L_1 provided herein,

[0253] R_{611} to R_{616} may be each independently selected from

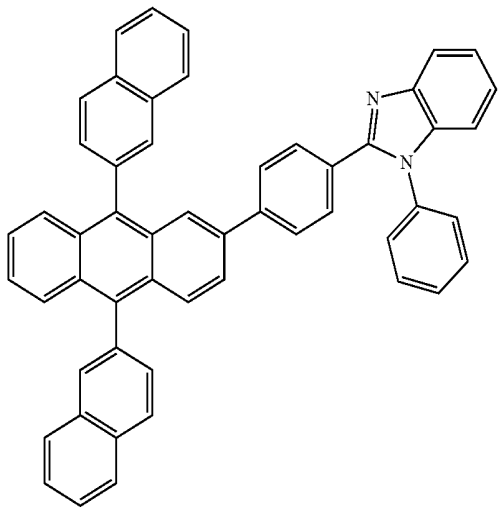
[0254] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

[0255] 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 pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl 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 phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, an azulenyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, and

[0256] xe611 to xe616 may be each independently selected from 0, 1, 2 and 3.

[0257] The compound represented by Formula 601 and the compound represented by Formula 602 may be each independently selected from Compounds ET1 to ET15:

ET1



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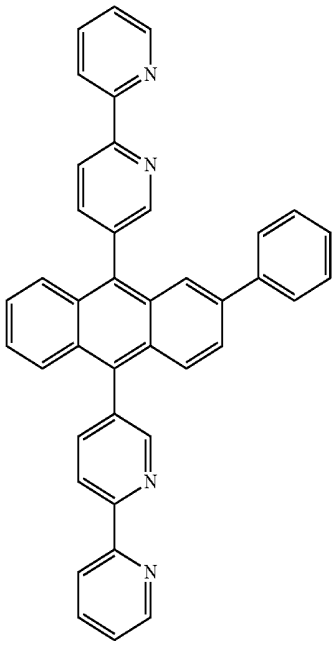
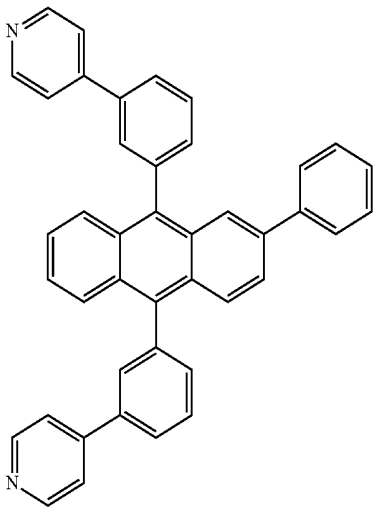
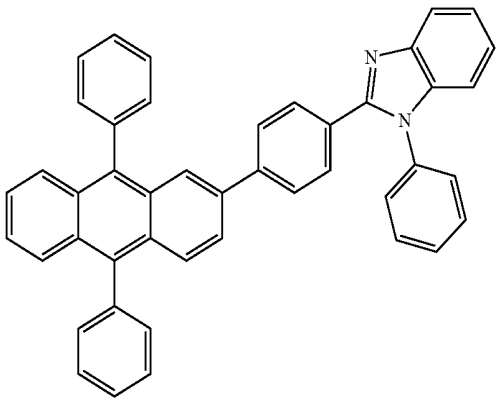
ET2



ET3



ET4



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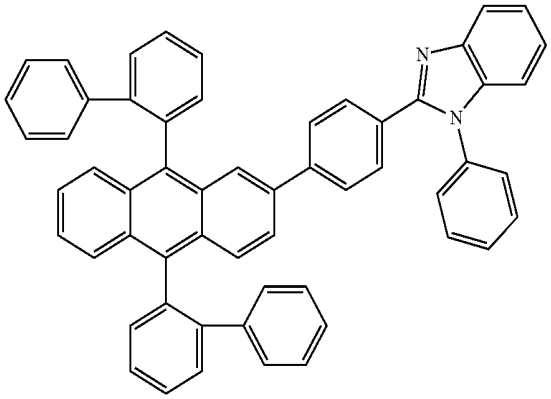
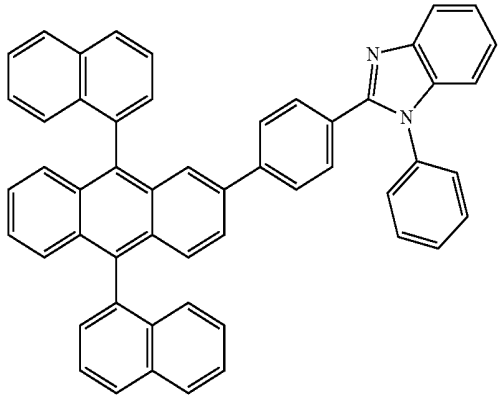
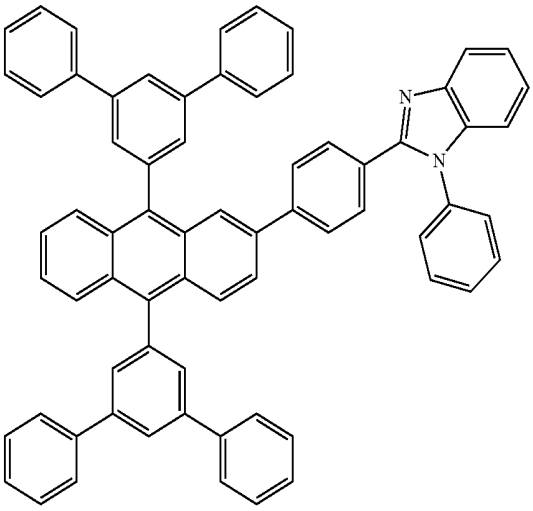
ET5



ET6



ET7



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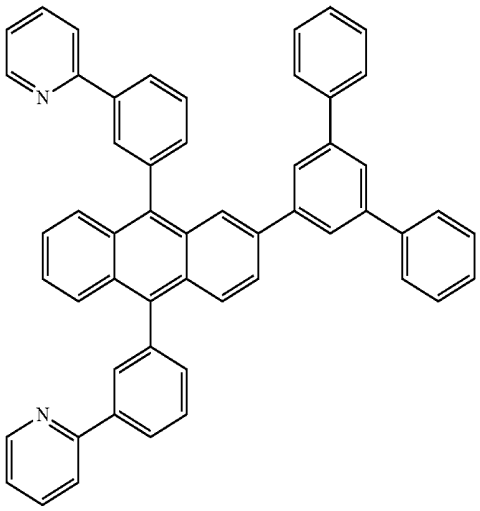
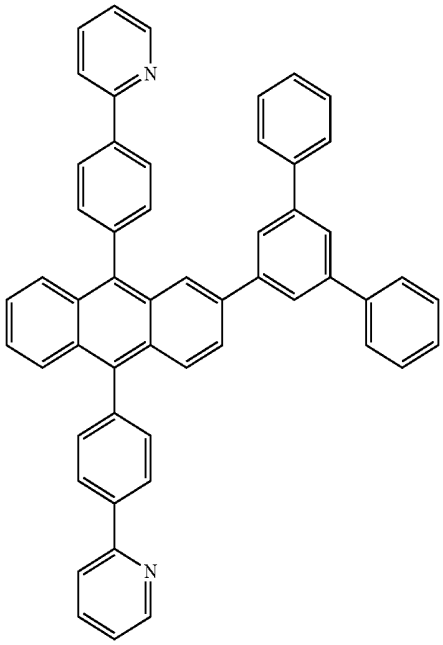
ET8



ET9



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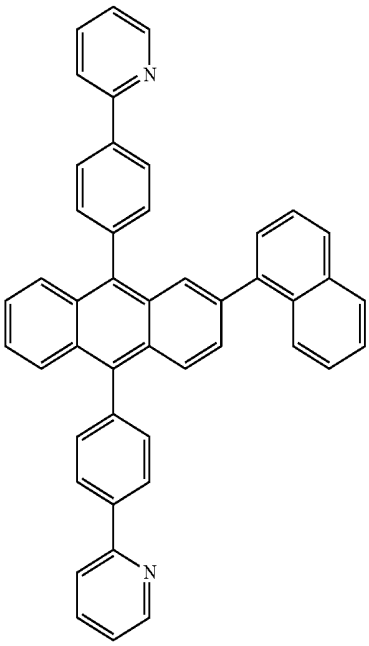
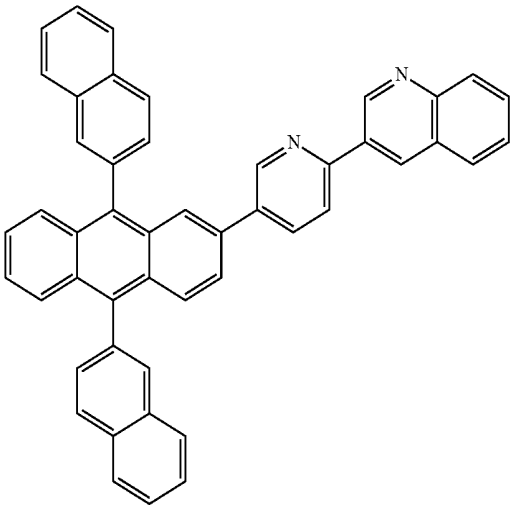
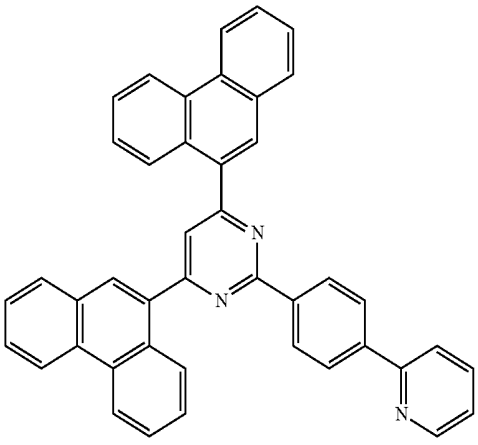
ET10



ET11



ET12



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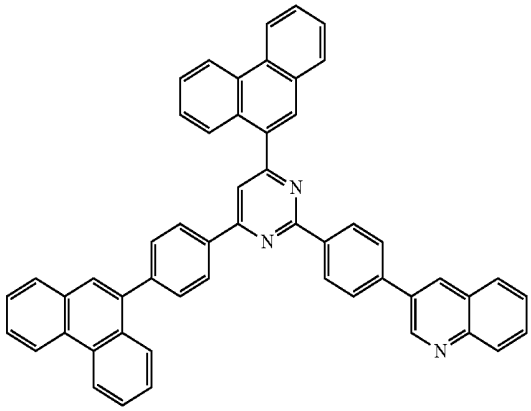
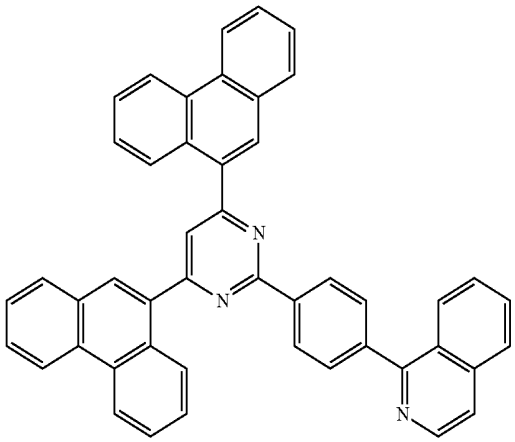
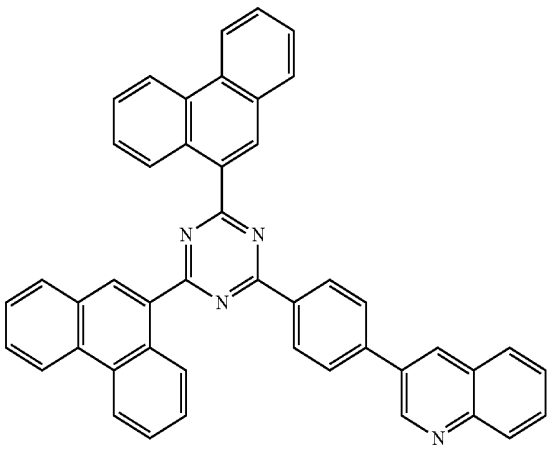
ET13



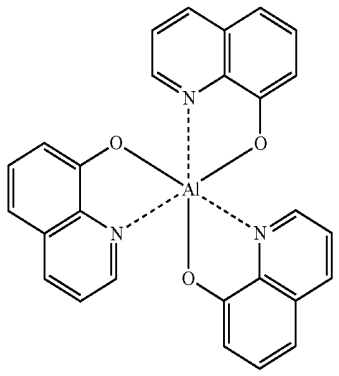
ET14



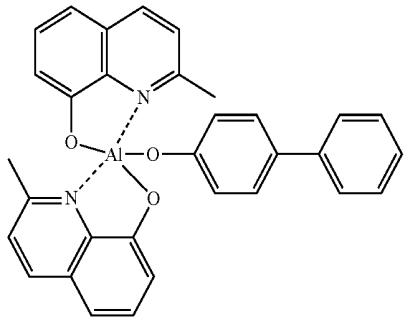
ET15



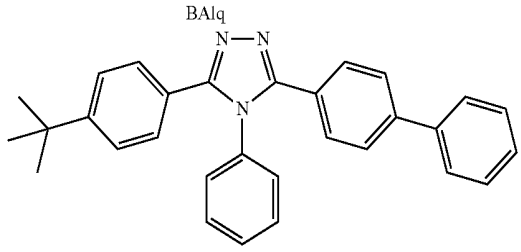
[0258] Alternatively, the electron transport layer may include at least one of BCP, Bphen, Alq_3, Balq, TAZ, and NTAZ.



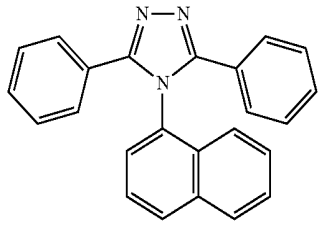
Alq_3



BAlq



TAZ



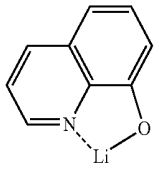
NTAZ

[0259] A thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, for example, about 150 Å to about 500 Å. When the thickness of the electron transport layer is within the range described above, the electron transport layer may have satisfactory electron transport characteristics without a substantial increase in driving voltage.

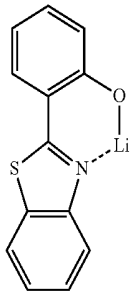
[0260] Also, the electron transport layer may further include, in addition to the materials described above, a metal-containing material.

[0261] The metal-containing material may include a Li complex. The Li complex may include, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2.

ET-D1



ET-D2



[0262] The electron transport region may include an electron injection layer that facilitates the injection of electrons from the second electrode **190**.

[0263] The electron injection layer may be formed on the electron transport layer by using one or more methods selected from vacuum deposition, spin coating, casting, a LB method, ink-jet printing, laser-printing, and laser-induced thermal imaging. When an electron injection layer is formed by vacuum deposition or spin coating, deposition and coating conditions for the electron injection layer may be determined by referring to the deposition and coating conditions for the hole injection layer.

[0264] The electron injection layer may include at least one selected from, LiF, NaCl, CsF, Li_2O, BaO, and LiQ.

[0265] A thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, about 3 Å to about 90 Å. When the thickness of the electron injection layer is within the range described above, the electron injection layer may have satisfactory electron injection characteristics without a substantial increase in driving voltage.

[0266] The second electrode **190** may be disposed on the organic layer **150** having such a structure. The second electrode **190** may be a cathode that is an electron injection electrode, and in this regard, a material for forming the second electrode **190** may be a material having a low work function, and such a material may be metal, alloy, an electrically conductive compound, or a mixture thereof. Examples of the second electrode **190** are lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), or magnesium-silver (Mg—Ag). In some embodiments, the material for forming the second electrode **190** may be ITO or IZO. The second electrode **190** may be a semi-transmissive electrode or a transmissive electrode.

[0267] An organic light-emitting device **20** of FIG. **2** may include 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** may include 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 **20** of FIG. **4** may include a first capping layer **210**, a first electrode **110**, an organic layer **150**, a second electrode **190**, and a second capping layer **220**.

[0268] Regarding FIGS. **2** to **4**, descriptions of 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**.

[0269] 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.

[0270] The first capping layer **210** and the second capping layer **220** may improve external luminescent efficiency according to the principle of constructive interference.

[0271] In an implementation, the first capping layer **210** of FIG. **2** and the second capping layer **220** of FIG. **3** may include the condensed cyclic compound represented by Formula 1.

[0272] In an implementation, at least one of the first capping layer **210** and the second capping layer **220** of FIG. **4** may include the condensed cyclic compound represented by Formula 1.

[0273] In an implementation, the organic layer **150** of FIGS. **2** to **4** may not include the condensed cyclic compound represented by Formula 1.

[0274] The organic light-emitting device has been described above with reference to FIGS. **1** to **4**.

[0275] A C_1-C_{60} alkyl group used herein refers to a linear or branched aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms, and detailed examples thereof are 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. A C_1-C_{60} alkylene group used herein refers to a divalent group having the same structure as the C_1-C_{60} alkyl group.

[0276] A C_1-C_{60} alkoxy group used herein refers to a monovalent group represented by —OA_{101} (wherein A_{101} is the C_1-C_{60} alkyl group), and detailed examples thereof are a methoxy group, an ethoxy group, and an isopropyloxy group.

[0277] A C_2-C_{60} alkenyl group used herein refers to a hydrocarbon group including at least one carbon double bond in the middle or at the terminal of the C_2-C_{60} alkyl group, and detailed examples thereof are an ethenyl group, a prophenyl group, and a butenyl group. A C_2-C_{60} alkenylene group used herein refers to a divalent group having the same structure as the C_2-C_{60} alkenyl group.

[0278] A C_2-C_{60} alkynyl group used herein refers to a hydrocarbon group including at least one carbon triple bond in the middle or at the terminal of the C_2-C_{60} alkyl group, and detailed examples thereof are an ethynyl group and a propynyl group. A C_2-C_{60} alkynylene group used herein refers to a divalent group having the same structure as the C_2-C_{60} alkynyl group.

[0279] A C_3-C_{10} cycloalkyl group used herein refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and detailed examples thereof are a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. A C_3-C_{10} cycloalkylene group used herein refers to a divalent group having the same structure as the C_3-C_{10} cycloalkyl group.

[0280] A C_1-C_{10} heterocycloalkyl group 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 detailed examples thereof are a tetrahydrofuranyl group and a tetrahydrothiophenyl group. A C_1-C_{10} heterocycloalkylene group used herein refers to a divalent group having the same structure as the C_1-C_{10} heterocycloalkyl group.

[0281] A C_3-C_{10} cycloalkenyl group 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 does not have aromaticity, and detailed examples thereof are a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. A C_3-C_{10} cycloalkenylene group used herein refers to a divalent group having the same structure as the C_3-C_{10} cycloalkenyl group.

[0282] A C_1-C_{10} heterocycloalkenyl group 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. Detailed examples of the C_1-C_{10} heterocycloalkenyl group are a 2,3-hydrofuranyl group and a 2,3-hydrothiophenyl group. A C_1-C_{10} heterocycloalkenylene group used herein refers to a divalent group having the same structure as the C_1-C_{10} heterocycloalkenyl group.

[0283] A C_6-C_{60} aryl group used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms, and a C_6-C_{60} arylene group used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. Detailed examples of the C_6-C_{60} aryl group are a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C_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.

[0284] A C_1-C_{60} heteroaryl group used herein refers to a monovalent group having a carbocyclic aromatic system that includes at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom and has 1 to 60 carbon atoms. A C_1-C_{60} heteroarylene group used herein refers to a divalent group having a carbocyclic aromatic system that includes at least one heteroatom selected from N, O, P, and S as a ring-forming atom and 1 to 60 carbon atoms. Examples of the C_1-C_{60} heteroaryl group are a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_1-C_{60} heteroaryl group and the C_1-C_{60} heteroarylene group each include two or more rings, the rings may be fused to each other.

[0285] A C_6-C_{60} aryloxy group used herein indicates —OA_{102} (wherein A_{102} is the C_6-C_{60} aryl group), and a C_6-C_{60} arylthio group used herein indicates —SA_{103} (wherein A_{103} is the C_6-C_{60} aryl group).

[0286] A monovalent non-aromatic condensed polycyclic group used herein refers to a monovalent group (for example, having 8 to 60 carbon atoms) that has two or more rings condensed to each other, includes only carbon atoms as a ring forming atom, and has non-aromaticity in the entire molecular structure. A detailed example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. A divalent non-aromatic condensed polycyclic group used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0287] A monovalent non-aromatic condensed heteropolycyclic group used herein refers to a monovalent group (for example, having 1 to 60 carbon atoms) that has two or more rings condensed to each other, includes a heteroatom selected from N, O, Si, P, and S, other than carbon atoms, as

a ring forming atom, and has non-aromaticity in the entire molecular structure. An example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. A divalent non-aromatic condensed heteropolycyclic group used herein refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0288] As used herein, at least one of substituents of the substituted condensed polycyclic group, substituted C_3-C_{10} cycloalkylene group, substituted C_1-C_{10} heterocycloalkylene group, substituted C_3-C_{10} cycloalkenylene group, substituted C_1-C_{10} heterocycloalkenylene group, substituted C_6-C_{60} arylene group, substituted C_1-C_{60} heteroarylene group, substituted divalent non-aromatic condensed polycyclic group, substituted divalent non-aromatic condensed heteropolycyclic group, substituted C_1-C_{60} alkyl group, substituted C_2-C_{60} alkenyl group, substituted C_2-C_{60} alkynyl group, substituted C_1-C_{60} alkoxy group, substituted C_3-C_{10} cycloalkyl group, substituted C_1-C_{10} heterocycloalkyl group, substituted C_3-C_{10} cycloalkenyl group, substituted C_1-C_{10} heterocycloalkenyl group, substituted C_6-C_{60} aryl group, substituted C_6-C_{60} aryloxy group, substituted C_6-C_{60} arylthio group, substituted C_1-C_{60} heteroaryl group, substituted monovalent non-aromatic condensed polycyclic group, and substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from

[0289] 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_{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;

[0290] a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a 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 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_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, $—N(Q_{11})(Q_{12})$, $—Si(Q_{13})(Q_{14})(Q_{15})$, and $—B(Q_{16})(Q_{17})$;

[0291] 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;

[0292] 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 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_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $—N(Q_{21})(Q_{22})$, $—Si(Q_{23})(Q_{24})(Q_{25})$, and $—B(Q_{26})(Q_{27})$; and

[0293] $—N(Q_{31})(Q_{32})$, $—Si(Q_{33})(Q_{34})(Q_{35})$, and $—B(Q_{36})(Q_{37})$,

[0294] wherein Q_1 to Q_7, Q_{11} to Q_{17}, Q_{21} to Q_{27}, and Q_{31} to Q_{37} may be each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

[0295] The term "Ph" used herein refers to a phenyl group, the term "Me" used herein refers to a methyl group, the term "Et" used herein refers to an ethyl group, and the term "ter-Bu" or "Bu^t" used herein refers to a tert-butyl group.

[0296] The following Examples and Comparative Examples are provided in order to highlight characteristics of one or more embodiments, but it will be understood that the Examples and Comparative Examples are not to be construed as limiting the scope of the embodiments, nor are the Comparative Examples to be construed as being outside the scope of the embodiments. Further, it will be understood that the embodiments are not limited to the particular details described in the Examples and Comparative Examples.

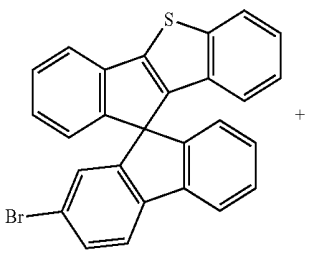
[0297] Hereinafter, an organic light-emitting device according to an embodiment will be described in detail with reference to Synthesis Examples and Examples. The wording "B was used instead of A" used in describing Synthesis Examples below means that a molar equivalent of A is identical to a molar equivalent of B.

EXAMPLE

Synthesis Example 1

Synthesis of Compound 1

[0298]



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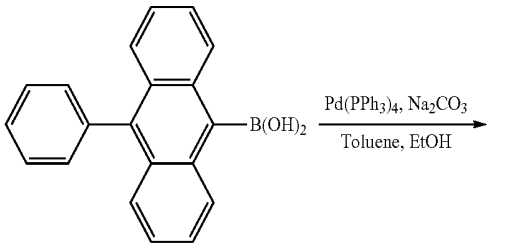
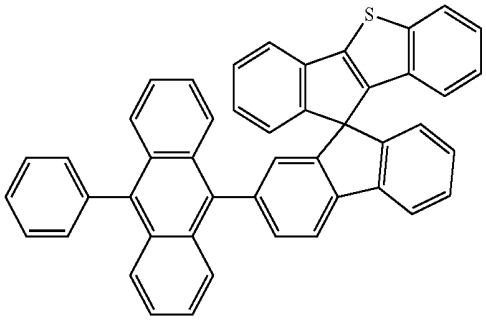
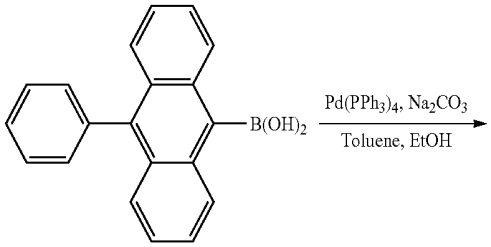
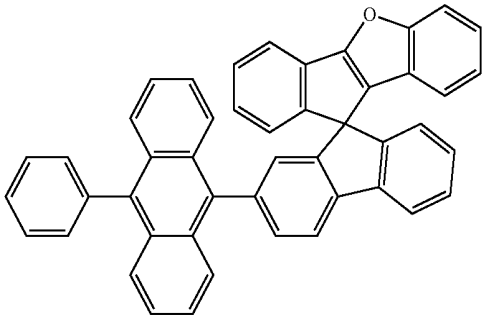




Compound 1

-continued





Compound 2

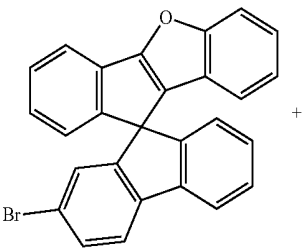
[0299] 0.585 g (1 eq, 1.30 mmol) of 2'-bromospiro[benzo[b]indeno[2,1-d]thiophene-10,9'-fluorene], 0.43 g (1.1 eq, 1.43 mmol) of (10-phenylanthracen-9-yl)boronic acid, and 0.06 g (0.04 eq, 0.052 mmol) of tetrakis(triphenylphosphine) palladium(0) were put into a reaction vessel, dried under vacuum, and then the reaction vessel was purged with nitrogen gas. After 13 mL of toluene was added to the reaction vessel, 6.5 mL of ethanol and 6.5 mL (10 eq, 13.0 mmol) of a 2.0 molar (M) sodium carbonate aqueous solution were added thereto and stirred under reflux at a temperature of about 80° C. for about 3 hours. Once the reaction was complete, the resulting reaction product was washed with distilled water, followed by extraction with ethyl acetate to obtain an organic layer. The obtained product was dried using magnesium sulfate, filtered using Celite, and then purified using silica silica gel column chromatography to obtain 0.6480 g (yield=80%) of Compound 1 (2'-(10-phenylanthracen-9-yl)spiro[benzo[b]indeno[2,1-d]thiophene-10,9'-fluorene]).

[0300] ^{1}H NMR 7.98 (1H), 7.91 (5H), 7.87 (1H), 7.73 (1H), 7.67 (3H), 7.51 (7H), 7.37 (7H), 7.32 (3H), atmospheric-pressure chemical ionization mass spectrometry (APCI-MS) (m/z): 624[M+]

Synthesis Example 2

Synthesis of Compound 2

[0301]



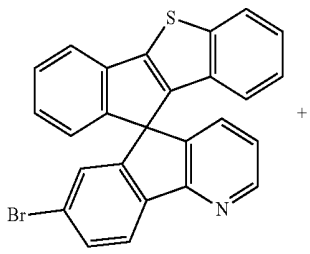
[0302] 0.592 g (yield=75%) of Compound 2 (2-(10-phenylanthracen-9-yl)spiro[fluorene-9,10'-indeno[1,2-b]benzofuran]) was obtained in the same manner as in Synthesis Example 1, except that 0.564 g (1 eq, 1.30 mmol) of 2-bromospiro[fluorene-9,10'-indeno[1,2-b]benzofuran] was used instead of 2'-bromospiro[benzo[b]indeno[2,1-d]thiophene-10,9'-fluorene].

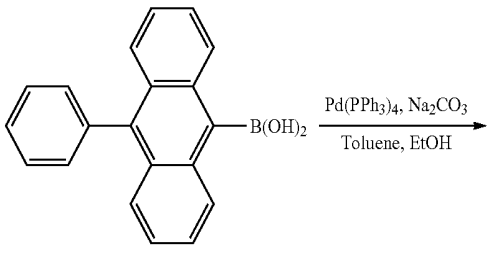
[0303] ^{1}H NMR: 7.91 (5H), 7.87 (2H), 7.77 (1H), 7.67 (3H), 7.51 (7H), 7.37 (7H), 7.32 (3H) APCI-MS (m/z): 608[M+]

Synthesis Example 3

Synthesis of Compound 11

[0304]





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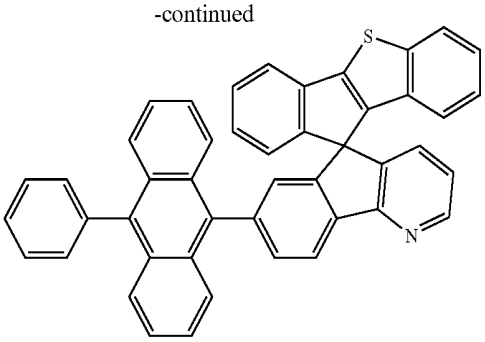


Compound 11

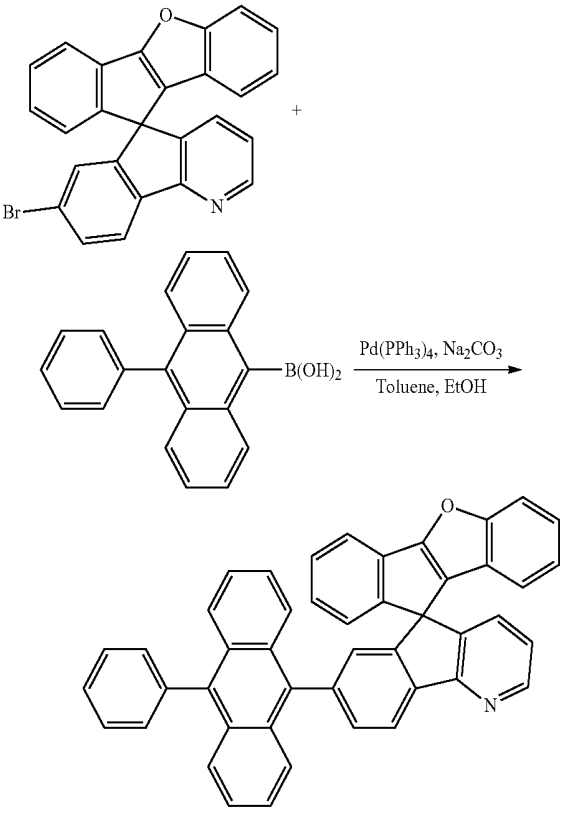
[0305] 0.609 g (yield=75%) of Compound 11 (7'-(10-phenylanthracen-9-yl)spiro[benzo[b]indeno[2,1-d]thiophene-10,5'-indeno[1,2-b]pyridine]) was obtained in the same manner as in Synthesis Example 1, except that 0.586 g (1 eq, 1.30 mmol) of 2'-bromospiro[benzo[b]indeno[2,1-d]thiophene-10,5'-indeno[1,2-c]pyridine] was used instead of 2'-bromospiro[benzo[b]indeno[2,1-d]thiophene-10,9'-fluorene].

[0306] ^{1}H NMR: 8.48 (1H), 8.24 (1H), 7.98 (1H), 7.91 (4H), 7.88 (1H), 7.67 (2H), 7.51 (6H), 7.41 (5H), 7.29 (4H), 7.09 (1H) APCI-MS (m/z): 625[M+]

Synthesis Example 4

Synthesis of Compound 12

[0307]



Compound 12

[0308] 0.592 g (yield=75%) of Compound 12 (7'-(10-phenylanthracen-9-yl)spiro[indeno[1,2-b]benzofuran-10,5'-indeno[1,2-b]pyridine]) was obtained in the same manner as in Synthesis Example 1, except that 0.556 g of (1 eq, 1.30 mmol) of 7'-bromospiro[indeno[1,2-b]benzofuran-10,5'-indeno[1,2-c]pyridine] was used instead of 2'-bromospiro[benzo[b]indeno[2,1-d]thiophene-10,9'-fluorene].

[0309] ^{1}H NMR: 8.48 (1H), 8.24 (1H), 7.91 (4H), 7.88 (2H), 7.67 (2H), 7.51 (6H), 7.41 (5H), 7.29 (4H), 7.09 (1H) APCI-MS (m/z): 609[M+]

Example 1

[0310] A 15 ohms per square centimeter (Ω/cm^2) ITO glass substrate (having a thickness of 1,200 Å, available from Corning) was cut to a size of 50 millimeters (mm)×50 mm×0.7 mm and then sonicated for five minutes in each of isopropyl alcohol and deionized water, and then cleaned by irradiation with ultraviolet rays for 30 minutes and by exposure to ozone. The resulting glass substrate (including an ITO anode) was mounted in a vacuum deposition device.

[0311] 2-TNATA was vacuum-deposited on the ITO anode of the glass substrate to form a hole injection layer (HIL) having a thickness of 600 Å, and 4,4'-bis[N-(1-naphthyl)-N-phenylan amino group]biphenyl (hereinafter, "NPB") was then vacuum-deposited on the HIL to form a hole transport layer (HTL) having a thickness of about 300 Å.

[0312] Compound 1 (as a host) and DPAVBi (as a dopant) were co-deposited on the HTL at a weight ratio of about 95:5 to form an emission layer (EML) having a thickness of about 20 nm.

[0313] Compound ET1 was deposited on the EML to form an electron transport layer (ETL) having a thickness of about 300 Å, and then LiF was deposited on the ETL to form an electron injection layer (EIL) having a thickness of about 10 Å. Aluminum (Al) was then vacuum-deposited on the EIL to form a cathode having a thickness of about 3,000 Å, thereby completing the manufacture of an organic light-emitting device.

Examples 2 to 4 and Comparative Examples 1 to 4

[0314] Organic light-emitting devices were manufactured in the same manner as in Example 1 except that, instead of Compound 1 of Example 1, the compounds listed in Table 1 were used as hosts to form the respective EMLs of Examples 2 to 4 and Comparative Examples 1 to 4.

Evaluation Example 1

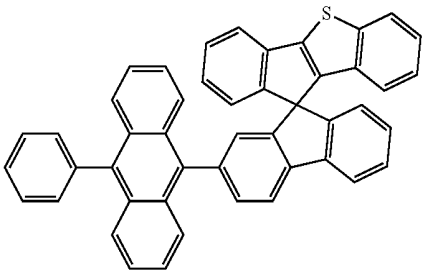
[0315] Driving voltages, current densities, luminances, and efficiencies of the organic light-emitting devices of Examples 1 to 4 and Comparative Examples 1 to 4 were evaluated using a Keithley Source-Measure Unit (SMU 236) and a luminance meter (PR650). The evaluation results are shown in Table 1.

TABLE 1

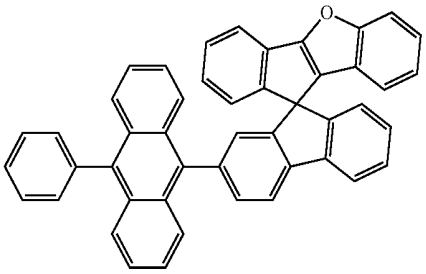
	Host	Driving voltage (V)	Current density (mA/cm^2)	Luminance (cd/m^2)	Efficiency (cd/A)
Example 1	Compound 1	3.2	10	578	5.78
Example 2	Compound 2	3.1	10	545	5.45
Example 3	Compound 11	3.8	10	480	4.80
Example 4	Compound 12	3.7	10	495	4.95

TABLE 1-continued

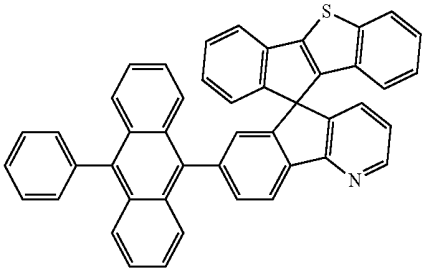
	Host	Driving voltage (V)	Current density (mA/cm^2)	Luminance (cd/m^2)	Efficiency (cd/A)
Comparative Example 1	Compound A	4.5	10	311	3.11
Comparative Example 2	Compound B	4.3	10	367	3.67
Comparative Example 3	Compound C	4.2	10	416	4.16
Comparative Example 4	Compound D	4.4	10	422	4.22



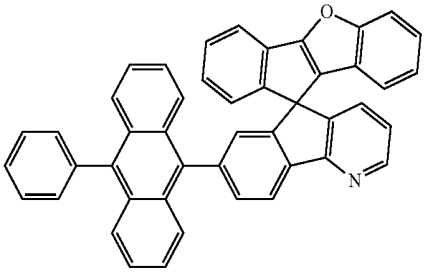
1



2



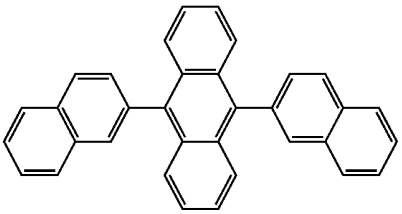
11



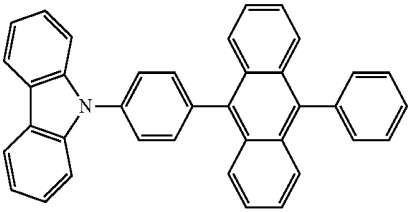
12

TABLE 1-continued

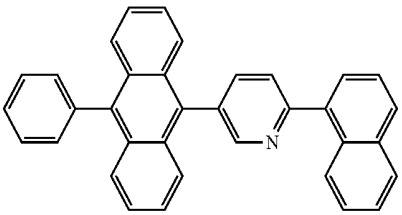
Host	Driving voltage (V)	Current density (mA/cm^2)	Luminance (cd/m^2)	Efficiency (cd/A)



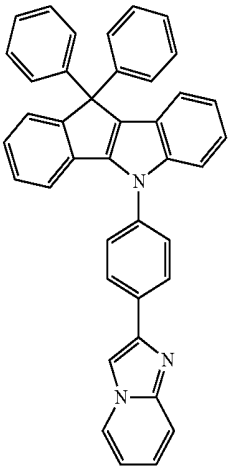
Compound A



Compound B



Compound C



Compound D

[0316] Referring to Table 1, the organic light-emitting devices of Examples 1 to 4 exhibited improved driving voltages, luminances, and efficiencies, compared to the organic light-emitting devices of Comparative Examples 1 to 4.

[0317] An organic light-emitting device including a condensed cyclic compound according to embodiments may have a low driving voltage, high efficiency, and high luminance.

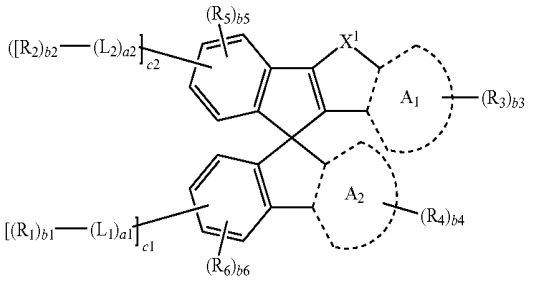
[0318] Example embodiments have been disclosed herein, and although specific terms are employed, they are used and are to be interpreted in a generic and descriptive sense only and not for purpose of limitation. In some instances, as would be apparent to one of ordinary skill in the art as of the

filing of the present application, features, characteristics, and/or elements described in connection with a particular embodiment may be used singly or in combination with features, characteristics, and/or elements described in connection with other embodiments unless otherwise specifically indicated. Accordingly, it will be understood by those of skill in the art that various changes in form and details may be made without departing from the spirit and scope of the present invention as set forth in the following claims.

What is claimed is:

1. A condensed cyclic compound represented by Formula 1:

<Formula 1>



wherein, in Formula 1,

ring A_1 and ring A_2 are each independently selected from a benzene, a naphthalene, a pyridine, a pyrimidine, a pyrazine, a quinoline, an isoquinoline, a quinoxaline, a quinazoline, and a cinnoline,

X_1 is N-[$(L_{11})_{a111}$-$(R_{11})_{b11}$], O, or S,

L_1, L_2, and L_{11} are each independently selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

a1 and a2 are each independently an integer of 1 to 5, a11 is an integer of 0 to 5, wherein when a1 is 2 or more, two or more L_1s are identical to or different from each other, when a2 is 2 or more, two or more L_es are identical to or different from each other, and when a11 is 2 or more, two or more L_{11}s are identical to or different from each other,

R_1 to R_6 and R_{11} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{60} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_1)(Q_2)$, —$Si(Q_3)(Q_4)(Q_5)$, and —$B(Q_6)(Q_7)$,

b1, b2, b5, b6, and b11 are each independently an integer of 0 to 4,

b3 and b4 are each independently an integer of 0 to 6,

c1 and c2 are each independently an integer of 0 to 4, and

at least one substituent of the substituted C_3-C_{10} cycloalkylene group, substituted C_1-C_{10} heterocycloalkylene group, substituted C_3-C_{10} cycloalkenylene group, substituted C_1-C_{10} heterocycloalkenylene group, substituted C_6-C_{60} arylene group, substituted C_1-C_{60} heteroarylene group, substituted divalent non-aromatic condensed polycyclic group, substituted divalent non-aromatic condensed heteropolycyclic group, substituted C_1-C_{60} alkyl group, substituted C_2-C_{60} alkenyl group, substituted C_2-C_{60} alkynyl group, substituted C_1-C_{60} alkoxy group, substituted C_3-C_{10} cycloalkyl group, substituted C_1-C_{10} heterocycloalkyl group, substituted C_3-C_{10} cycloalkenyl group, substituted C_1-C_{10} heterocycloalkenyl group, substituted C_6-C_{60} aryl group, substituted C_6-C_{60} aryloxy group, substituted C_6-C_{60} arylthio group, substituted C_1-C_{60} heteroaryl group, substituted monovalent non-aromatic condensed polycyclic group, and 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 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_{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;

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 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_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, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$B(Q_{16})(Q_{17})$;

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;

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 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_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_{21})(Q_{22})$, —$Si(Q_{23})(Q_{24})(Q_{25})$, and —$B(Q_{26})(Q_{27})$; and

—$N(Q_{31})(Q_{32})$, —$Si(Q_{33})(Q_{34})(Q_{35})$, and —$B(Q_{36})(Q_{37})$,

wherein Q_1 to Q_7, Q_{11} to Q_{17}, Q_{21} to Q_{27}, and Q_{31} to Q_{37} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

2. The condensed cyclic compound as claimed in claim **1**, wherein ring A_1 and ring A_2 are each independently selected from a benzene, a naphthalene, a pyridine, a quinoline, and an isoquinoline.

3. The condensed cyclic compound as claimed in claim **1**, wherein X_1 is O or S.

4. The condensed cyclic compound as claimed in claim **1**, wherein L_1, L_2, and L_{11} are each independently selected from:

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene 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 benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group, and an imidazopyrimidinylene group; and

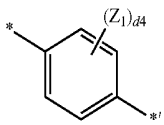
a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a Spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene 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 benzoimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group, and an imidazopyrimidinylene 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 car-

boxylic 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 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, 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 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 benzoimidazolyl 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 dibenzocarbazoiyi group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and —$Si(Q_{33})(Q_{34})(Q_{35})$,

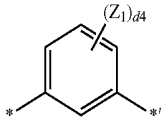
wherein Q_{33} to Q_{35} are each independently selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

5. The condensed cyclic compound as claimed in claim **1**, wherein L_1, L_2, and L_{11} are each independently a group represented by one of the following Formulae 3-1 to 3-41:

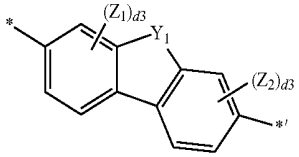
Formula 3-1



Formula 3-2



Formula 3-3



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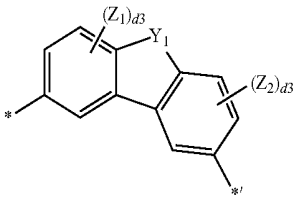
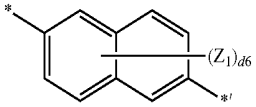
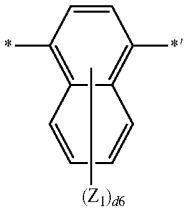
Formula 3-4



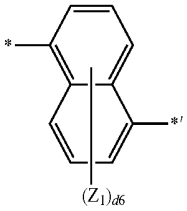
Formula 3-5



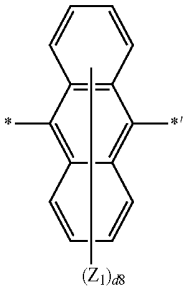
Formula 3-6



Formula 3-7



Formula 3-8



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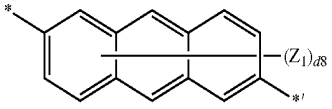
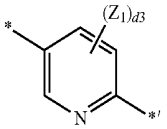


Formula 3-10



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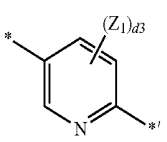
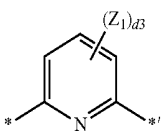


Formula 3-12



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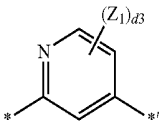

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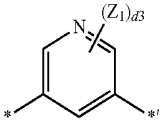

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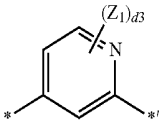
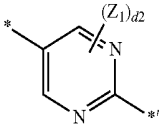


Formula 3-16



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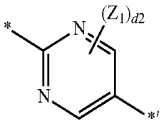

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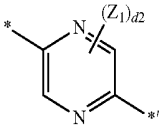

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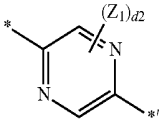

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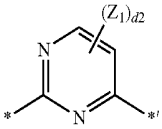

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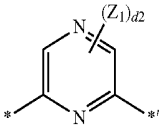

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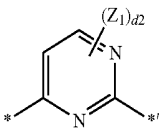
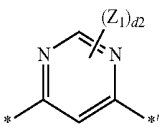


Formula 3-23



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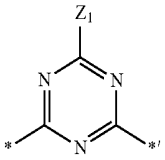
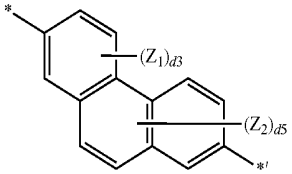
Formula 3-24



Formula 3-25



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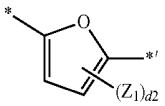

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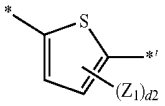

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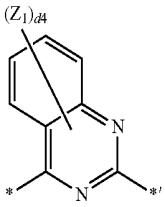

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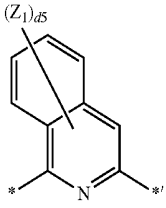

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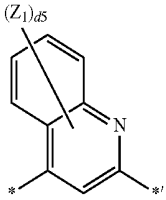
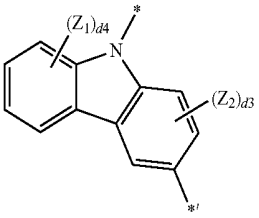
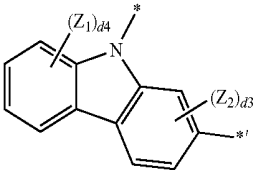


Formula 3-31



Formula 3-32



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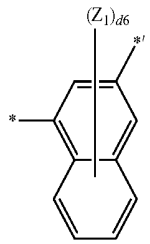
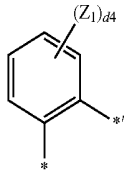
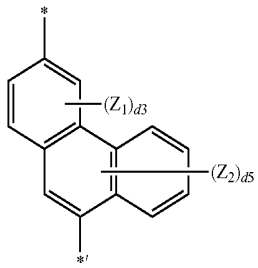
Formula 3-33



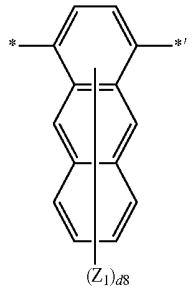
Formula 3-34



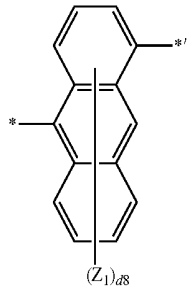
Formula 3-35



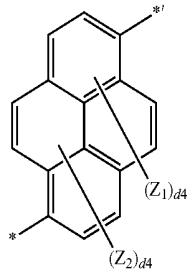
Formula 3-36



Formula 3-37



Formula 3-38



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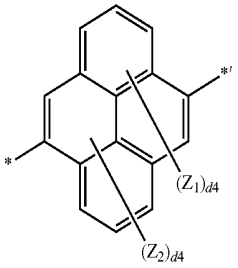
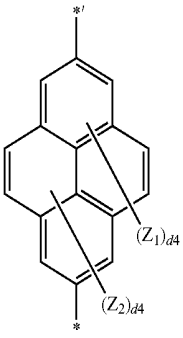
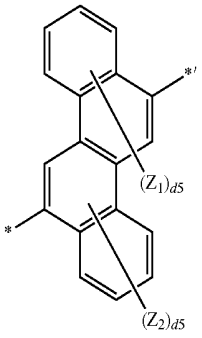
Formula 3-39



Formula 3-40



Formula 3-41



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

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

Z_1 to Z_7 are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an 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 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 pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and $—Si(Q_{33})(Q_{34})(Q_{35})$,

wherein Q_{33} to Q_{35} are each independently selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

d2 is an integer of 1 or 2,

d3 is an integer of 1 to 3,

d4 is an integer of 1 to 4,

d5 is an integer of 1 to 5,

d6 is an integer of 1 to 6,

d8 is an integer of 1 to 8, and

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

6. The condensed cyclic compound as claimed in claim **1**, wherein:

L_1 and L_2 are each independently selected from substituted or unsubstituted condensed polycyclic groups having 3 or more carbocyclic groups condensed with each other,

at least one substituent of the substituted condensed polycyclic groups having 3 or more carbocyclic groups condensed with each other is 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_{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;

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 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_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, —$N(Q_{11})(Q_{12})$, —$Si(Q_{13})(Q_{14})(Q_{15})$, and —$B(Q_{16})(Q_{17})$;

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;

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 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_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —$N(Q_{21})(Q_{22})$, —$Si(Q_{23})(Q_{24})(Q_{25})$, and —$B(Q_{26})(Q_{27})$; and

—$N(Q_{31})(Q_{32})$, —$Si(Q_{33})(Q_{34})(Q_{35})$ and —$B(Q_{36})(Q_{37})$,

wherein Q_1 to Q_7, Q_{11} to Q_{17}, Q_{21} to Q_{27}, and Q_{31} to Q_{37} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, and

a sum of c1 and c2 is 1 or greater.

7. The condensed cyclic compound as claimed in claim **1**, wherein L_1 and L_2 are each independently selected from:

an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, and an ovalenylene group; and

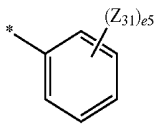
an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, and an ovalenylene 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 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, 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 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 benzoimidazolyl 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, an imidazopyridinyl group, an imidazopyrimidinyl group, and —Si(Q_{33})(Q_{34})(Q_{35}),

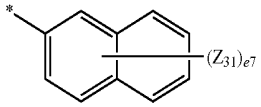
wherein Q_{33} to Q_{35} are each independently selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

8. The condensed cyclic compound as claimed in claim **1**, wherein R_1 to R_6 and R_{11} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a group represented by one of the following Formulae 5-1 to 5-75, and -Si(Q_3)(Q_4)(Q_5), in which Q_3 to Q_5 are each independently selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group:

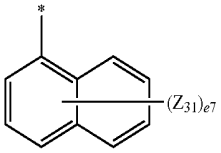
Formula 5-1



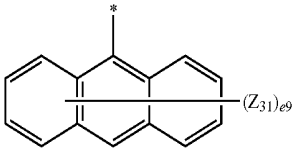
Formula 5-2



Formula 5-3



Formula 5-4



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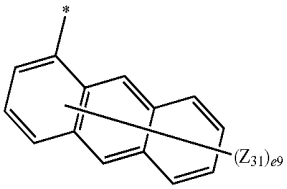
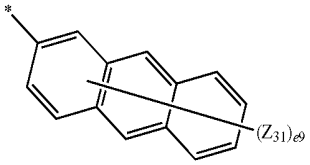
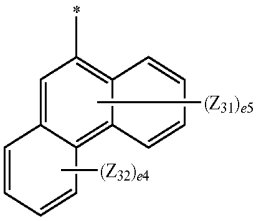
Formula 5-5



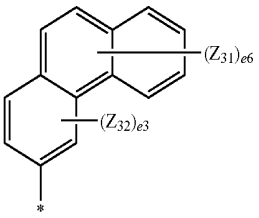
Formula 5-6



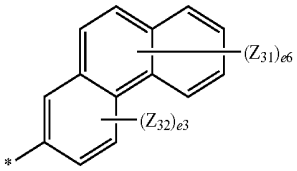
Formula 5-7



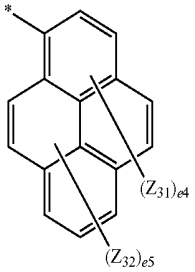
Formula 5-8



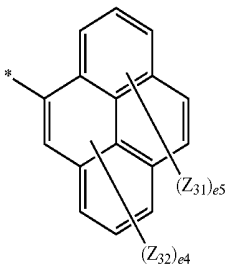
Formula 5-9



Formula 5-10



Formula 5-11



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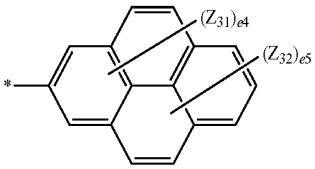
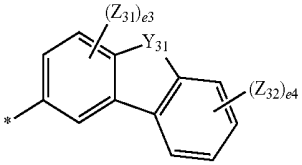
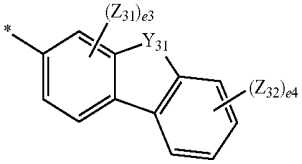
Formula 5-12



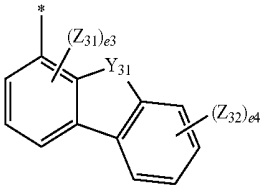
Formula 5-13



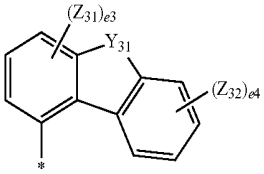
Formula 5-14



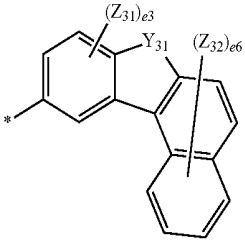
Formula 5-15



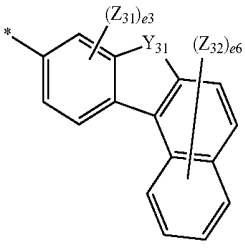
Formula 5-16



Formula 5-17



Formula 5-18



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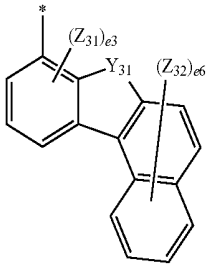
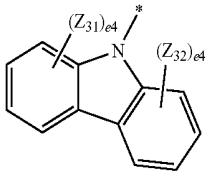
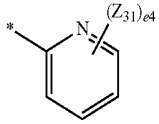
Formula 5-19



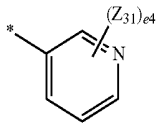
Formula 5-20



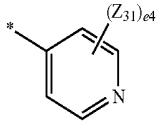
Formula 5-21



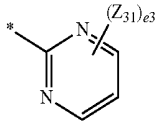
Formula 5-22



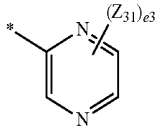
Formula 5-23



Formula 5-24



Formula 5-25



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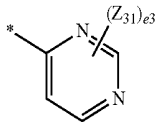

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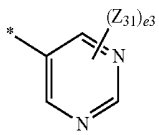

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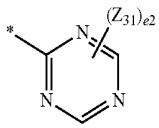

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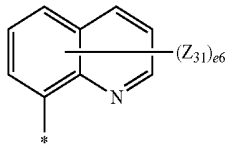

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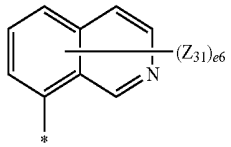

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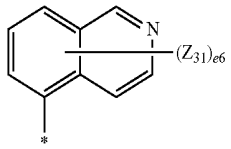

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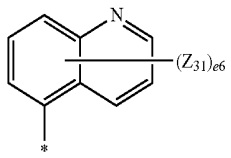

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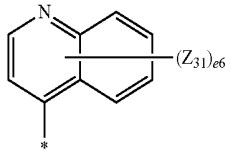
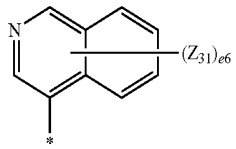
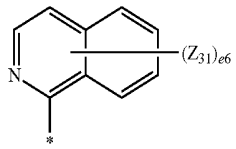


Formula 5-34



Formula 5-35



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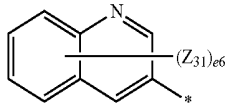

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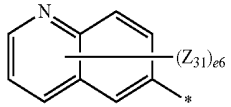

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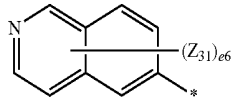

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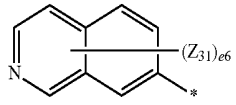

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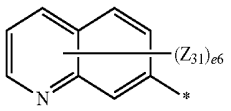

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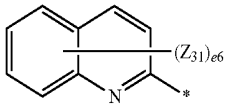
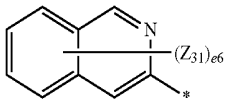
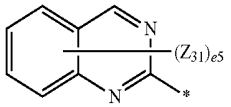


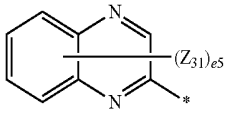
Formula 5-42



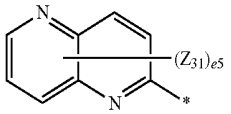
Formula 5-43



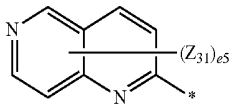
Formula 5-44



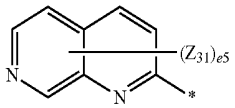
Formula 5-45



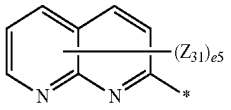
Formula 5-46



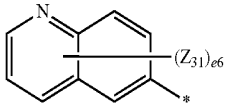
Formula 5-47



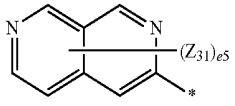
Formula 5-48



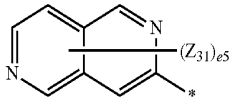
Formula 5-49



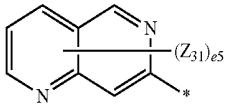
Formula 5-50



Formula 5-51



Formula 5-52



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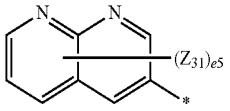
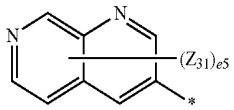
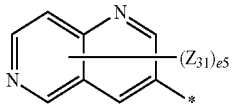
Formula 5-53



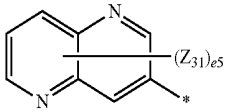
Formula 5-54



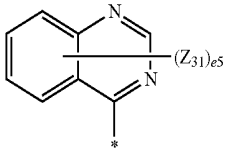
Formula 5-55



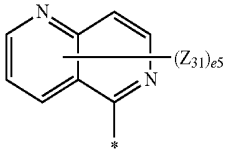
Formula 5-56



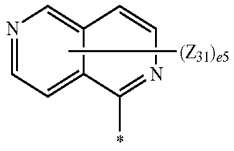
Formula 5-57



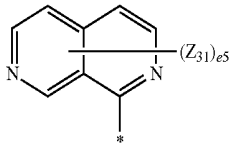
Formula 5-58



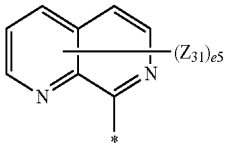
Formula 5-59



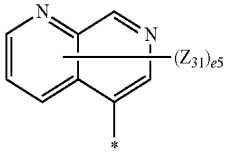
Formula 5-60



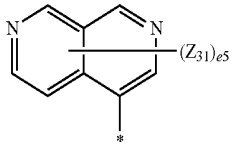
Formula 5-61



Formula 5-62



Formula 5-63



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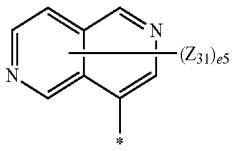
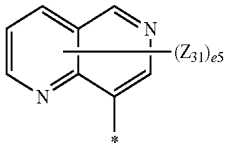
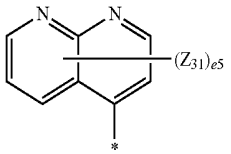
Formula 5-64



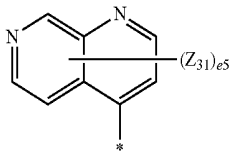
Formula 5-65



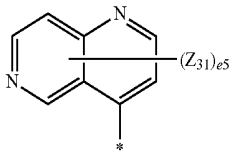
Formula 5-66



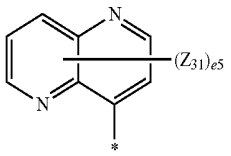
Formula 5-67



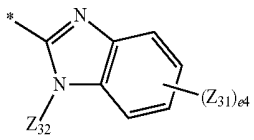
Formula 5-68



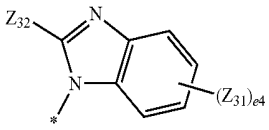
Formula 5-69



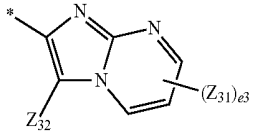
Formula 5-70



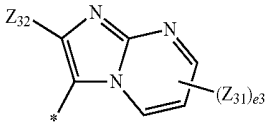
Formula 5-71



Formula 5-72



Formula 5-73



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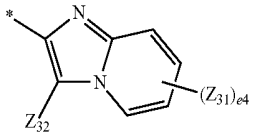
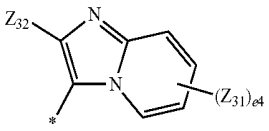
Formula 5-74



Formula 5-75



wherein, in Formulae 5-1 to 5-75,

Y_{31} is O, S, $C(Z_{33})(Z_{34})$, $N(Z_{35})$, or $Si(Z_{36})(Z_{37})$,

Z_{31} to Z_{37} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and $—Si(Q_{33})(Q_{34})(Q_{35})$,

wherein Q_{33} to Q_{35} are each independently selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

e2 is an integer of 1 or 2,

e3 is an integer of 1 to 3,

e4 is an integer of 1 to 4,

e5 is an integer of 1 to 5,

e6 is an integer of 1 to 6,

e7 is an integer of 1 to 7,

e9 is an integer of 1 to 9, and

* indicates a binding site to a neighboring atom.

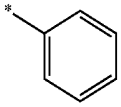
9. The condensed cyclic compound as claimed in claim **1**, wherein:

R_3 to R_6 are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a 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, and $—Si(Q_3)(Q_4)(Q_5)$, and

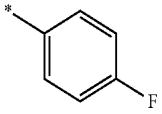
R_1, R_2, and R_{11} are each independently a group represented by one of the following Formulae 6-1 to 6-43 or a group represented by one of the following Formulae 10-1 to 10-117,

wherein Q_3 to Q_5 are each independently selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group:

Formula 6-1



Formula 6-2



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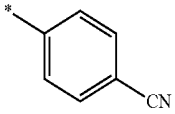

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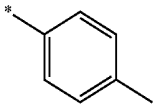

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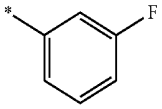

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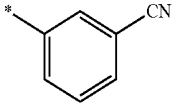

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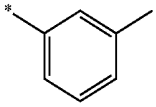

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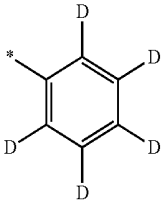

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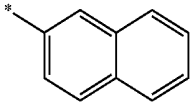

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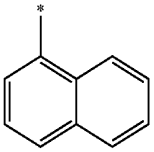

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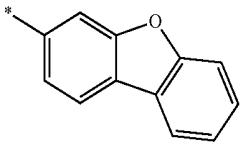

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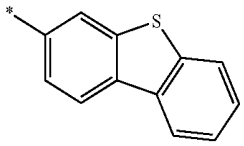

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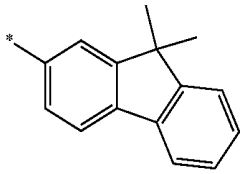

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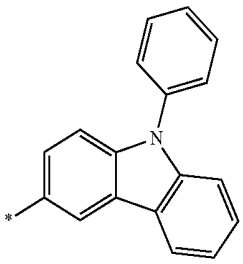

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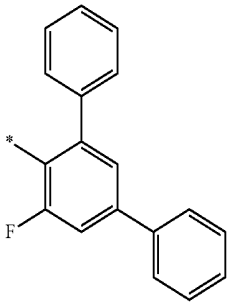

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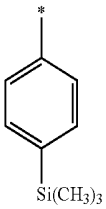

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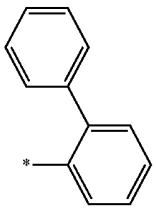

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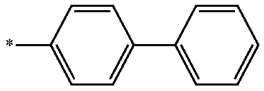

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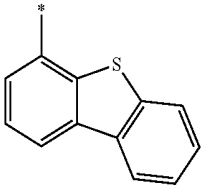

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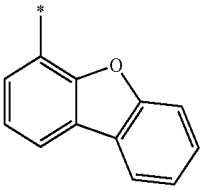

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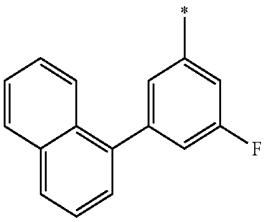

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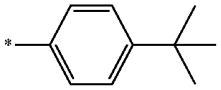

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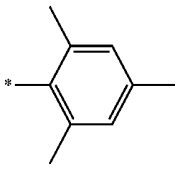

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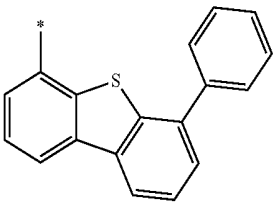

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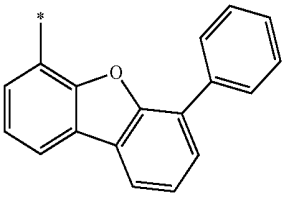

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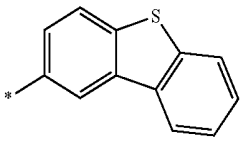

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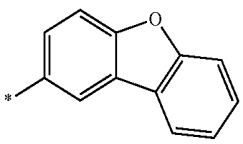

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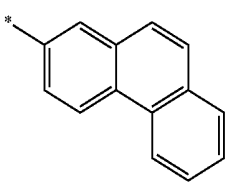

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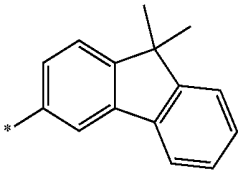

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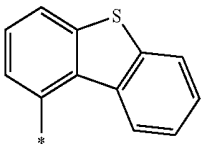

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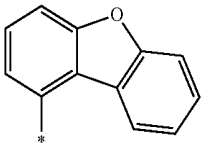

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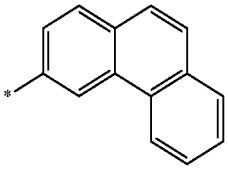

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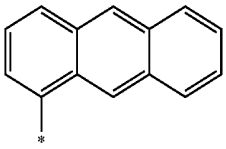

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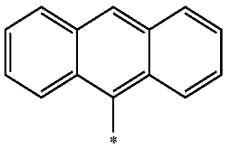

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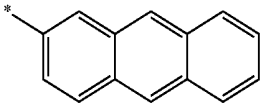

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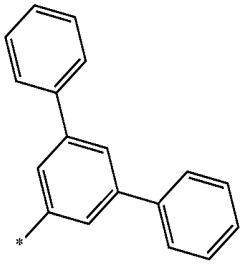

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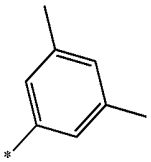

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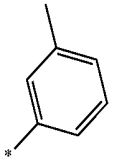

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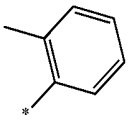

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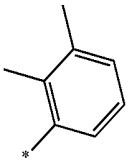

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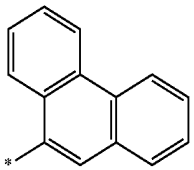

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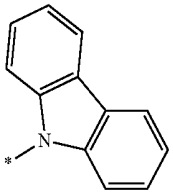

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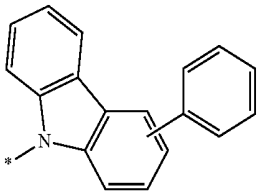

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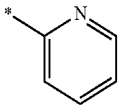

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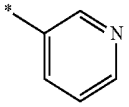

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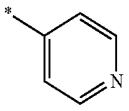

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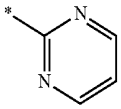

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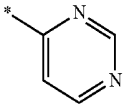

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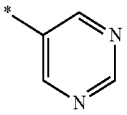

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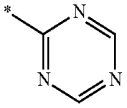

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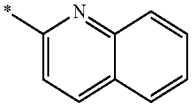

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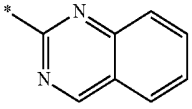

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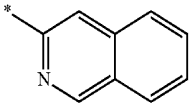

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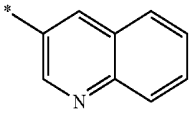

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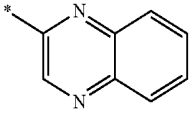

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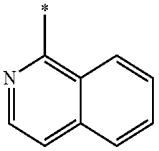

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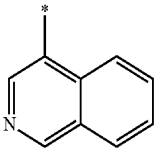

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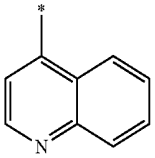

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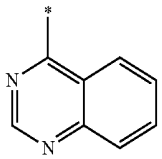
Formula 10-16



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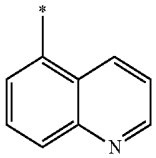

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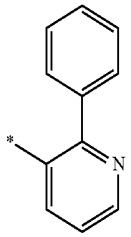

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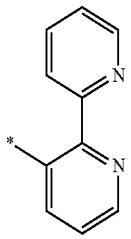

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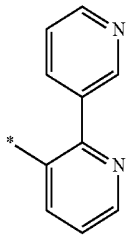

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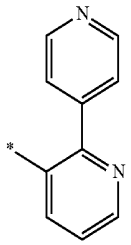

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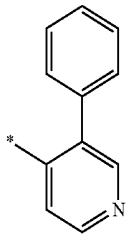

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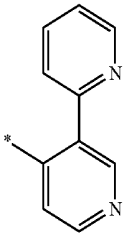

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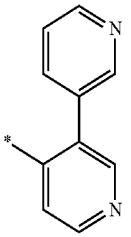

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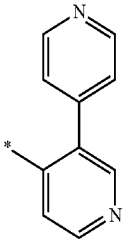

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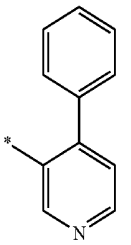

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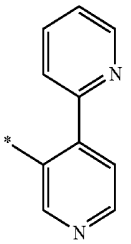

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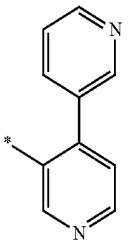

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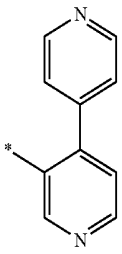

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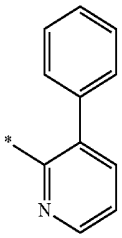

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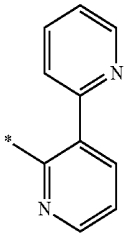

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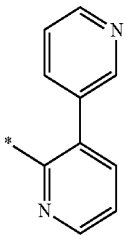

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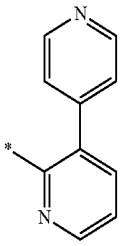

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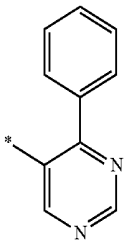

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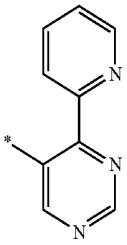

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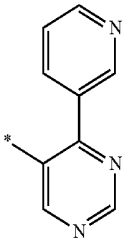

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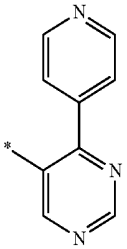

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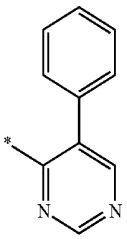

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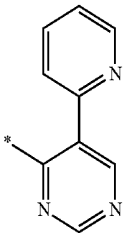

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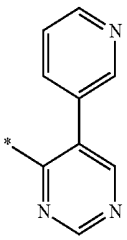

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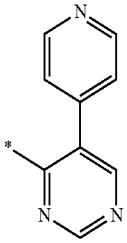

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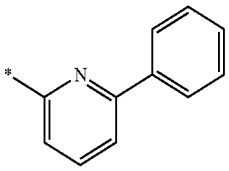

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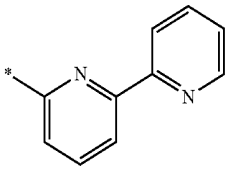

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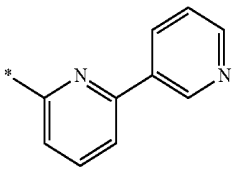

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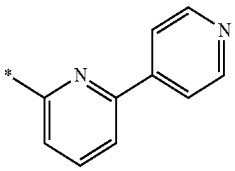

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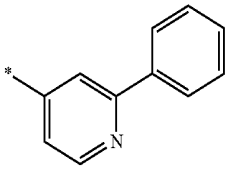

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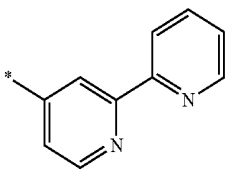

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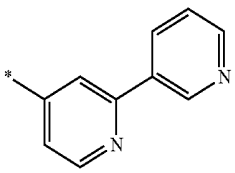

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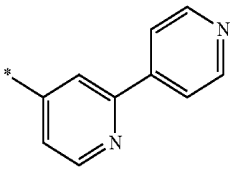

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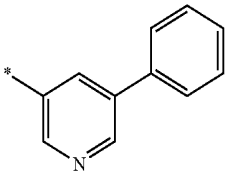

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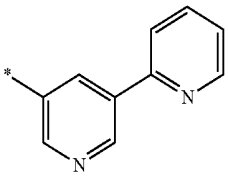

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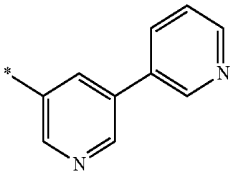

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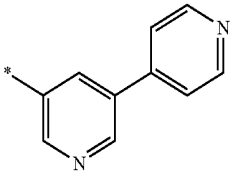

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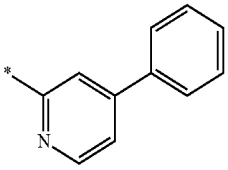

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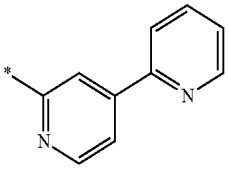

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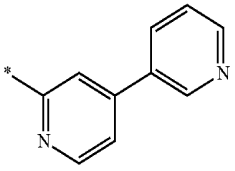

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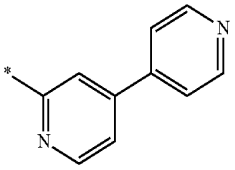

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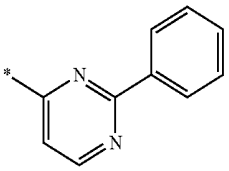

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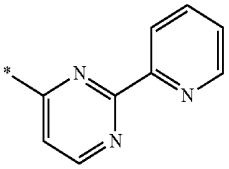

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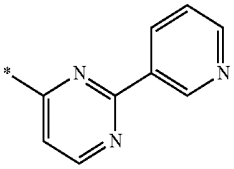

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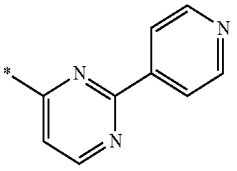

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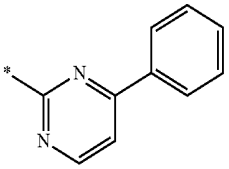

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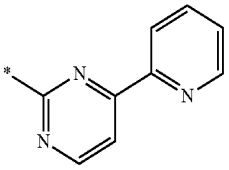

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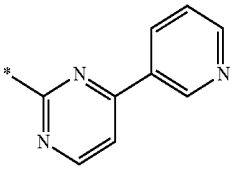

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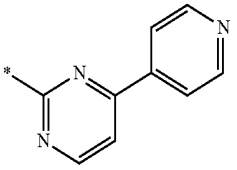

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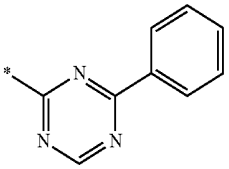

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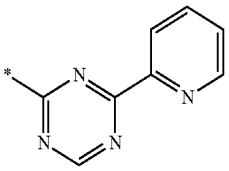

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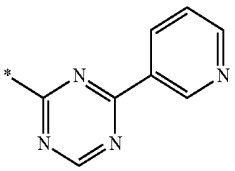

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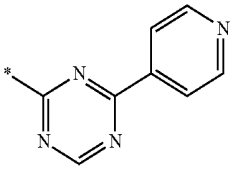

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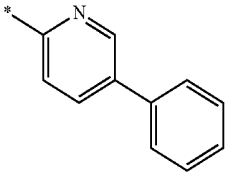

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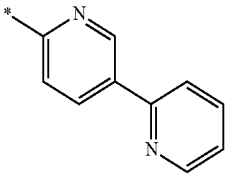

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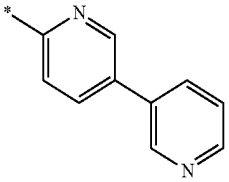

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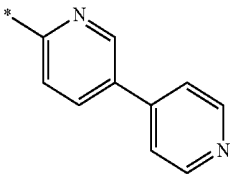
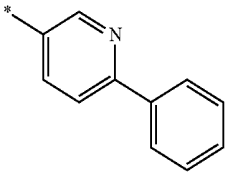
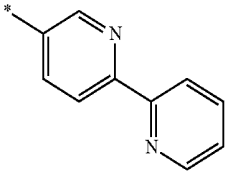


Formula 10-74



Formula 10-75



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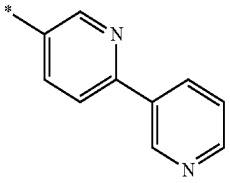
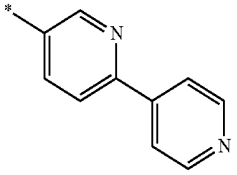
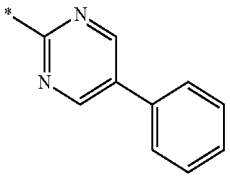
Formula 10-76



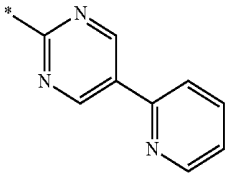
Formula 10-77



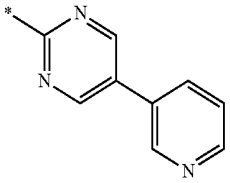
Formula 10-78



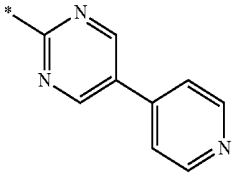
Formula 10-79



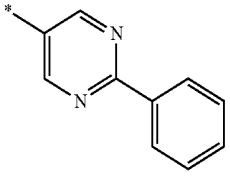
Formula 10-80



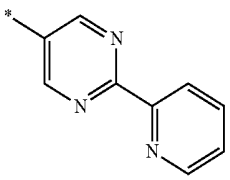
Formula 10-81



Formula 10-82



Formula 10-83



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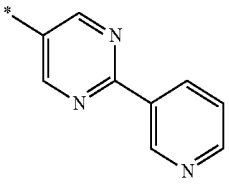
Formula 10-84



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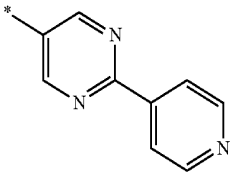
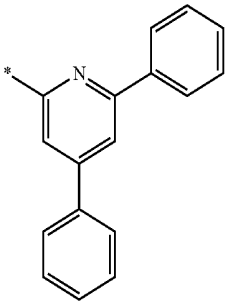
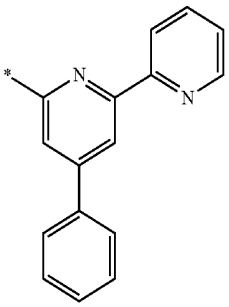


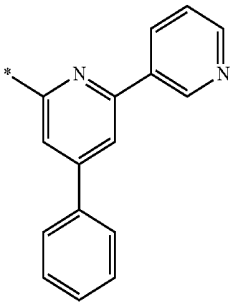
Formula 10-86



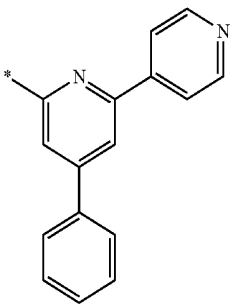
Formula 10-87



Formula 10-88



Formula 10-89



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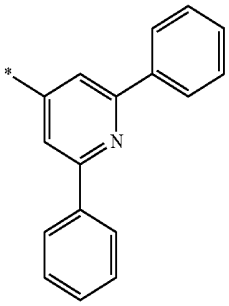
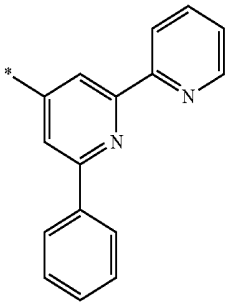
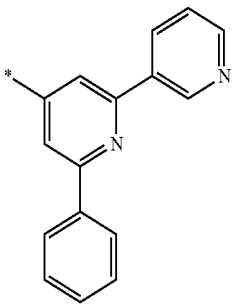
Formula 10-90



Formula 10-91



Formula 10-92



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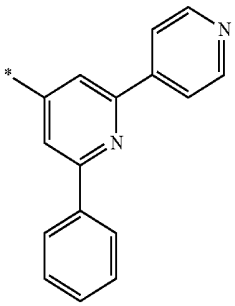
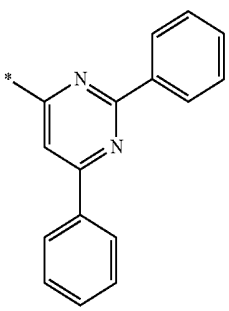


Formula 10-94



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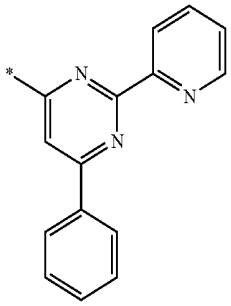
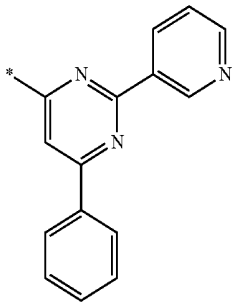
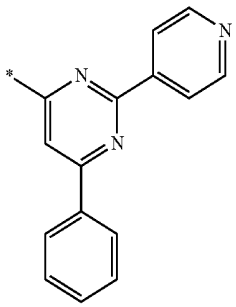


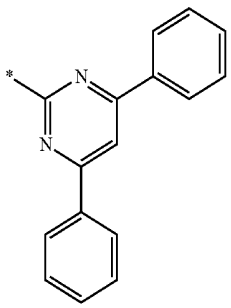
Formula 10-96



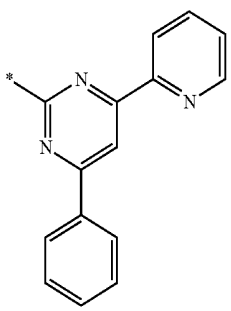
Formula 10-97



Formula 10-98



Formula 10-99



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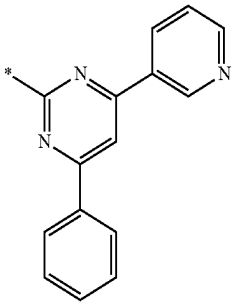
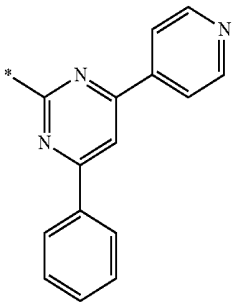
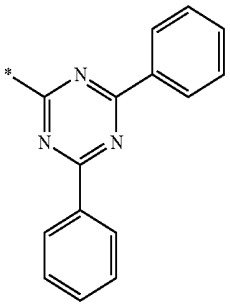
Formula 10-100



Formula 10-101



Formula 10-102



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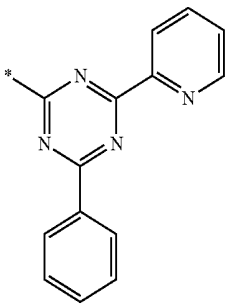
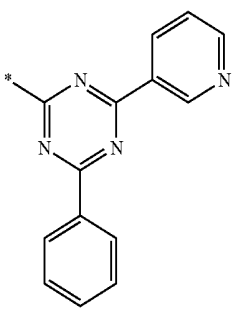


Formula 10-104



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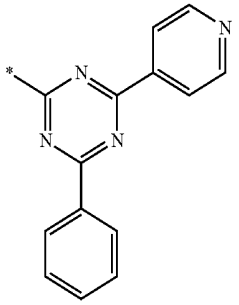
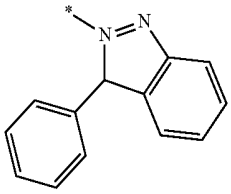
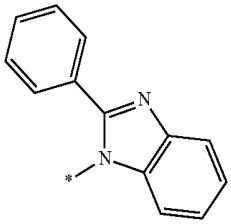


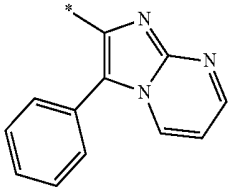
Formula 10-106



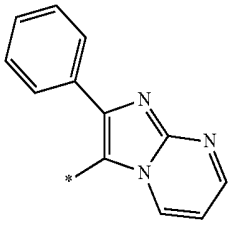
Formula 10-107



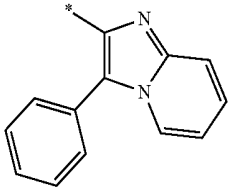
Formula 10-108



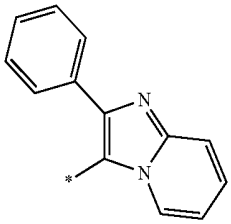
Formula 10-109



Formula 10-110



Formula 10-111



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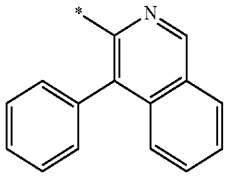
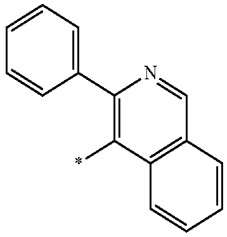
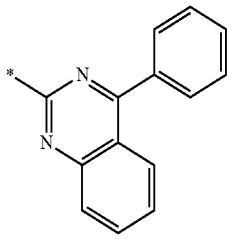
Formula 10-112



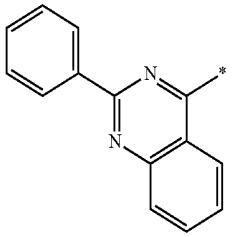
Formula 10-113



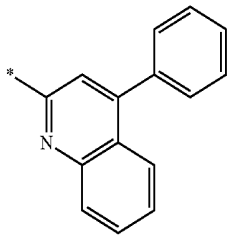
Formula 10-114



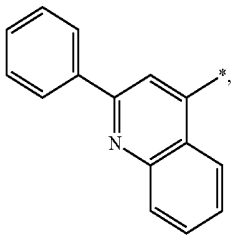
Formula 10-115



Formula 10-116



Formula 10-117



and

* in Formulae 6-1 to 6-41 and 10-1 to 10-117 indicates a binding site to a neighboring atom.

10. The condensed cyclic compound as claimed in claim **1**, wherein a sum of c1 and c2 is 1 or greater.

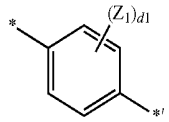
11. The condensed cyclic compound as claimed in claim **1**, wherein:

L_1 and L_2 are each independently a group represented by one of the following Formulae 3-8, 3-9, 3-25, and 3-35 to 3-41,

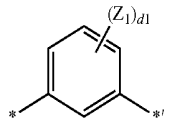
L_{11} is a group represented by one of the following Formulae 3-1 to 3-41, and

a sum of c1 and c2 is 1 or greater:

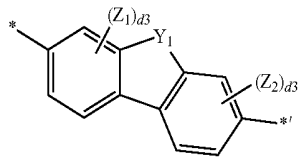
Formula 3-1



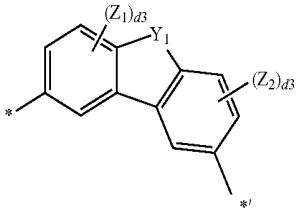
Formula 3-2



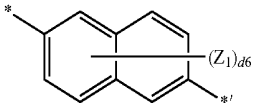
Formula 3-3



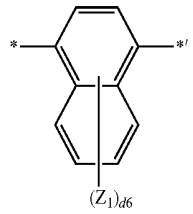
Formula 3-4



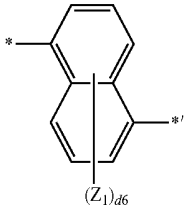
Formula 3-5



Formula 3-6



Formula 3-7



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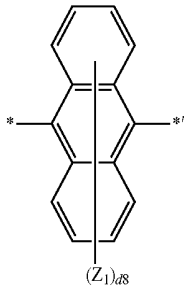
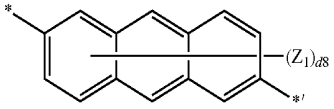
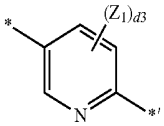
Formula 3-8



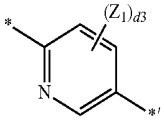
Formula 3-9



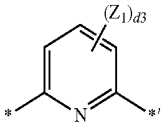
Formula 3-10



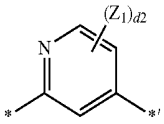
Formula 3-11



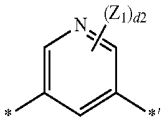
Formula 3-12



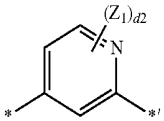
Formula 3-13



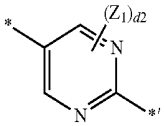
Formula 3-14



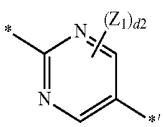
Formula 3-15



Formula 3-16



Formula 3-17



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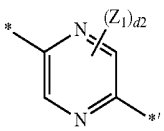

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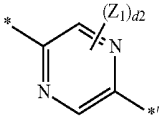
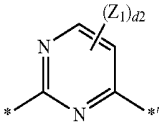
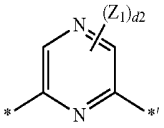


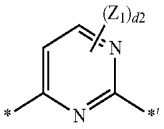
Formula 3-20



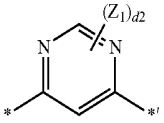
Formula 3-21



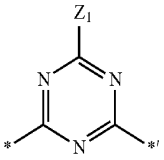
Formula 3-22



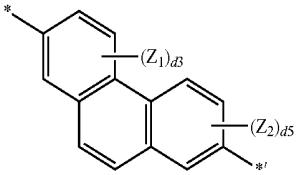
Formula 3-23



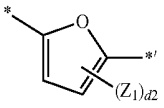
Formula 3-24



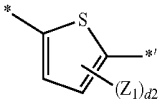
Formula 3-25



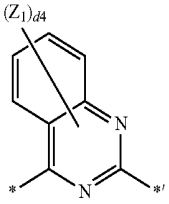
Formula 3-26



Formula 3-27



Formula 3-28



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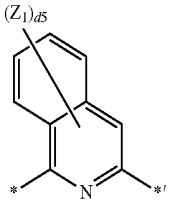
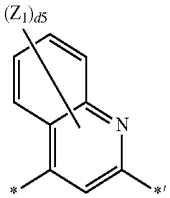
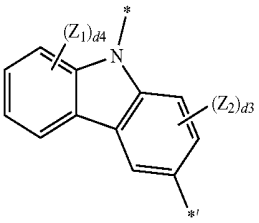
Formula 3-29



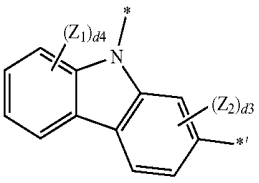
Formula 3-30



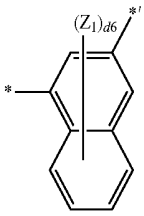
Formula 3-31



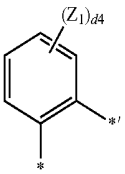
Formula 3-32



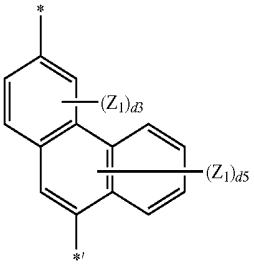
Formula 3-33



Formula 3-34



Formula 3-35



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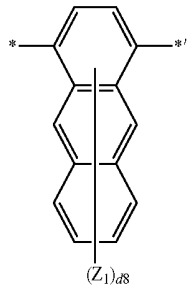
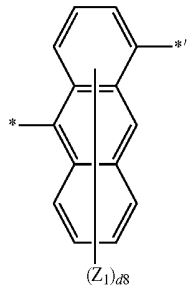
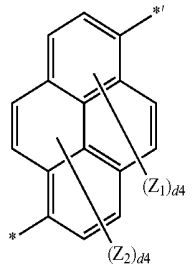
Formula 3-36



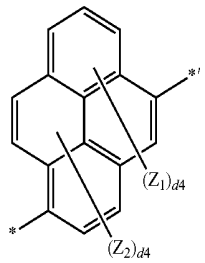
Formula 3-37



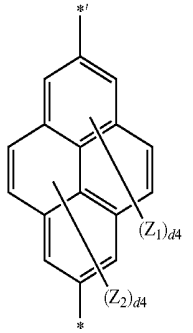
Formula 3-38



Formula 3-39



Formula 3-40



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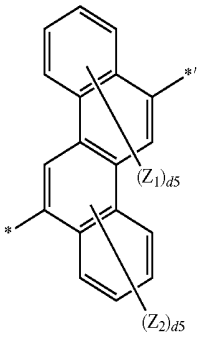
Formula 3-41



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

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

Z_1 to Z_7 are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an 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 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 pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and $—Si(Q_{33})(Q_{34})(Q_{35})$,

wherein Q_{33} to Q_{35} are each independently selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

d2 is an integer of 1 or 2,

d3 is an integer of 1 to 3,

d4 is an integer of 1 to 4,

d5 is an integer of 1 to 5,

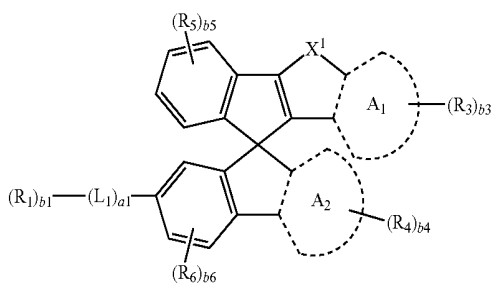
d6 is an integer of 1 to 6,

d8 is an integer of 1 to 8, and

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

12. The condensed cyclic compound as claimed in claim **1**, wherein the condensed cyclic compound represented by Formula 1 is represented by Formula 1A:

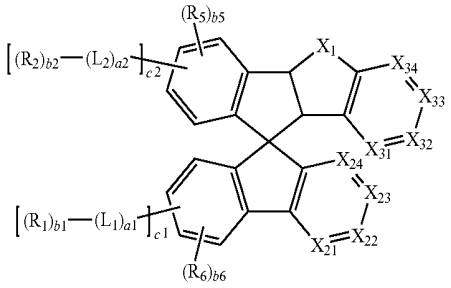
<Formula 1A>



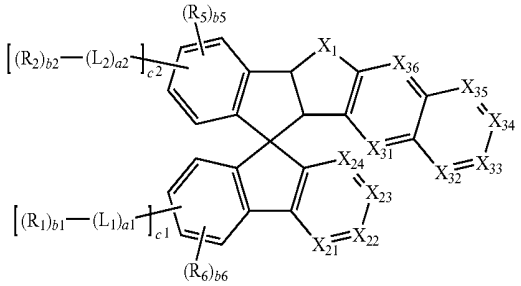
wherein, in Formula 1A, ring A_1, ring A_2, X_1, L_1, a1, R_1, R_3 to R_6, b1, and b3 to b6 are defined the same as those of Formula 1.

13. The condensed cyclic compound as claimed in claim **1**, wherein the condensed cyclic compound represented by Formula 1 is represented by one of Formulae 1-1 to 1-7:

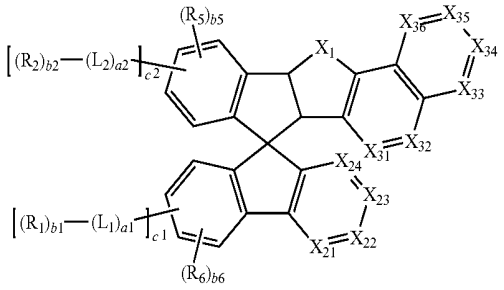
Formula 1-1



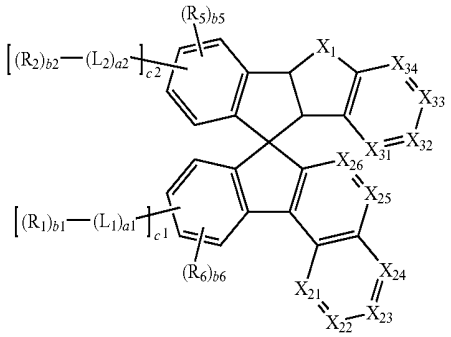
Formula 1-2



Formula 1-3



Formula 1-4



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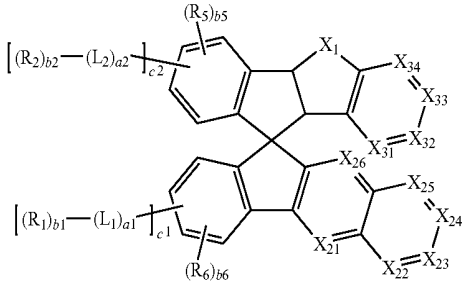
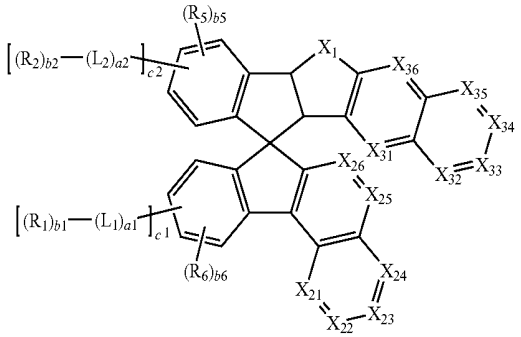
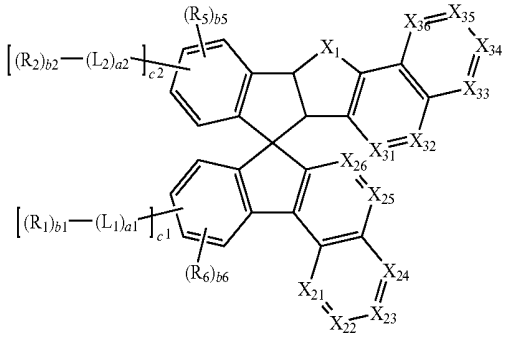
Formula 1-5



Formula 1-6



Formula 1-7



in Formulae 1-1 to 1-7,

X_1, L_1, L_2, a1, a2, R_1, R_2, R_5, R_6, b1, b2, b5, b6, c1, and c2 are defined the same

as those of Formula 1,

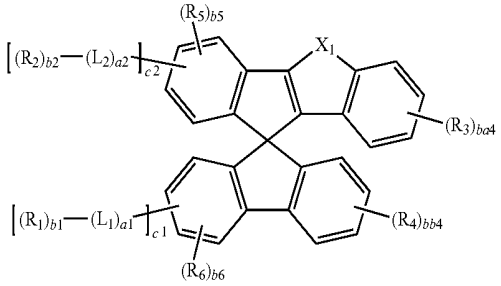
X_{21} is N or $C(R_{21})$, X_{22} is N or $C(R_{22})$, X_{23} is N or $C(R_{23})$, X_{24} is N or $C(R_{24})$, X_{25} is N or $C(R_{25})$, X_{26} is N or $C(R_{26})$, X_{31} is N or $C(R_{31})$, X_{32} is N or $C(R_{32})$, X_{33} is N or $C(R_{33})$, X_{34} is N or $C(R_{34})$, X_{35} is N or $C(R_{35})$, and X_{36} is N or $C(R_{36})$,

each of R_{21} to R_{26} are defined the same as R_3 of Formula 1, and

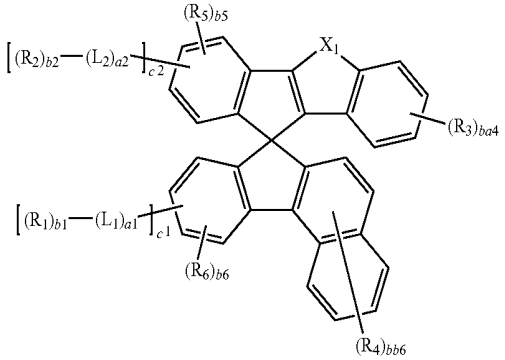
each of R_{31} to R_{36} are defined the same as R_4 of Formula 1.

14. The condensed cyclic compound as claimed in claim **1**, wherein the condensed cyclic compound represented by Formula 1 is represented by one of the following Formulae 1(1) to 1(19):

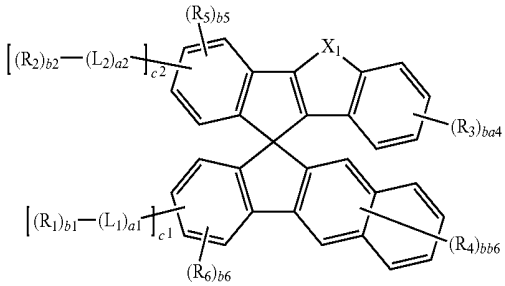
Formula 1(1)



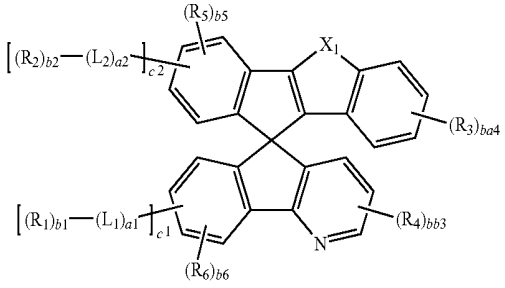
Formula 1(2)



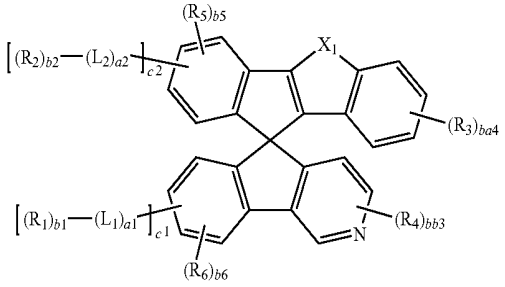
Formula 1(3)



Formula 1(4)



Formula 1(5)



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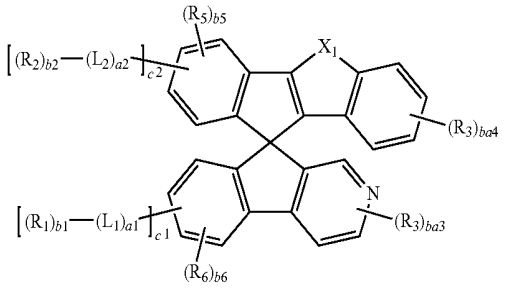
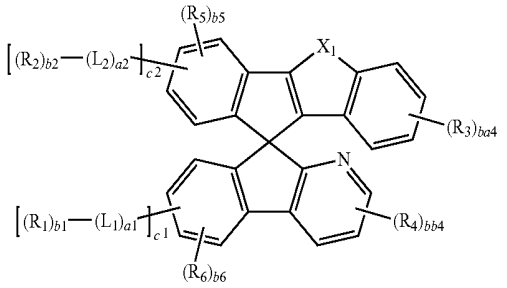
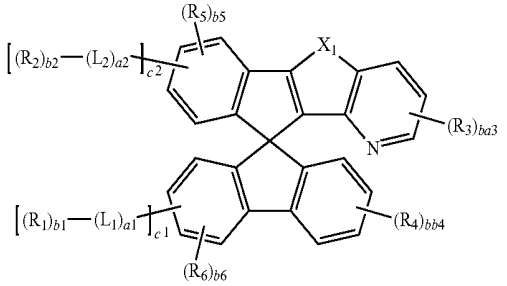
Formula 1(6)



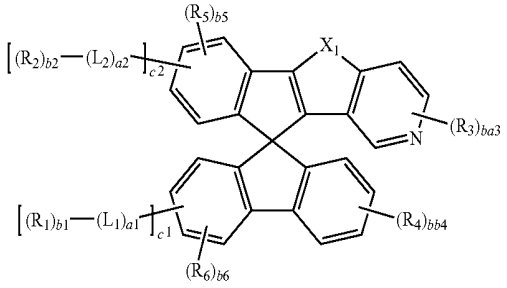
Formula 1(7)



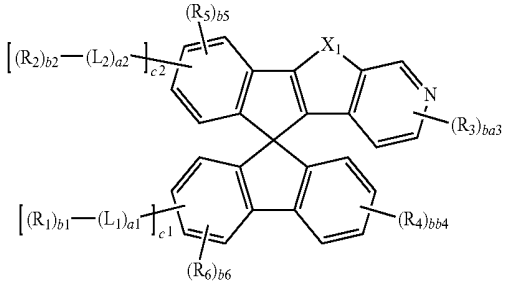
Formula 1(8)



Formula 1(9)



Formula 1(10)



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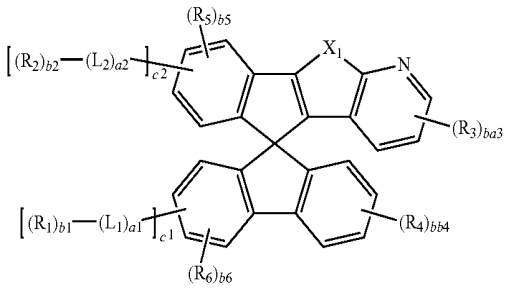
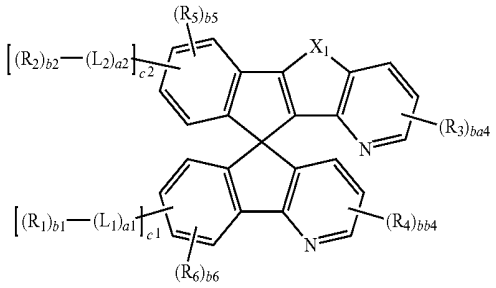
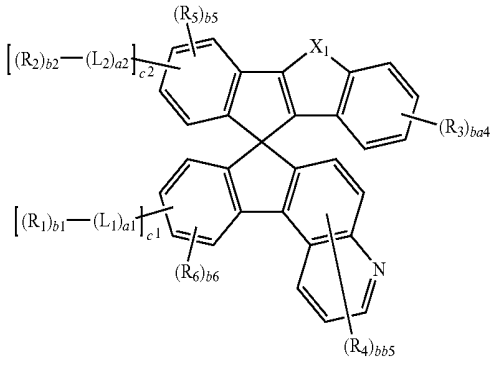
Formula 1(11)



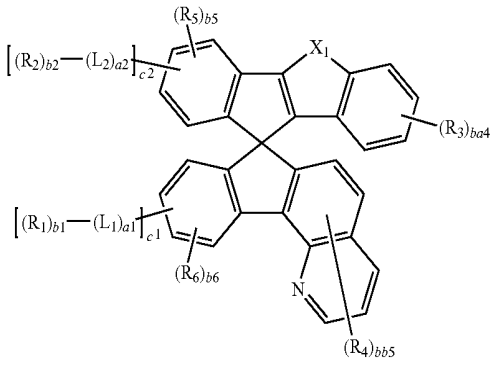
Formula 1(12)



Formula 1(13)



Formula 1(14)



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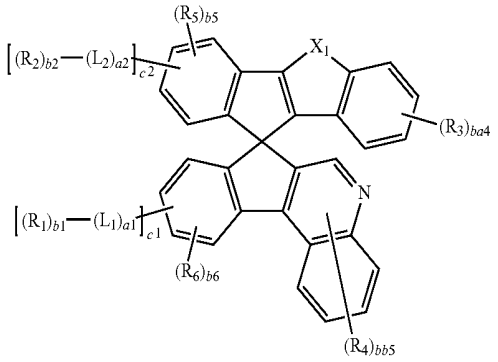
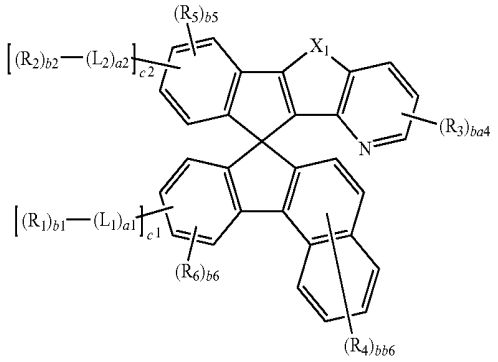
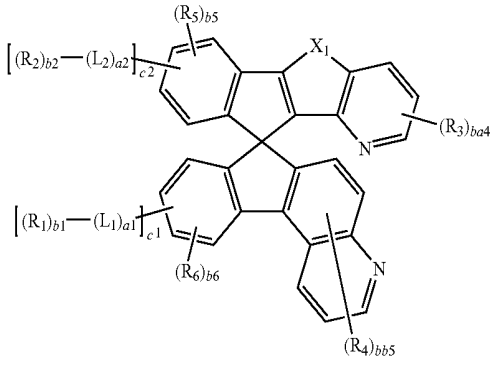
Formula 1(15)



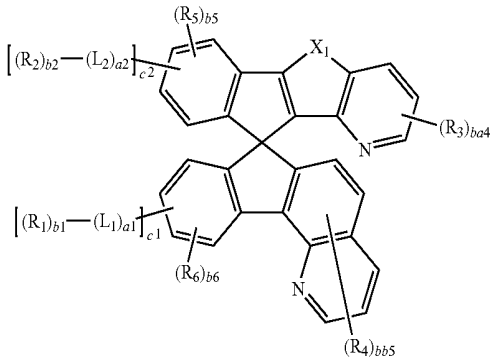
Formula 1(16)



Formula 1(17)



Formula 1(18)



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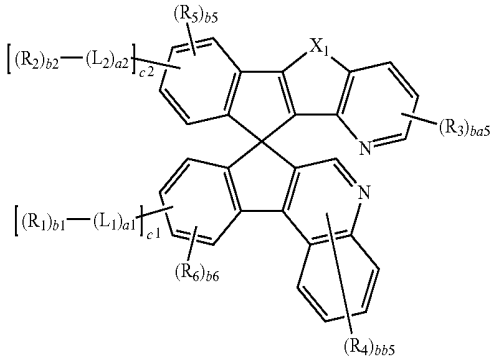
Formula 1(19)



wherein, in Formulae 1(1) to 1(19),

X_1, L_1, L_2, a1, a2, R_1 to R_6, b1 to b6, c1, and c2 are defined the same as those of Formula 1,

ba3 and bb3 are each independently an integer of 0 to 3,

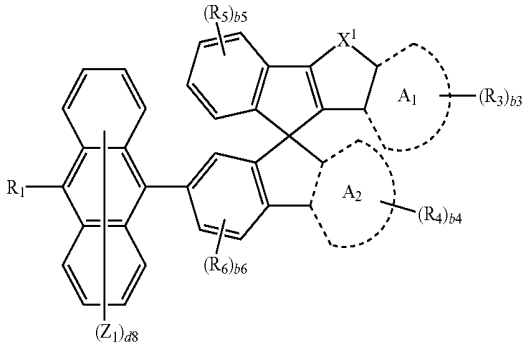
ba4 and bb4 are each independently an integer of 0 to 4,

ba5 and bb5 are each independently an integer of 0 to 5, and

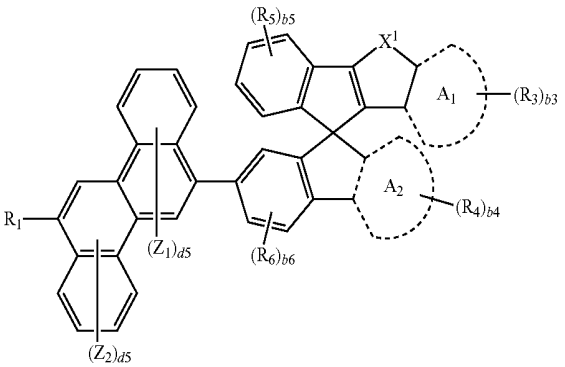
ba6 and bb6 are each independently an integer of 0 to 6.

15. The condensed cyclic compound as claimed in claim **1**, wherein the condensed cyclic compound represented by Formula 1 is represented by one of the following Formulae 1A-1 to 1A-4:

Formula 1A-1



Formula 1A-2



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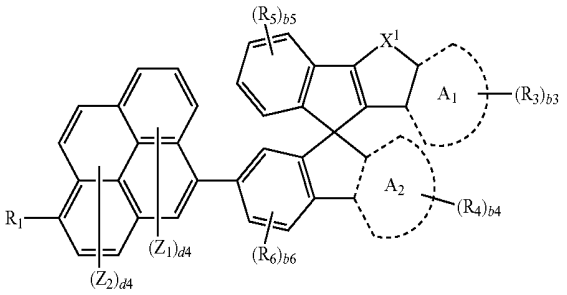
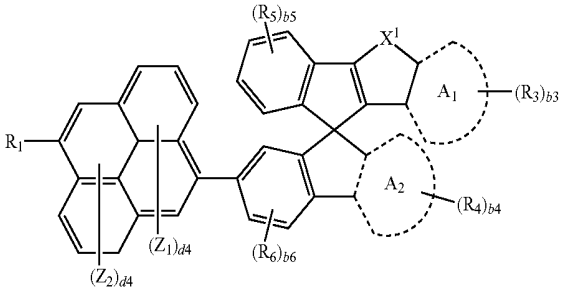
Formula 1A-3



Formula 1A-4



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

ring A_1 and ring A_2 are each independently selected from a benzene, a naphthalene, a pyridine, a quinoline, and an isoquinoline,

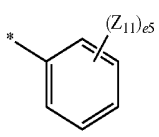
X_1 is O or S,

R_1 is a represented by one of the following Formulae 5-1 to 5-75,

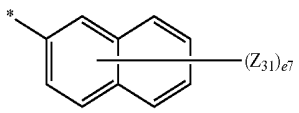
R_3 to R_6 are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and —$Si(Q_3)(Q_4)(Q_5)$, and

b3 to b6, d4, d5, and d8 are each independently 0, 1, or 2:

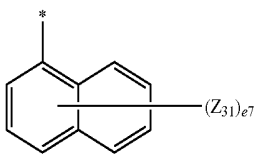
Formula 5-1



Formula 5-2



Formula 5-3



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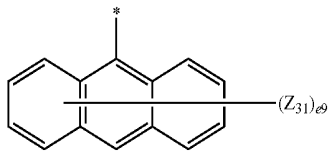
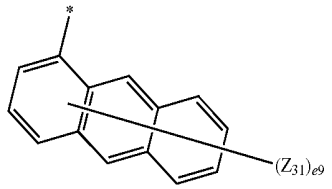
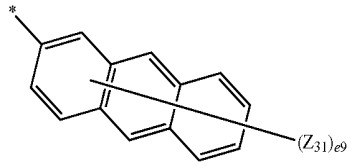
Formula 5-4



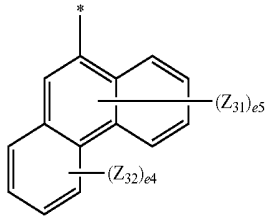
Formula 5-5



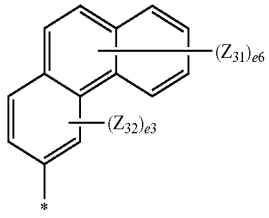
Formula 5-6



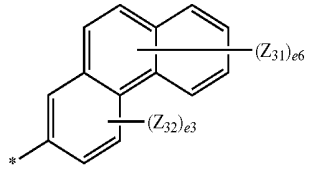
Formula 5-7



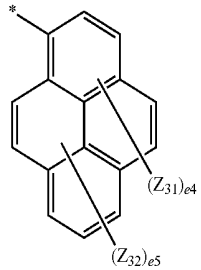
Formukla 5-8



Formula 5-9



Formula 5-10



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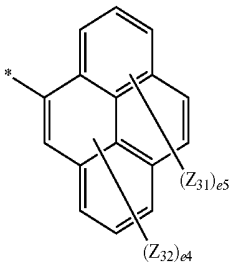
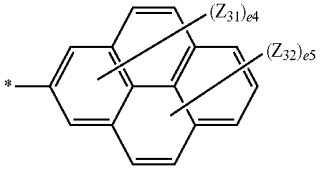
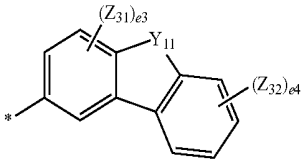
Formula 5-11



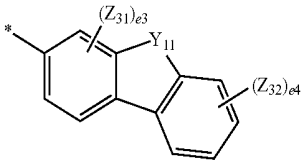
Formula 5-12



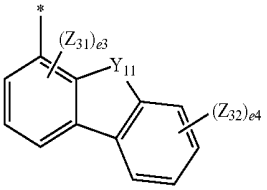
Formula 5-13



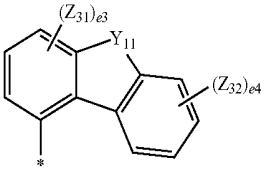
Formula 5-14



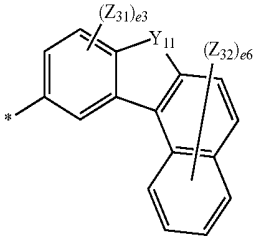
Formula 5-15



Formula 5-16



Formula 5-17



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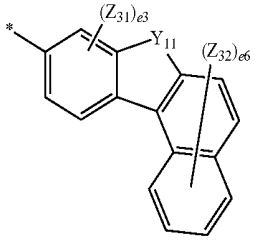
Formula 5-18



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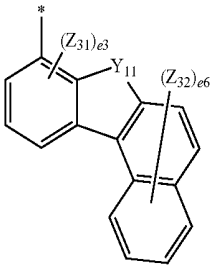

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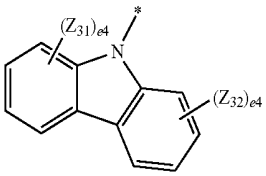

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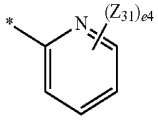

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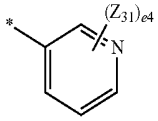

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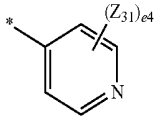

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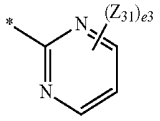

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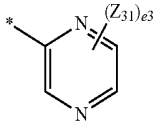

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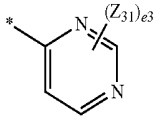

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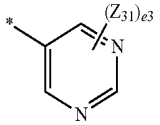

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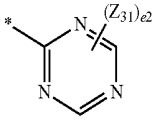

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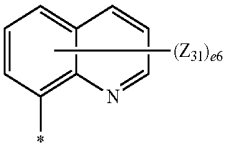

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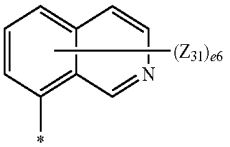
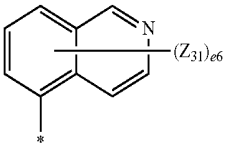


Formula 5-31



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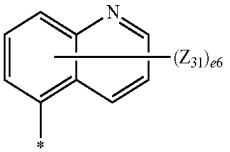

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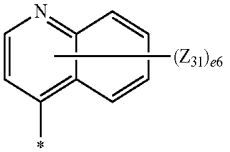

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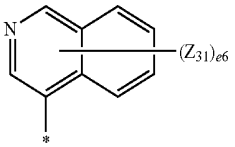

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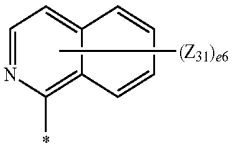

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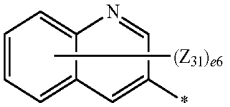

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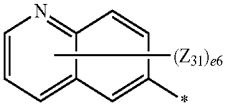
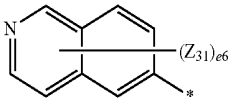


Formula 5-38



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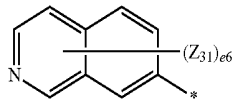

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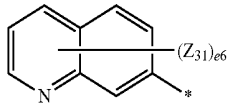

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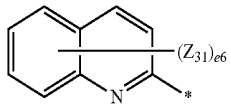
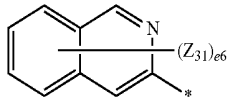
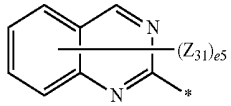


Formula 5-42



Formula 5-43



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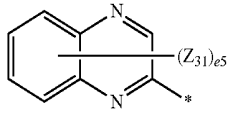
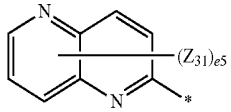


Formula 5-45



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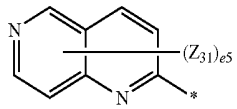
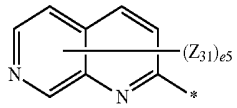


Formula 5-47



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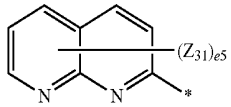

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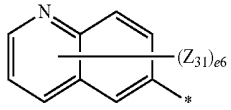

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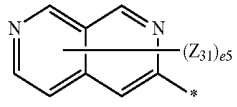

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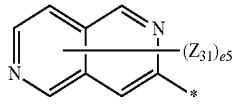

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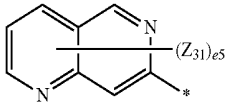
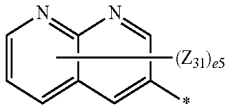


Formula 5-53



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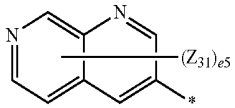

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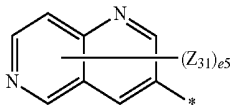

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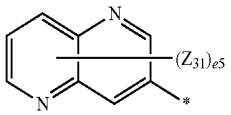

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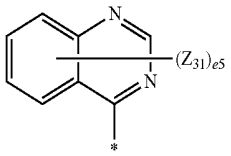

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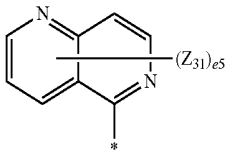

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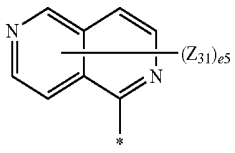

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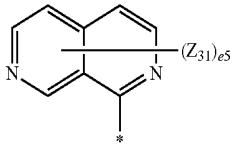

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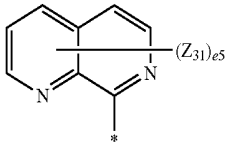

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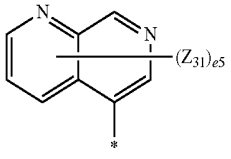

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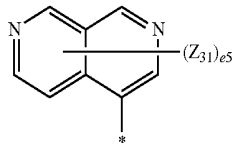
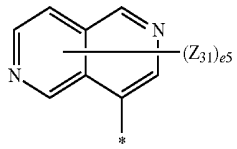


Formula 5-64



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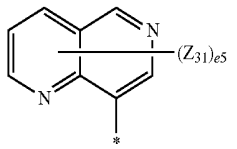

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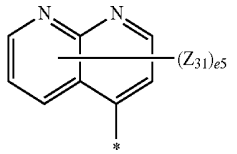

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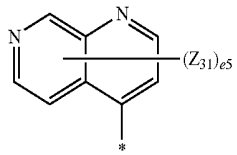

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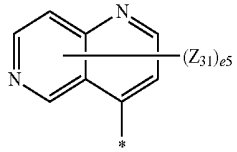

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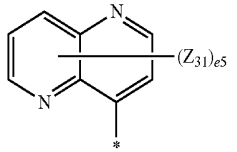

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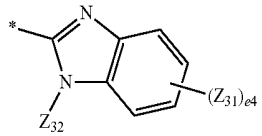
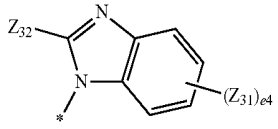


Formula 5-71



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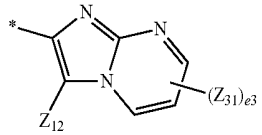

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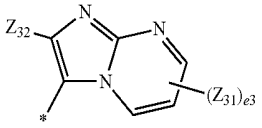

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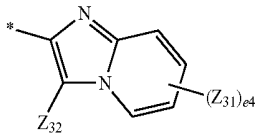

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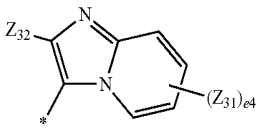

wherein,

Y_{31} is O, S, $C(Z_{33})(Z_{34})$, $N(Z_{35})$, or $Si(Z_{36})(Z_{37})$,

Z_1, Z_2, and Z_{31} to Z_{37} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, and $—Si(Q_{33})(Q_{34})(Q_{35})$,

Q_3 to Q_5 and Q_{33} to Q_{35} are each independently selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

e2 is an integer of 1 or 2,

e3 is an integer of 1 to 3,

e4 is an integer of 1 to 4,

e5 is an integer of 1 to 5,

e6 is an integer of 1 to 6,

e7 is an integer of 1 to 7, and

e9 is an integer of 1 to 9.

16. The condensed cyclic compound as claimed in claim **1**, wherein the condensed cyclic compound represented by Formula 1 is one of the following Compounds 1 to 64:

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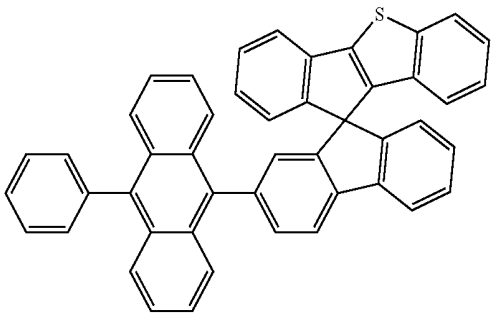
1



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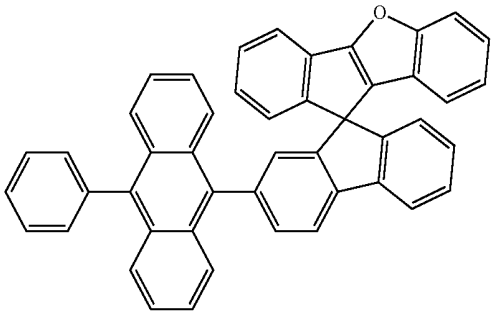

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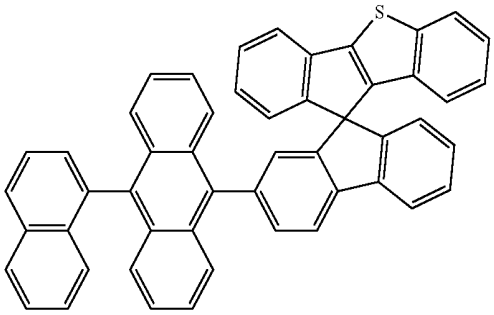

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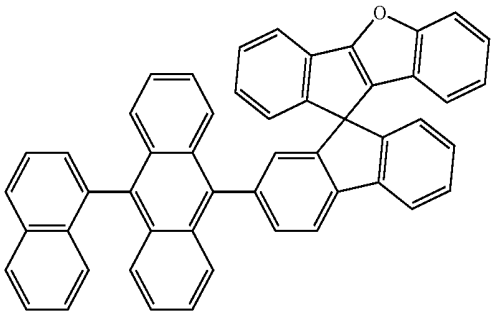

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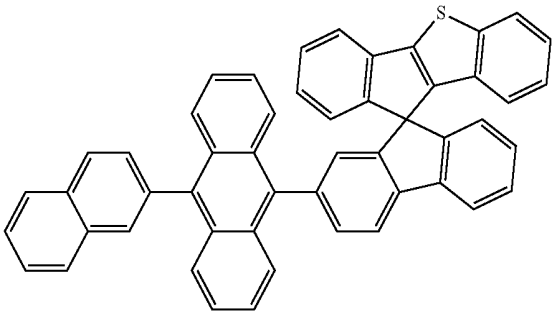

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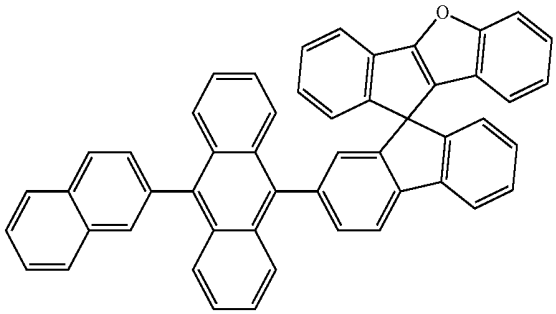

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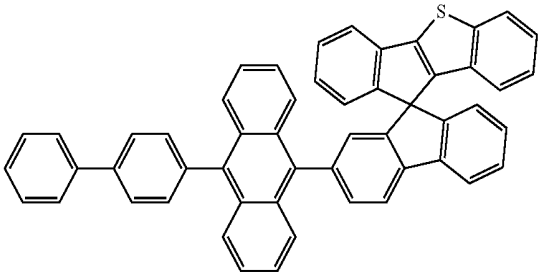

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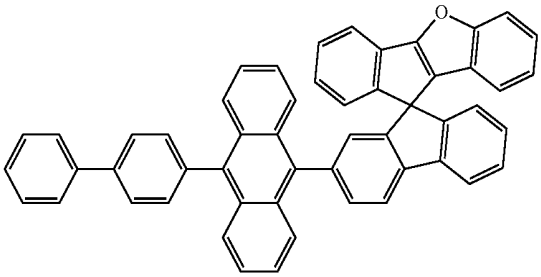

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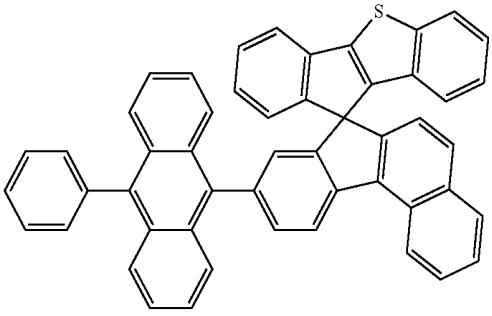

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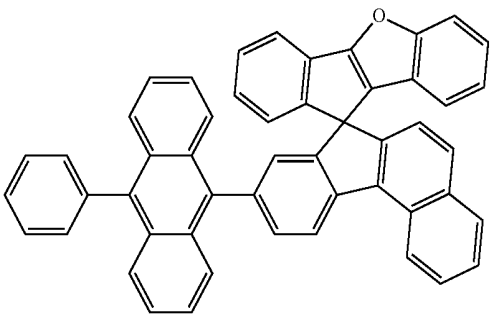

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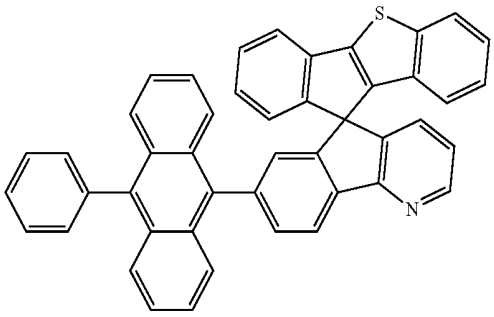

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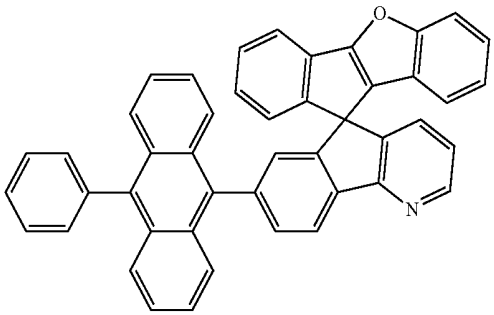

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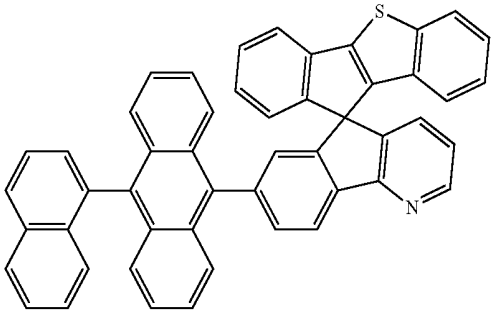

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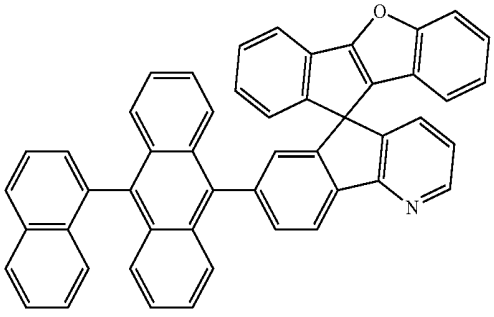

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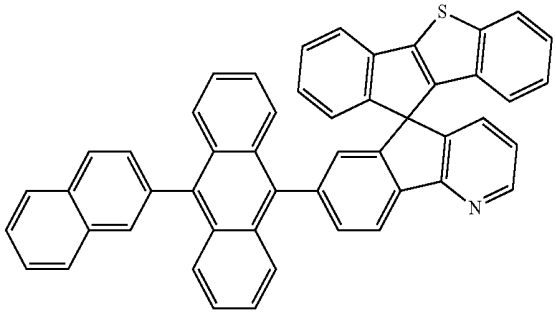

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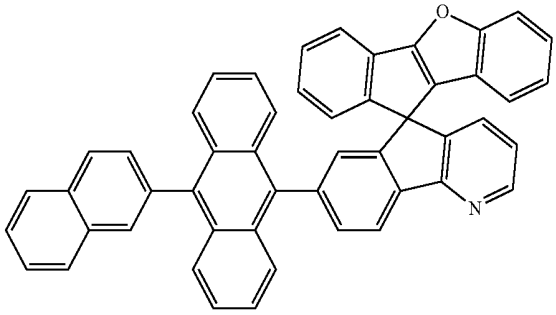

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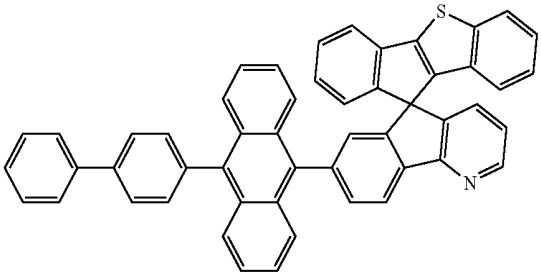

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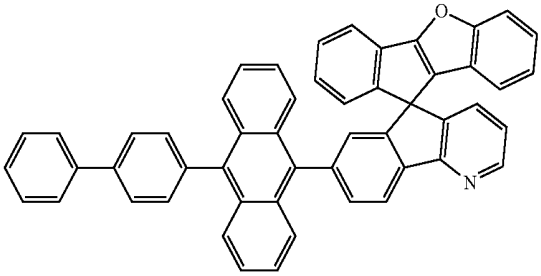

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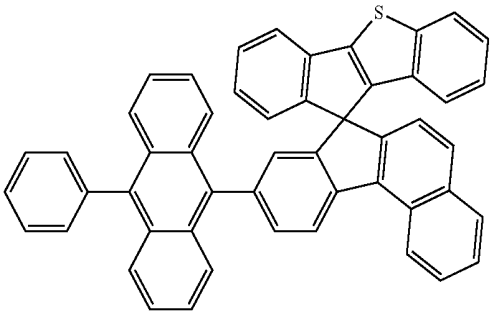

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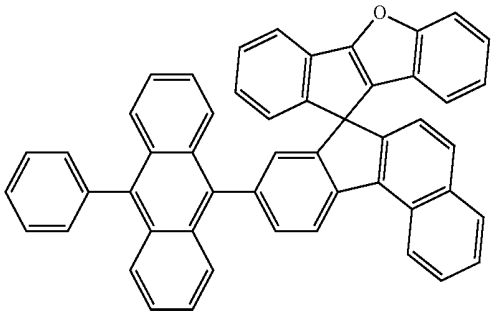

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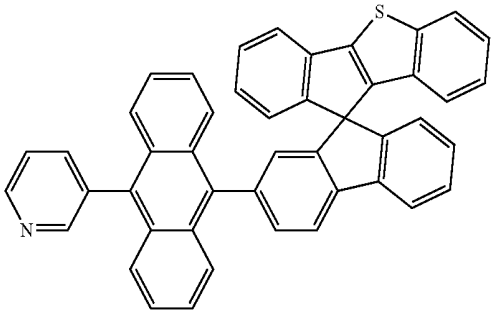

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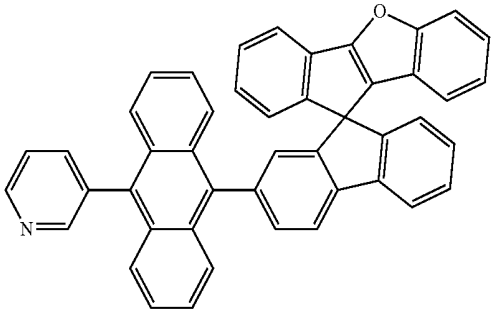

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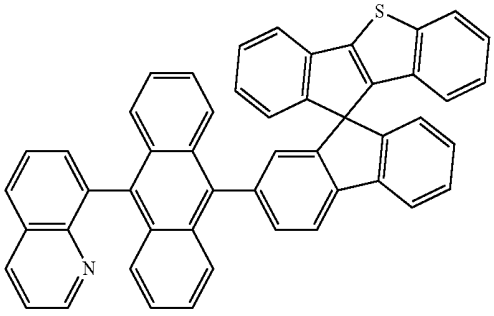

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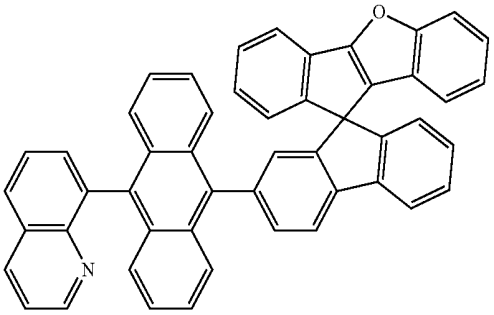

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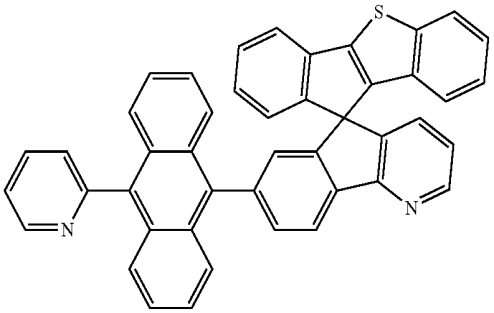

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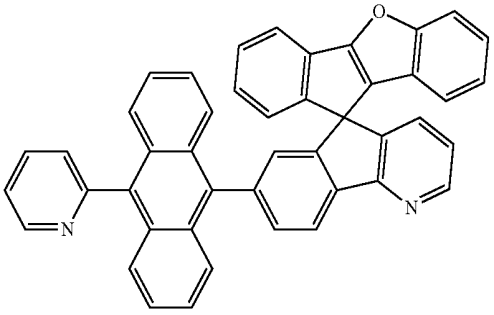

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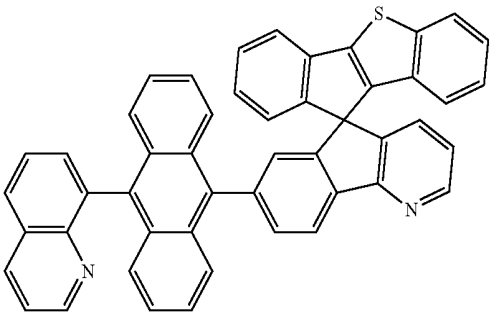

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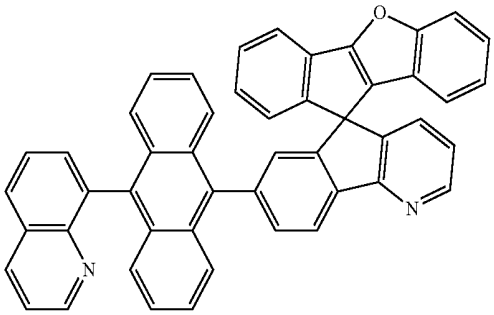

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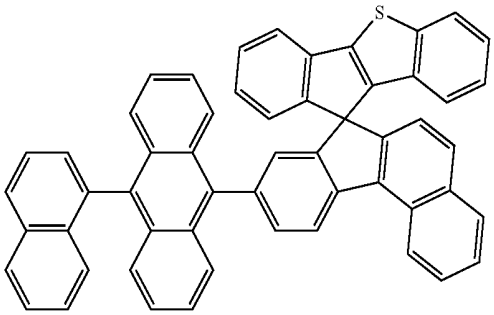

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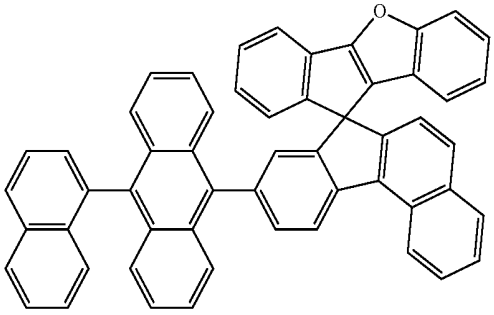

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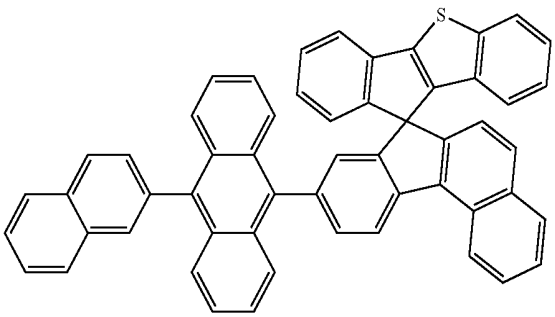

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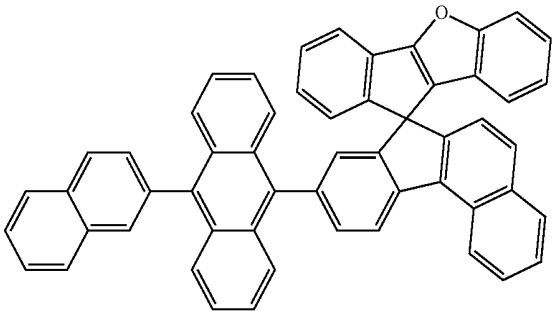

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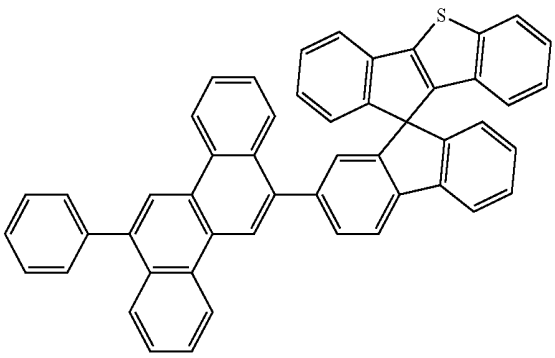

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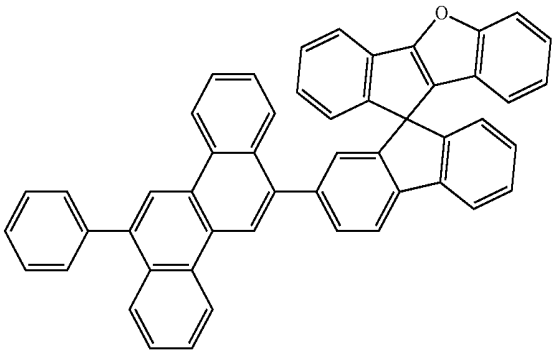

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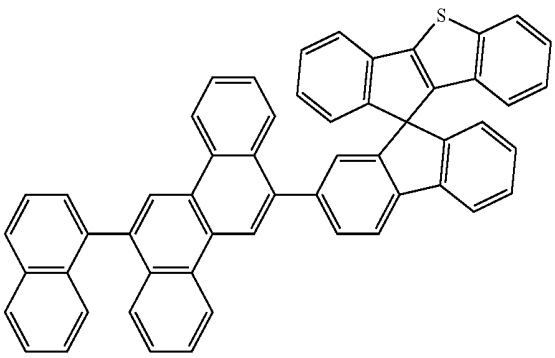

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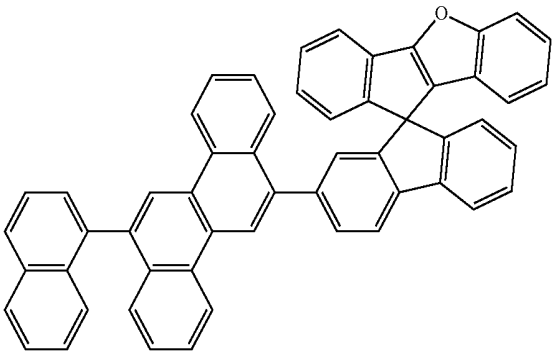

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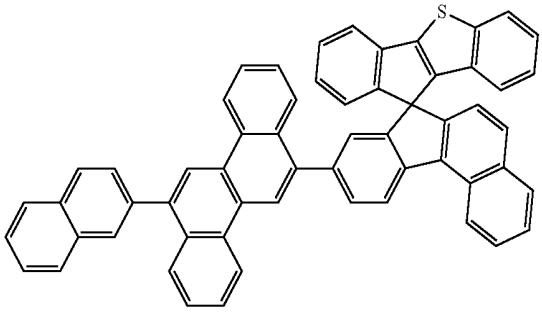

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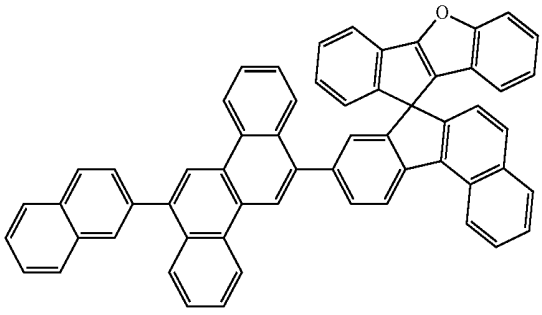

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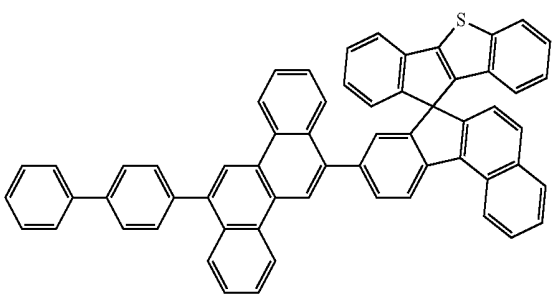

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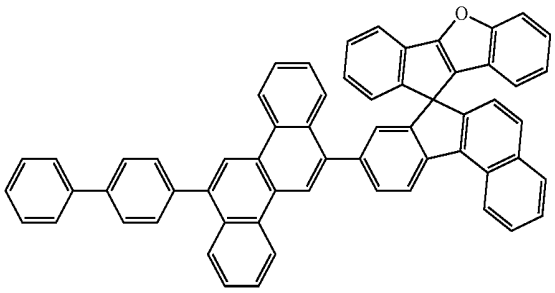

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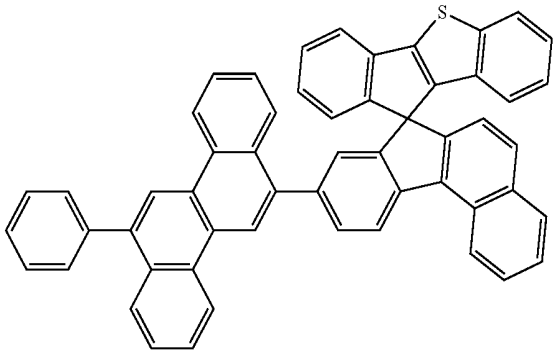

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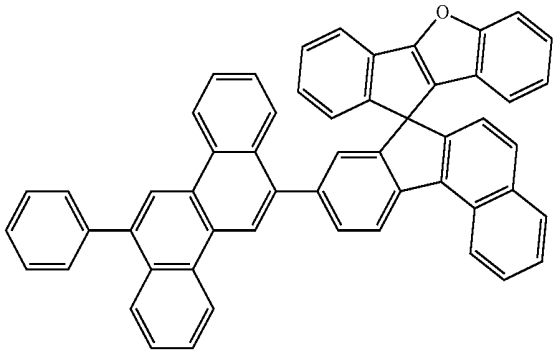

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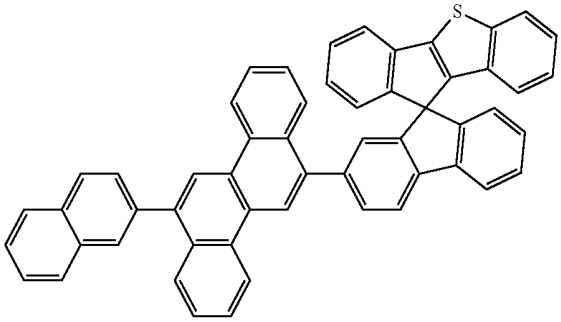

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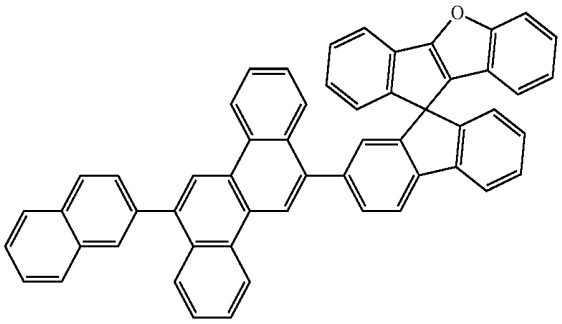

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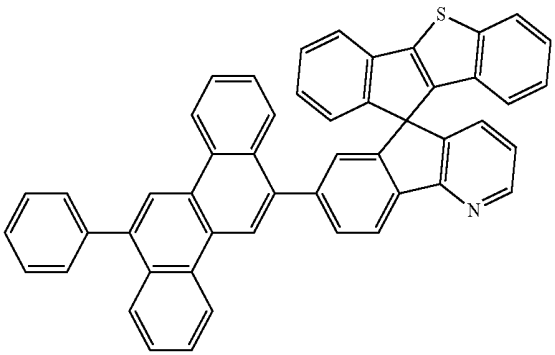

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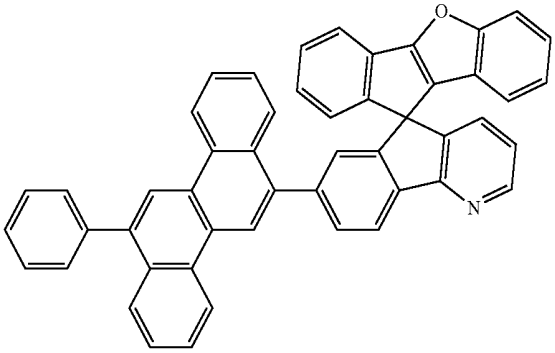

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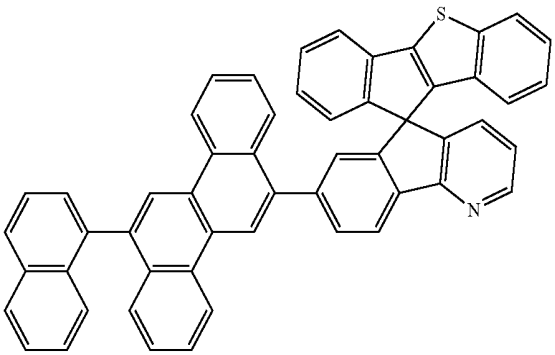

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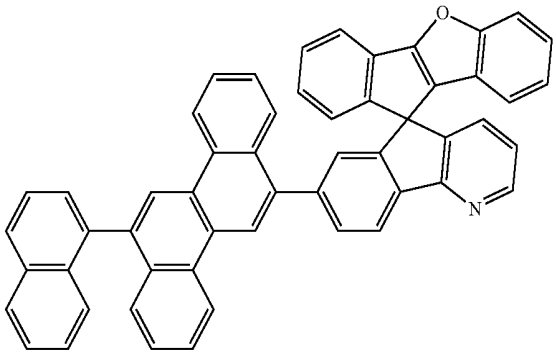

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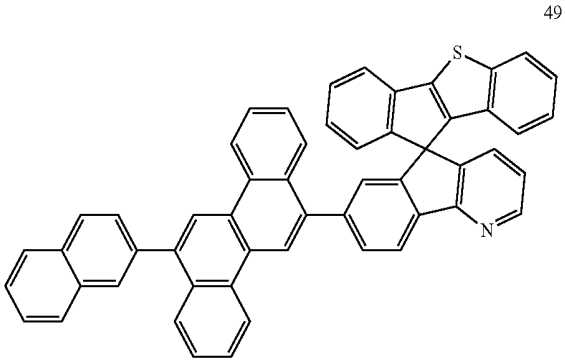

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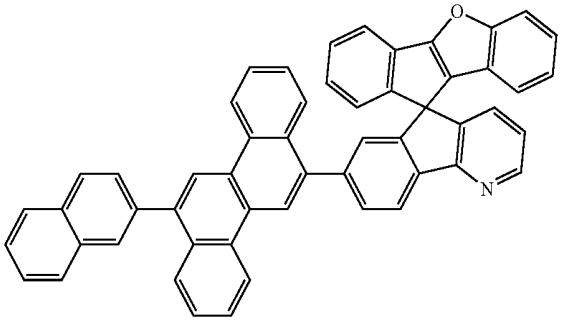

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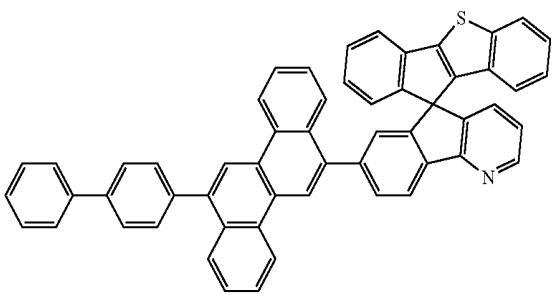

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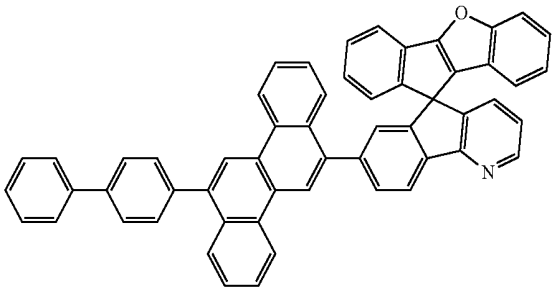

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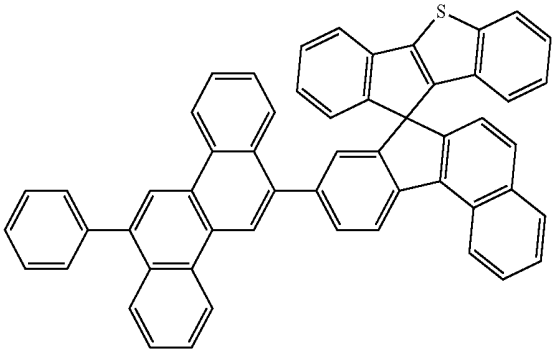

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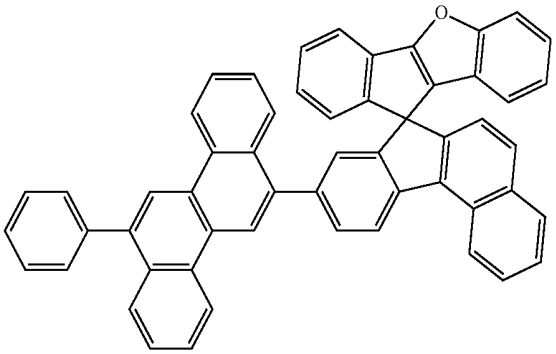

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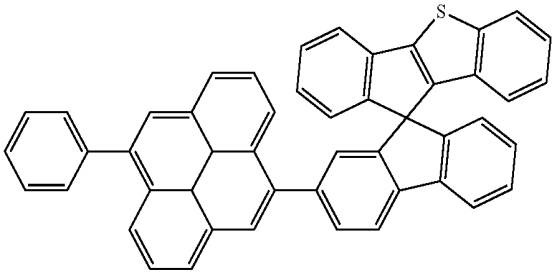

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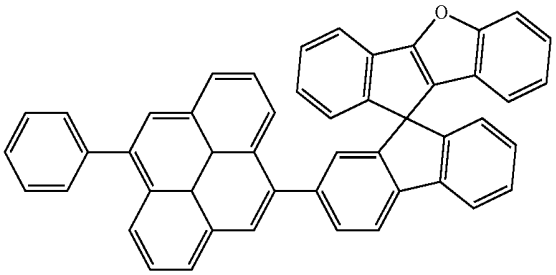

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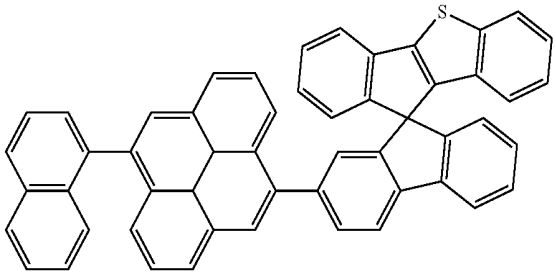

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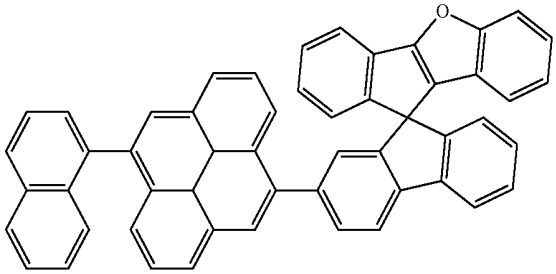

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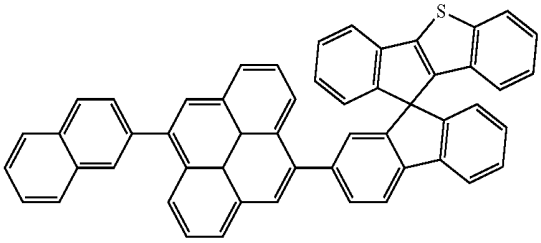

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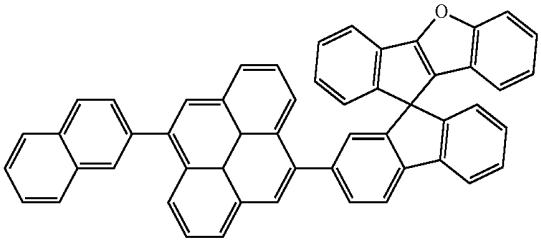

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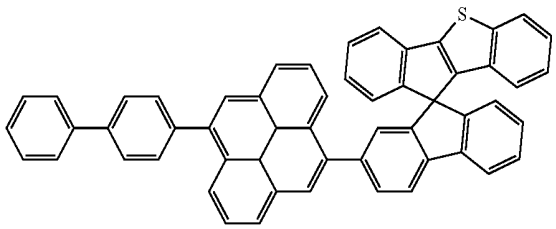

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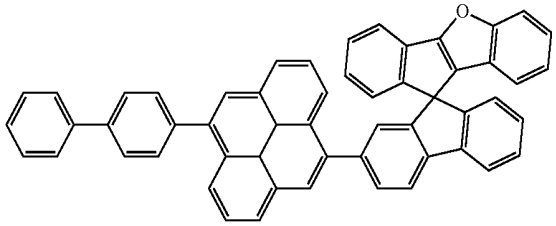

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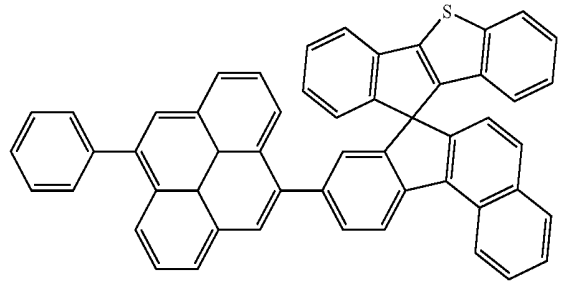

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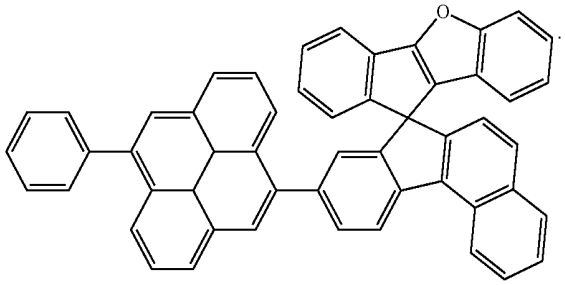

17. An organic light-emitting device, comprising:
a first electrode;
a second electrode facing the first electrode; and
an organic layer between the first electrode and the second electrode, the organic layer including an emission layer,
wherein the organic layer includes the condensed cyclic compounds as claimed in claim **1**.

18. The organic light-emitting device as claimed in claim **17**, wherein:
the first electrode is an anode,
the second electrode is a cathode,
the organic layer includes a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode,
the hole transport region includes a hole injection layer, a hole transport layer, a buffer layer, an electron blocking layer, or a combination thereof and
the electron transport region includes a hole blocking layer, an electron transport layer, an electron injection layer, or a combination thereof.

19. The organic light-emitting device as claimed in claim **17**, wherein the condensed cyclic compound is in the emission layer.

20. The organic light-emitting device as claimed in claim **19**, wherein the emission layer further includes a fluorescent dopant.

* * * * *

专利名称(译)	缩合环状化合物和包括其的有机发光器件		
公开(公告)号	US20170069847A1	公开(公告)日	2017-03-09
申请号	US15/252258	申请日	2016-08-31
[标]申请(专利权)人(译)	三星显示有限公司 成均馆大学校产学协力团		
申请(专利权)人(译)	三星DISPLAY CO.，LTD. 研究与业务基础韩国成均馆大学		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD. 研究与业务基础韩国成均馆大学		
[标]发明人	KIM SUNG WOOK KIM MYEONG SUK CHO HWAN HEE KHO SAM IL YOON SEUNG SOO		
发明人	KIM, SUNG-WOOK KIM, MYEONG-SUK CHO, HWAN-HEE KHO, SAM-IL YOON, SEUNG-SOO		
IPC分类号	H01L51/00 C07D333/78 C07D491/107 C07D307/94 C07D495/10 C09K11/06 C09K11/02		
CPC分类号	H01L51/0052 C09K11/06 C07D333/78 H01L51/0074 C09K11/025 C07D307/94 C09K2211/1014 H01L51/0071 C07D495/10 C07D491/107 H01L51/0059 H01L51/5012 C09K2211/1007 H01L51/0073 C09K2211/1029 C09K2211/1044 C09K2211/1059 C09K2211/1088 C09K2211/1092 C09K2211/185		
优先权	1020150124940 2015-09-03 KR		
其他公开文献	US10170703		
外部链接	Espacenet USPTO		

摘要(译)

缩合环状化合物和包含其的有机发光装置，缩合环状化合物由下式1表示：