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

HETEROCYCLISCHE VERBINDUNG UND ORGANISCHE LICHTEMITTIERENDE VORRICHTUNG DAMIT

COMPOSÉ HÉTÉROCYCLIQUE ET DISPOSITIF ÉLECTROLUMINESCENT ORGANIQUE L'INCLUANT

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EP 3 748 706 B1

Description

BACKGROUND

1. Field

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

2. Description of the Related Art

[0002] Organic light-emitting devices are self-emission devices that produce full-color images, and may also have wide viewing angles, high contrast ratios, short response times, and/or excellent characteristics in terms of brightness, driving voltage, and response speed, as compared to other devices in the related art.

[0003] 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 sequentially on the first electrode. Holes provided from the first electrode may move toward the emission layer through the hole transport region, and electrons provided from the second electrode may move toward the emission layer through the electron transport region. Carriers, such as holes and electrons, recombine in the emission layer to produce excitons. These excitons may transition (or relax) from an excited state to a ground state to thereby generate light.

[0004] Organic light-emitting devices comprising polycyclic heteroaromatic compounds are known in the art such as in e.g. WO 2016/080791 A1 and US 2016/163998 A1.

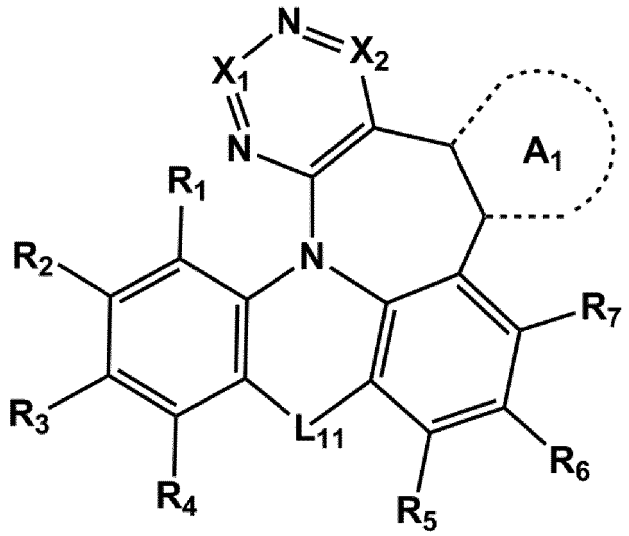
SUMMARY

[0005] One or more aspects of embodiments of the present disclosure are directed toward a heterocyclic compound and an organic light-emitting device including the same.

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

[0007] One or more embodiments of the present disclosure provide a heterocyclic compound represented by Formula 1 below:

Formula 1



Formula 2 $*\text{-}(L_1)_{a1}\text{-}(Ar_1)_{b1}$.

In Formulae 1 and 2,

A_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,

X_1 and X_2 are each independently C(Rs) or N,
L_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
a1 is an integer from 0 to 3,
L_{11} is a single bond, *-$N(R_9)$-*', *-$C(R_{10})(R_{11})$-*', *-O-*', or *-S-*',
Ar_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
b1 is an integer from 1 to 3,
R_1 to R_{11} are each independently selected from a group represented by Formula 2, hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, a 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 C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, -$Si(Q_1)(Q_2)(Q_3)$, -$N(Q_1)(Q_2)$, -$B(Q_1)(Q_2)$, -$S(=O)_2(Q_1)$, and -$P(=O)(Q_1)(Q_2)$,
at least one substituent of the substituted C_5-C_{60} carbocyclic group, the substituted C_1-C_{60} heterocyclic group, the substituted C_1-C_{60} alkyl group, the substituted C_2-C_{60} alkenyl group, the substituted C_2-C_{60} alkynyl group, the substituted C_1-C_{60} alkoxy group, the substituted C_3-C_{10} cycloalkyl group, the substituted C_1-C_{10} heterocycloalkyl group, the substituted C_3-C_{10} cycloalkenyl group, the substituted C_1-C_{10} heterocycloalkenyl group, the substituted C_6-C_{60} aryl group, the substituted C_6-C_{60} aryloxy group, the substituted C_6-C_{60} arylthio group, the substituted C_1-C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from:

deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;
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, -Cl, - Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C6-C60 aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, -$Si(Q_{11})(Q_{12})(Q_{13})$, -$N(Q_{11})(Q_{12})$, -$B(Q_{11})(Q_{12})$, -$C(=O)(Q_{11})$, - $S(=O)_2(O_{11})$, and -$P(=O)(Q_{11})(Q_{12})$;
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, a biphenyl group, and a terphenyl 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, a biphenyl group, and a terphenyl group, each substituted with at least one selected from deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, a terphenyl group, -$Si(Q_{21})(Q_{22})(Q_{23})$, -$N(Q_{21})(Q_{22})$, -$B(Q_{21})(Q_{22})$, -$C(=O)(Q_{21})$, -$S(=O)_2(Q_{21})$, and -$P(=O)(Q_{21})(Q_{22})$; and
-$Si(Q_{31})(Q_{32})(Q_{33})$, -$N(Q_{31})(Q_{32})$, -$B(Q_{31})(Q_{32})$, -$C(=O)(Q_{31})$, -$S(=O)_2(Q_{31})$, and -$P(=O)(Q_{31})(Q_{32})$,
Q_1 to Q_3, Q_{11} to Q_{13}, Q_{21} to Q_{23}, and Q_{31} to Q_{33} are each independently selected from hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl

group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with a C_1-C_{60} alkyl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, and
* and *' each indicate a binding site to a neighboring atom.

[0008] One or more embodiments of the present disclosure provide an organic light-emitting device including: a first electrode; a second electrode facing the first electrode; an organic layer between the first electrode and the second electrode and including an emission layer; and at least one of the heterocyclic compound described herein.

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

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] These and/or other aspects of embodiments will become apparent and more readily appreciated from the following description of the embodiments of the present disclosure, taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic view of an organic light-emitting device according to an embodiment of the present disclosure;
FIG. 2 is a schematic view of an organic light-emitting device according to another embodiment of the present disclosure;
FIG. 3 is a schematic view of an organic light-emitting device according to another embodiment of the present disclosure; and
FIG. 4 is a schematic view of an organic light-emitting device according to another embodiment of the present disclosure.

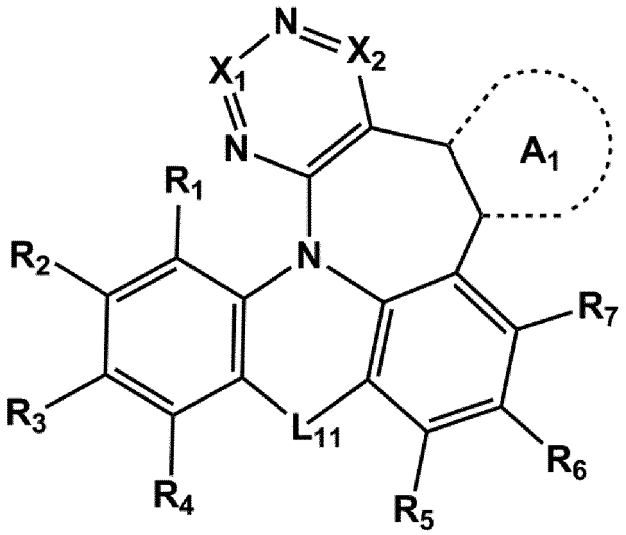
DETAILED DESCRIPTION

[0011] Reference will now be made in more detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout and duplicative descriptions may not be repeated. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described herein below, by referring to the figures, to explain aspects of embodiments 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," "one of," "selected from," "at least one selected from," and "one selected from," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list.

[0012] The thicknesses of layers, films, panels, regions, etc., may be exaggerated in the drawings for clarity. It will be understood that when an element such as a layer, film, region, or substrate is referred to as being "on" another element, it can be directly on the other element or intervening element(s) may also be present. In contrast, when an element is referred to as being "directly on" another element, no intervening elements are present. Further, the use of "may" when describing embodiments of the present disclosure refers to "one or more embodiments of the present disclosure."

[0013] One or more embodiments of the present disclosure provide a heterocyclic compound represented by Formula 1 below:

Formula 1



Formula 2 $*\text{-}(L_1)_{a1}\text{-}(Ar_1)_{b1}$

[0014] A_1 in Formula 1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group. For example, A_1 in Formula 1 may be a substituted or unsubstituted C_5-C_{30} carbocyclic group or a substituted or unsubstituted C_1-C_{20} heterocyclic group.

[0015] In one embodiment, A_1 may be selected from:

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group;

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group, each substituted with at least one selected from deuterium, - Cl, -Br, -I, a hydroxyl group, a cyano group, a C_1-C_{20} (e.g. C_1-C_{10}) alkyl group, a C_1-C_{20} (e.g. C_1-C_{10}) alkoxy group, a 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 pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzofuranyl group, a benzothiophenyl group, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, and $-B(Q_{31})(Q_{32})$, and

Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} (e.g. C_1-C_{10}) alkyl group, a C_1-C_{20} (e.g. C_1-C_{10})

alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group.

[0016] X_1 and X_2 in Formula 1 are each independently C(Rs) or N.

[0017] In one embodiment, X_1 and X_2 may each independently be C(Rs).

[0018] L_1 in Formula 2 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group. For example, L_1 in Formula 2 may be a substituted or unsubstituted C_5-C_{30} carbocyclic group or a substituted or unsubstituted C_1-C_{20} heterocyclic group.

[0019] In one embodiment, L_1 may be selected from:

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group; and

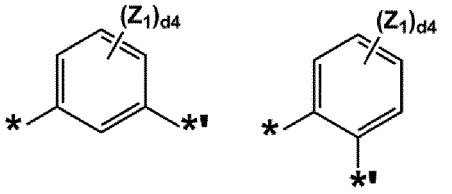
a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group, each substituted with at least one selected from deuterium, - CI, -Br, -I, a hydroxyl group, a cyano group, a C_1-C_{20} (e.g. C_1-C_{10}) alkyl group, a C_1-C_{20} (e.g. C_1-C_{10}) alkoxy group, a 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 pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzofuranyl group, a benzothiophenyl group, -Si(Q_{31})(Q_{32})(Q_{33}), -N(Q_{31})(Q_{32}), and -B(Q_{31})(Q_{32}), and

Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} (e.g. C_1-C_{10}) alkyl group, a C_1-C_{20} (e.g. C_1-C_{10}) alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group.

[0020] For example, L_1 may be selected from a benzene group; and a benzene group substituted with at least one selected from deuterium, -F, -CI, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} (*e.g.* C_1-C_{20}) alkyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkenyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkynyl group, a C_1-C_{60} (*e.g.* C_1-C_{20}) alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryloxy group, a C_6-C_{60} (*e.g.* C_6-C_{30}) arylthio group, a C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, -Si(Q_{21})(Q_{22})(Q_{23}), -N(Q_{21})(Q_{22}), - B(Q_{21})(Q_{22}), -C(=O)(Q_{21}), -S(=O)$_2$(Q_{21}), and -P(=O)(Q_{21})(Q_{22}), and

[0021] Q_{21} to Q_{23} may be each independently selected from hydrogen, deuterium, - CI, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C2-C60 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} aryl group substituted with a C_1-C_{60} alkyl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group.

[0022] In one embodiment, L_1 may be selected from groups represented by Formula 3-1 or 3-2:



3-1 3-2

In Formulae 3-1 and 3-2,

Z_1 is selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a C_1-C_{20} (*e.g.* C_1-C_{10}) alkyl group, a C_1-C_{20} (*e.g.* C_1-C_{10}) alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzosilolyl group, and -$Si(Q_{31})(Q_{32})(Q_{33})$,
Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} (e.g. C_1-C_{10}) alkyl group, a C_1-C_{20} (*e.g.* C_1-C_{10}) alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group,
d4 is an integer from 0 to 4, and
* and *' each indicate a binding site to a neighboring atom.

[0023] In Formula 2, a1 is an integer from 0 to 3.

[0024] In one embodiment, a1 may be 0 or 1.

[0025] In Formula 1, L_{11} is a single bond, *-$N(R_9)$-*', *-$C(R_{10})(R_{11})$-*', *-O-*', or *-S-*'. For example, L_{11} may be a single bond or *-$C(R_{10})(R_{11})$-*'.

[0026] In one embodiment, L_{11} may be a single bond or *-$C(R_{10})(R_{11})$-*',

[0027] R_{10} and R_{11} may each independently be selected from:

hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, and a C_1-C_{20} (e.g. C_1-C_{10}) alkyl group; and
a C_1-C_{20} (e.g. C_1-C_{10}) alkyl group substituted with at least one selected from deuterium, -Cl, -Br, -I, a hydroxyl group, and a cyano group.

[0028] In Formula 2, Ar_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group. For example, Ar_1 in Formula 2 may be a substituted or unsubstituted C_5-C_{30} carbocyclic group or a substituted or unsubstituted C_1-C_{20} heterocyclic group.

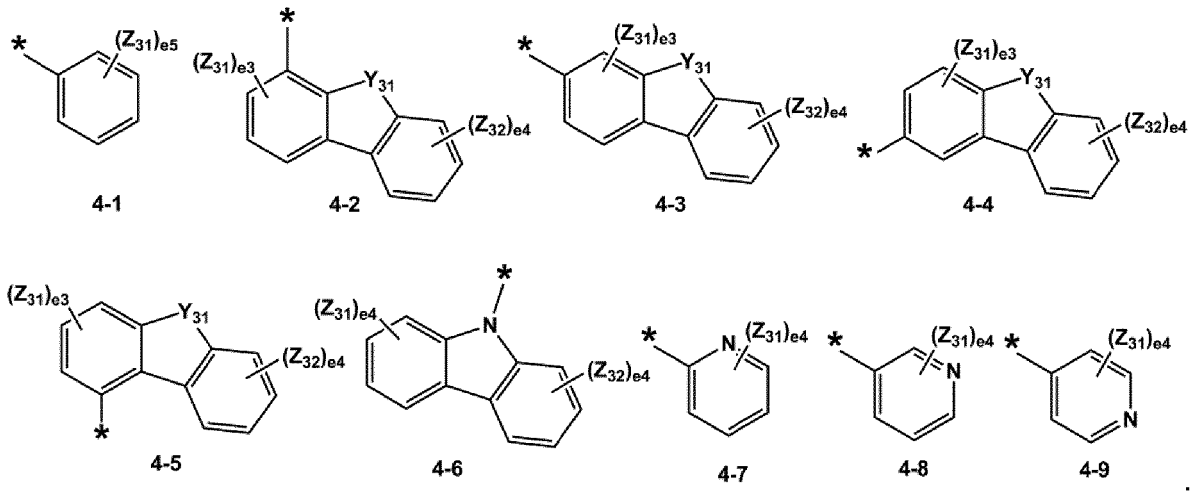
[0029] In one embodiment, Ar_1 may be selected from:

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group;
a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a

dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group, each substituted with at least one selected from deuterium, - Cl, -Br, -I, a hydroxyl group, a cyano group, a C_1-C_{20} (*e.g.* C_1-C_{10}) alkyl group, a C_1-C_{20} (e.g. C_1-C_{10}) alkoxy group, a 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 pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzofuranyl group, a benzothiophenyl group, -Si(Q_{31})(Q_{32})(Q_{33}), -N(Q_{31})(Q_{32}), and -B(Q_{31})(Q_{32}), and

Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} (*e.g.* C_1-C_{10}) alkyl group, a C_1-C_{20} (*e.g.* C_1-C_{10}) alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group.

[0030] For example, Ar_1 may be represented by one of Formulae 4-1 to 4-9, but embodiments of the present disclosure are not limited thereto:



In Formulae 4-1 to 4-9,

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 C_1-C_{20} (*e.g.* C_1-C_{10}) alkyl group, a C_1-C_{20} (*e.g.* C_1-C_{10}) alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a carbazolyl group, a benzosilolyl group, a dibenzosilolyl group, and -Si(Q_{31})(Q_{32})(Q_{33}),

Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} (*e.g.* C_1-C_{10}) alkyl group, a C_1-C_{20} (*e.g.* C_1-C_{10}) alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group,

e3 is an integer from 0 to 3,

e4 is an integer from 0 to 4,

e5 is an integer from 0 to 5, and

* indicates a binding site to a neighboring atom.

[0031] For example, Z_{31} to Z_{37} may each independently be selected from hydrogen, a cyano group, a C_1-C_{20} (e.g. C_1-C_{10}) alkyl group, a phenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a carbazolyl group, and -Si(Q_{31})(Q_{32})(Q_{33}), and

Q_{31} to Q_{33} may each independently be selected from a C_1-C_{20} (*e.g.* C_1-C_{10}) alkyl group, a C_1-C_{20} (*e.g.* C_1-C_{10}) alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group, but embodiments of the present disclosure are not limited thereto.

[0032] In Formula 2, b1 is an integer from 1 to 3.

[0033] For example, b1 may be 1, but embodiments of the present disclosure are not limited thereto.

[0034] In Formula 1, R_1 to R_{11} are each independently selected from a group represented by Formula 2, hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, a 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 C1-C60 (*e.g.* C_1-C_{20}) alkyl group, a substituted or unsubstituted C_2-C_{60} (*e.g.* C_2-C_{20}) alkenyl group, a substituted or unsubstituted C_2-C_{60} (*e.g.* C_2-C_{20}) alkynyl group, a substituted or unsubstituted C_1-C_{60} (*e.g.* C_1-C_{20}) alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{30}) aryl group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{30}) aryloxy group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{30}) arylthio group, a substituted or unsubstituted C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$, and $-P(=O)(Q_1)(Q_2)$.

[0035] In one embodiment, R_1 to R_{11} may each independently be selected from a group represent independently Formula 2, hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} (*e.g.* C_1-C_{10}) alkyl group, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$, and $-P(=O)(Q_1)(Q_2)$; and

a C_1-C_{20} (*e.g.* C_1-C_{10}) alkyl group substituted with at least one selected from deuterium, -Cl, -Br, -I, a hydroxyl group, and a cyano group, and

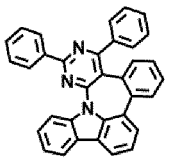
Q_1 to Q_3 may each independently be selected from hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} (*e.g.* C_1-C_{20}) alkyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkenyl group, a C_2-C_{60} (*e.g.*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

[0036] For example, R_1 to R_7 may be hydrogen, but embodiments of the present disclosure are not limited thereto.

[0037] For example, R_8 may be a group represented by Formula 2, but embodiments of the present disclosure are not limited thereto.

[0038] For example, R_9 to R_{11} may each independently be a C_1-C_{20} (*e.g.* C_1-C_{10}) alkyl group, but embodiments of the present disclosure are not limited thereto.

[0039] In one embodiment, the heterocyclic compound may be selected from Compounds 1 to 30, but embodiments of the present disclosure are not limited thereto:



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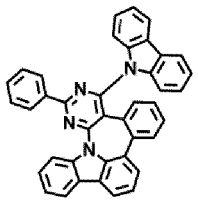

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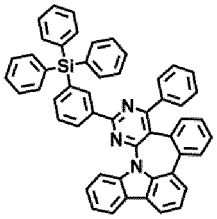

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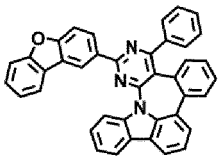

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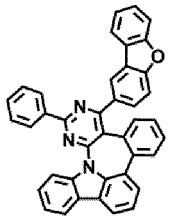

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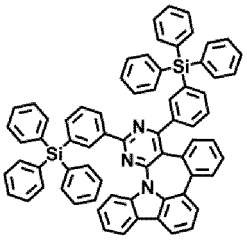

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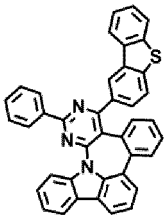

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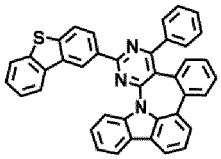

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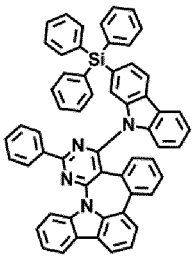

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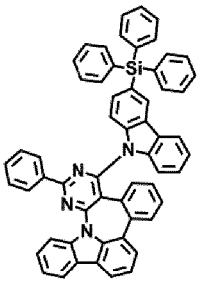

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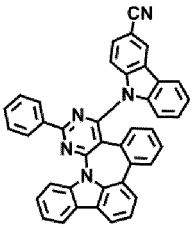

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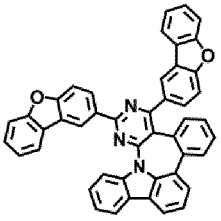

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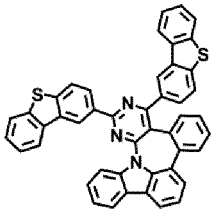

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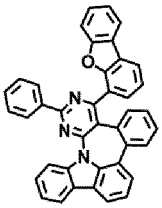

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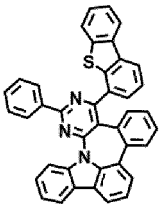

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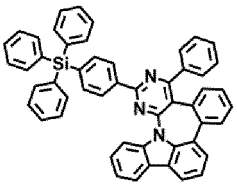

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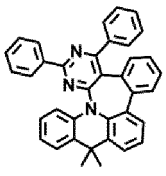

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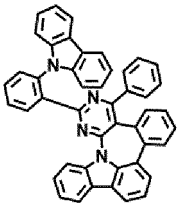

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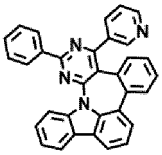

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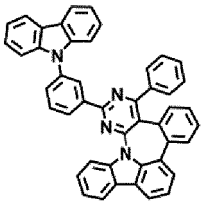

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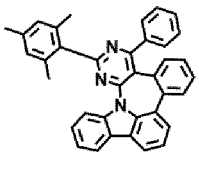

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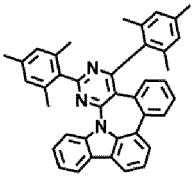

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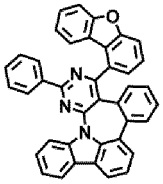

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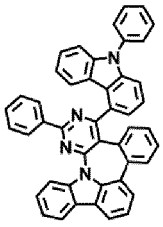

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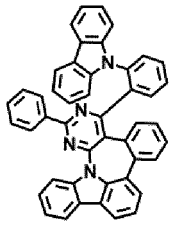

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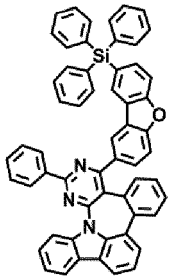

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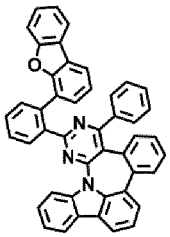

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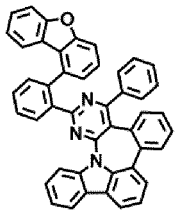

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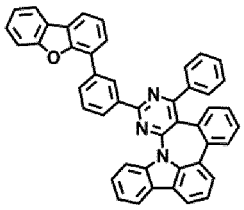

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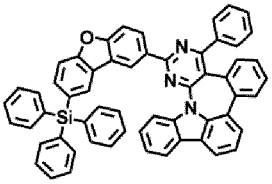

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[0040] Because the heterocyclic compound has the structure of Formula 1 described herein above, triplet energy may be increased. In this manner, thermally activated delayed fluorescence (TADF) may be exhibited.

[0041] In some embodiments, a singlet energy (S1) and a triplet energy (T1) of the heterocyclic compound satisfy the following equation:

$$\Delta E_{ST} = S1 - T1 < 0.3\ eV.$$

[0042] Because the heterocyclic compound includes two or more nitrogen atoms in an azine-based moiety, the two or more nitrogen atoms reduce a lowest unoccupied molecular orbital (LUMO) level (e.g., energy level) of the compound, thereby improving electron transport characteristics of the heterocyclic compound.

[0043] In addition, because the heterocyclic compound includes (or essentially includes) a nitrogen atom at ortho- or para-position with respect to a linking position of a carbazole-based moiety in an azine-based moiety, a resonance effect of stabilizing electrons may stabilize an electron energy level and improve electron mobility of the heterocyclic compound.

[0044] Furthermore, the heterocyclic compound fixes a dihedral angle between the azine-based moiety and the carbazole-based moiety via ring "A_1." In this manner, the molecular structure may be rigidly fixed (e.g., substantially rigidly fixed) by fixing the dihedral angle, thereby stabilizing the molecule and improving charge transport characteristics of the compound.

[0045] Therefore, an electronic device, for example, an organic light-emitting device, which includes the heterocyclic compound represented by Formula 1, may have a low driving voltage, and/or high maximum quantum efficiency.

[0046] Synthesis methods for the heterocyclic compound represented by Formula 1 will be apparent to those of ordinary skill in the art by reference to the following examples.

[0047] At least one of the heterocyclic compound of Formula 1 may be used between a pair of electrodes of an organic light-emitting device. For example, the heterocyclic compound may be included in an emission layer. In one or more embodiments, the heterocyclic compound represented by Formula 1 may be used as a material for forming a capping layer positioned outside the pair of electrodes of the organic light-emitting device.

[0048] Accordingly, one or more embodiments of the present disclosure provide an organic light-emitting device including: a first electrode; a second electrode facing the first electrode; an organic layer between the first electrode and the second electrode and including an emission layer; and at least one of the heterocyclic compound represented by Formula 1. In some embodiments, the organic layer may include the at least one of the heterocyclic compound represented by Formula 1.

[0049] The expression "(an organic layer) includes at least one of heterocyclic compounds" used herein may include a case in which "(an organic layer) includes identical heterocyclic compounds represented by Formula 1" and a case in which "(an organic layer) includes two or more different heterocyclic compounds represented by Formula 1."

[0050] In some embodiments, for example, the organic layer may include, as the heterocyclic compound, only Compound 1. In this regard, Compound 1 may exist (e.g., be included) only in the emission layer of the organic light-emitting device. In one or more embodiments, the organic layer may include, as the heterocyclic compound, Compound 1 and Compound 2. In this regard, Compound 1 and Compound 2 may exist in the same layer (for example, Compound 1 and Compound 2 may both (e.g., simultaneously) exist in an emission layer), or in different layers (for example, Compound 1 may exist in the emission layer and Compound 2 may exist in an electron transport layer).

[0051] In one embodiment,

the first electrode of the organic light-emitting device may be an anode,
the second electrode of the organic light-emitting device may be a cathode,
the organic layer may include at least one of the heterocyclic compound represented by Formula 1,
the organic layer may further include 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 may include a hole injection layer, a hole transport layer, an emission auxiliary layer, an electron blocking layer, or any combination thereof, and
the electron transport region may include a hole blocking layer, an electron transport layer, an electron injection layer, or any combination thereof.

[0052] In one or more embodiments, the emission layer may include the at least one of the heterocyclic compound represented by Formula 1.

[0053] In one embodiment, the emission layer may include a dopant and a host, and

[0054] the host may include at least one of the heterocyclic compound represented by Formula 1.

[0055] In one embodiment, an amount of the heterocyclic compound may be in a range of about 50 parts by weight to about 99.9 parts by weight based on 100 parts by weight of the emission layer.

[0056] For example, the dopant may be a phosphorescent dopant.

[0057] In one or more embodiments, the emission layer may include a dopant and a host, and

[0058] the dopant may include at least one of the heterocyclic compound represented by Formula 1.

[0059] For example, the host may further include a compound represented by Formula 301:

Formula 301 $[Ar_{301}]_{xb11}$-$[(L_{301})_{xb1}$-$R_{301}]_{xb21}$.

In Formula 301,

Ar_{301} is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
xb11 is 1, 2, or 3,
L_{301} is 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,
xb1 is an integer from 0 to 5,
R_{301} is selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, - $Si(Q_{301})(Q_{302})(Q_{303})$, -$N(Q_{301})(Q_{302})$, -$B(Q_{301})(Q_{302})$, -$C(=O)(Q_{301})$, -$S(=O)_2(Q_{301})$, and - $P(=O)(Q_{301})(Q_{302})$,
xb21 is an integer from 1 to 5, and
Q_{301} to Q_{303} 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.

[0060] In one embodiment, the hole transport region may include a p-dopant having a lowest unoccupied molecular orbital (LUMO) energy level of about -3.5 eV or less.

[0061] In one embodiment, the electron transport region may include an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth metal complex, a rare earth metal complex, or any combination thereof.

[0062] In one embodiment, the emission layer may be a first emission layer configured to emit a first color light, the organic light-emitting device may further include i) at least one second emission layer configured to emit a second color light or ii) at least one second emission layer configured to emit a second color light and at least one third emission layer configured to emit a third color light, between the first electrode and the second electrode,
a maximum emission wavelength of the first color light, a maximum emission wavelength of the second color light, and a maximum emission wavelength of the third color light may be identical to or different from each other, and
the first color light and the second color light may be emitted in the form of mixed light, or the first color light, the second color light, and the third color light may be emitted in the form of mixed light.

[0063] The term "organic layer" as used herein refers to a single layer and/or a plurality of layers between the first electrode and the second electrode of the organic light-emitting device. Materials included in the "organic layer" are not limited to being organic materials. For example, the organic layer may include an inorganic material.

[0064] For example, the organic light-emitting device may have i) a stacked structure including a first electrode, an organic layer, a second electrode, and a second capping layer sequentially stacked in this stated order, ii) a stacked structure including a first capping layer, a first electrode, an organic layer, and a second electrode sequentially stacked in this stated order, or iii) a stacked structure including a first capping layer, a first electrode, an organic layer, a second electrode, and a second capping layer sequentially stacked in this stated order, where at least one selected from the first capping layer and the second capping layer may include the heterocyclic compound.

Description of FIG. 1

[0065] FIG. 1 is a schematic cross-sectional view of an organic light-emitting device 10 according to an embodiment of the present disclosure. The organic light-emitting device 10 includes a first electrode 110, an organic layer 150, and a second electrode 190.

[0066] Hereinafter, the structure of the organic light-emitting device 10 according to an embodiment of the present disclosure and a method of manufacturing the organic light-emitting device 10 will be described in connection with FIG. 1.

First electrode 110

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

[0068] The first electrode 110 may be formed by depositing or sputtering a material for forming the first electrode 110 on the substrate. When the first electrode 110 is an anode, the material for forming the first electrode 110 may be selected from materials with a high work function to thereby facilitate hole injection.

[0069] The first electrode 110 may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. When the first electrode 110 is a transmissive electrode, the material for forming a first electrode 110 may be selected from indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO_2), zinc oxide (ZnO), and any combination thereof, but embodiments of the present disclosure are not limited thereto. In one or more embodiments, when the first electrode 110 is a semi-transmissive electrode or a reflective electrode, the material for forming a first electrode 110 may be selected from magnesium (Mg), silver (Ag), aluminium (Al), aluminium-lithium (Al-Li), calcium (Ca), magnesium-indium (Mg-In), magnesium-silver (Mg-Ag), and any combination thereof, but embodiments of the present disclosure are not limited thereto.

[0070] The first electrode 110 may have a single-layered structure, or a multi-layered structure including two or more layers. For example, the first electrode 110 may have a three-layered structure of ITO/Ag/ITO, but the structure of the first electrode 110 is not limited thereto.

Organic layer 150

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

[0072] The organic layer 150 may further include a hole transport region between the first electrode 110 and the emission layer and an electron transport region between the emission layer and the second electrode 190.

Hole transport region in organic layer 150

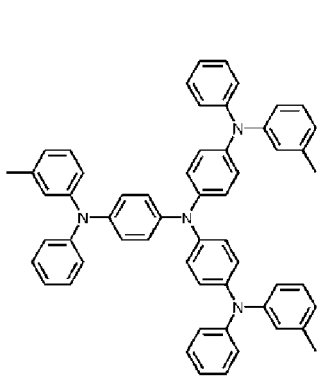
[0073] The hole transport region may have i) a single-layered structure including a single layer including a single

material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

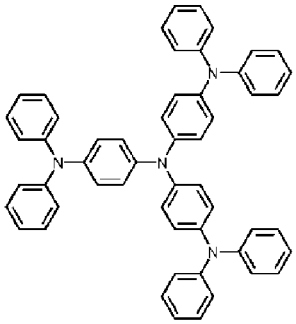
[0074] The hole transport region may include at least one layer selected from a hole injection layer, a hole transport layer, an emission auxiliary layer, and an electron blocking layer.

[0075] For example, the hole transport region may have a single-layered structure including a single layer including a plurality of different materials, or a multi-layered structure having a hole injection layer/hole transport layer structure, a hole injection layer/hole transport layer/emission auxiliary layer structure, a hole injection layer/emission auxiliary layer structure, a hole transport layer/emission auxiliary layer structure, or a hole injection layer/hole transport layer/electron blocking layer structure, wherein for each structure, constituting layers are sequentially stacked from the first electrode 110 in this stated order, but the structure of the hole transport region is not limited thereto.

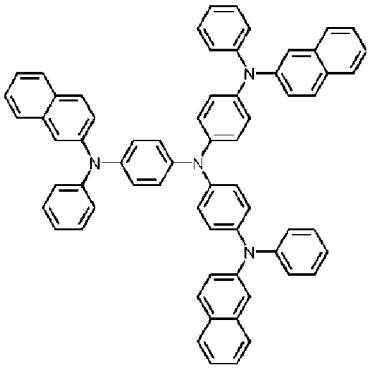
[0076] In one embodiment, the hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB(NPD), β-NPB, TPD, spiro-TPD, spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201, and a compound represented by Formula 202:



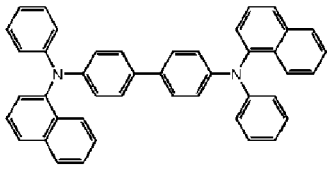
m-MTDATA



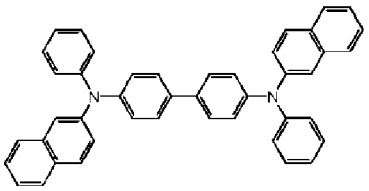
TDATA



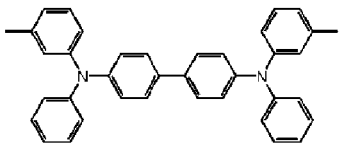
2-TNATA



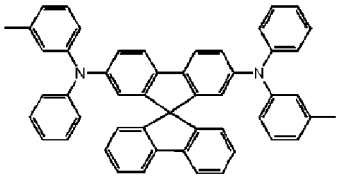
NPB



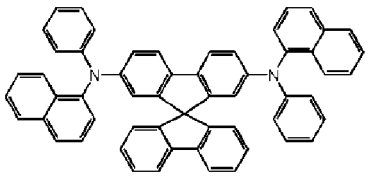
β-NPB



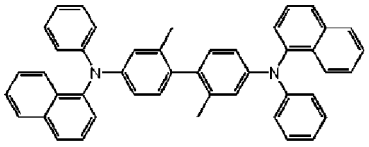
TPD



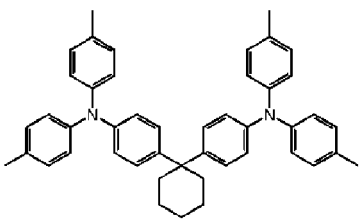
Spiro-TPD



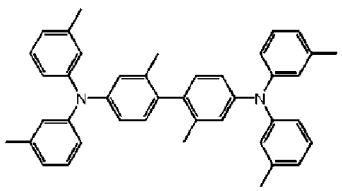
Spiro-NPB



methylated NPB

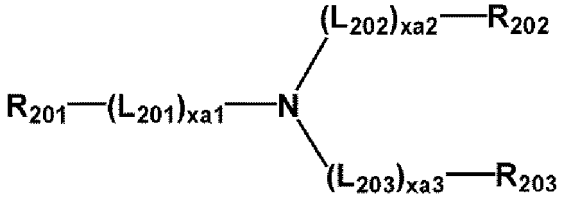


TAPC

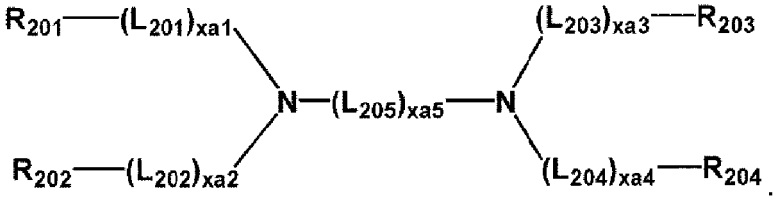


HMTPD

Formula 201



Formula 202



In Formulae 201 and 202,

L_{201} to L_{204} may each independently be selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} (e.g. C_6-C_{32}) arylene group, a substituted or unsubstituted C_1-C_{60} (e.g. C_1-C_{20}) heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

L_{205} may be selected from *-O-*', *-S-*', *-N(Q_{201})-*', a substituted or unsubstituted C_1-C_{20} alkylene group, a substituted or unsubstituted C_2-C_{20} alkenylene group, a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{32}) arylene group, a substituted or unsubstituted C_1-C_{60} (*e.g.* C_1-C_{20}) heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

xa1 to xa4 may each independently be an integer from 0 to 3,

xa5 may be an integer from 1 to 10, and

R_{201} to R_{204} and Q_{201} may each independently be selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{32}) aryl group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{32}) aryloxy group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{32}) arylthio group, a substituted or unsubstituted C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0077] In one embodiment, R_{201} and R_{202} in Formula 202 may optionally be linked to each other via a single bond, a dimethyl-methylene group, or a diphenyl-methylene group, and/or R_{203} and R_{204} may optionally be linked via a single bond, a dimethyl-methylene group, or a diphenyl-methylene group.

[0078] In one or more embodiments, in Formulae 201 and 202,

L_{201} to L_{205} may each independently be selected from:

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-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 thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, and a pyridinylene 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 thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, and a pyridinylene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with -F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, -Si(Q_{31})(Q_{32})(Q_{33}), and -N(Q_{31})(Q_{32}), and
Q_{31} to Q_{33} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

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

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

[0081] In one or more embodiments, R_{201} to R_{204} and Q_{201} may each independently be selected from:

a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group; and

a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with -F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, -Si(Q_{31})(Q_{32})(Q_{33}), and -N(Q_{31})(Q_{32}), and
Q_{31} to Q_{33} are the same as described herein above.

[0082] In one or more embodiments, at least one selected from R_{201} to R_{203} in Formula 201 may each independently be selected from:

a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and
a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with -F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group,
but embodiments of the present disclosure are not limited thereto.

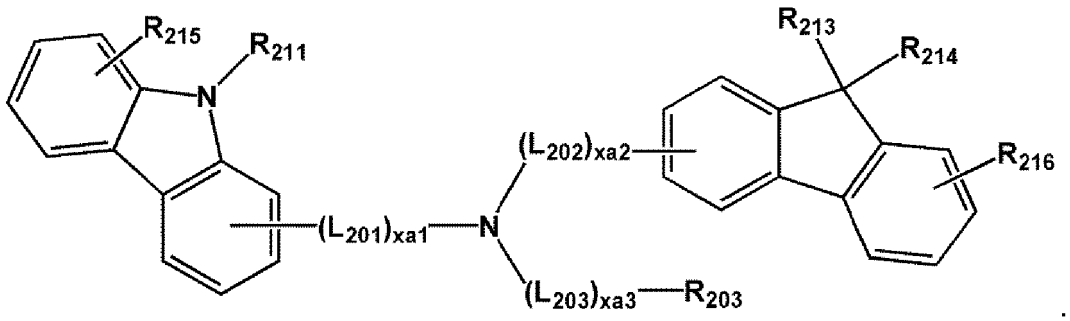
[0083] In one or more embodiments, in Formula 202, i) R_{201} and R_{202} may be linked to each other via a single bond, and/or ii) R_{203} and R_{204} may be linked to each other via a single bond.

[0084] In one or more embodiments, at least one selected from R_{201} to R_{204} in Formula 202 may be selected from:

a carbazolyl group; and
a carbazolyl group substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with -F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group,
but embodiments of the present disclosure are not limited thereto.

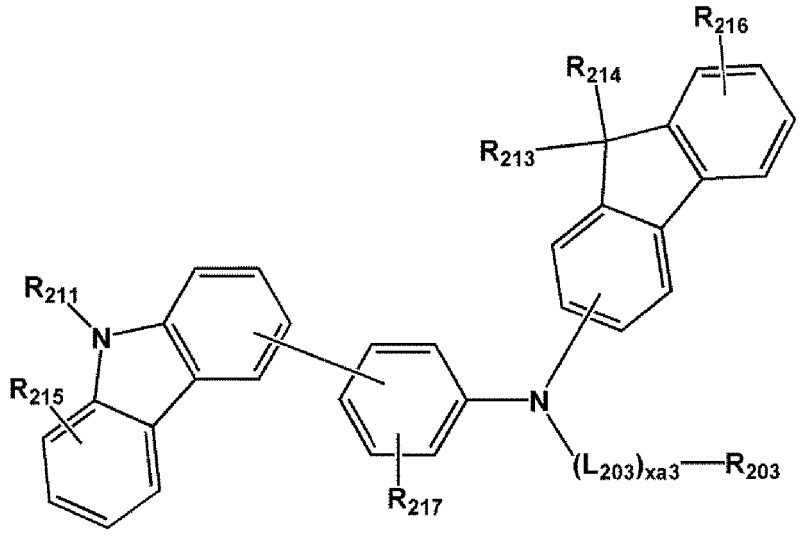
[0085] The compound represented by Formula 201 may be represented by Formula 201A:

Formula 201A



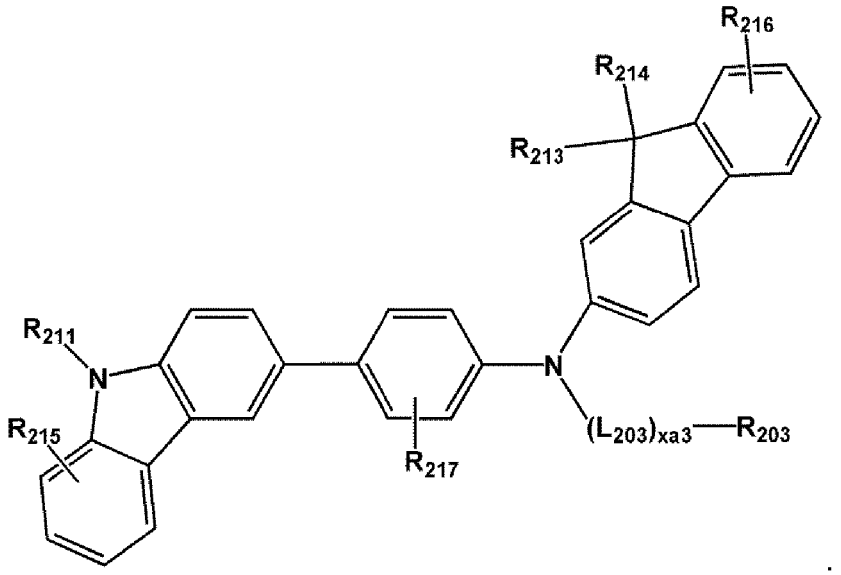
[0086] In one embodiment, the compound represented by Formula 201 may be represented by Formula 201 A(1) below, but embodiments of the present disclosure are not limited thereto:

Formula 201A(1)



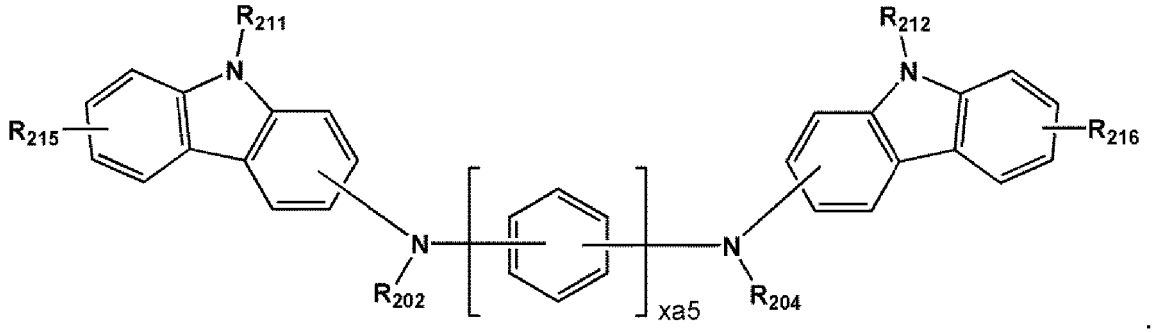
[0087] In one embodiment, the compound represented by Formula 201 may be represented by Formula 201A-1 below, but embodiments of the present disclosure are not limited thereto:

Formula 201A-1



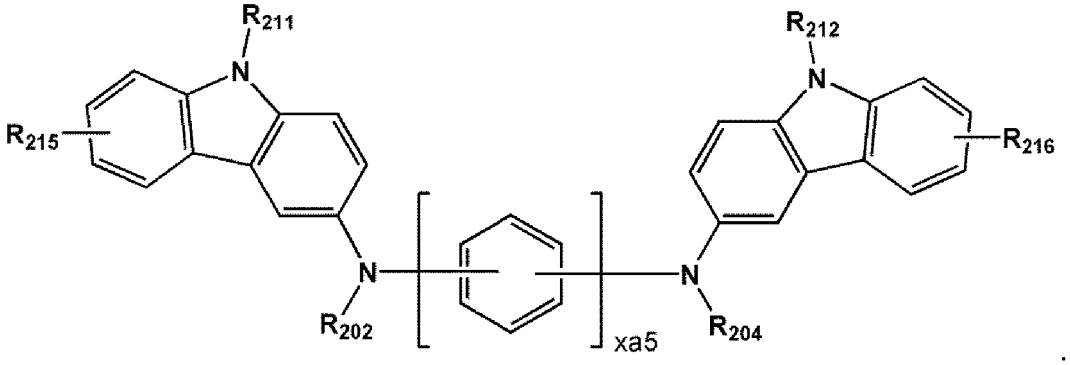
[0088] In one embodiment, the compound represented by Formula 202 may be represented by Formula 202A below, but embodiments of the present disclosure are not limited thereto:

Formula 202A



[0089] In one embodiment, the compound represented by Formula 202 may be represented by Formula 202A-1 below, but embodiments of the present disclosure are not limited thereto:

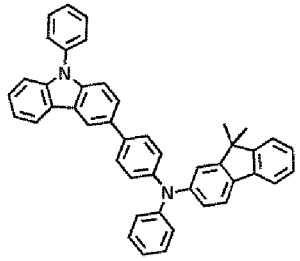
Formula 202A-1



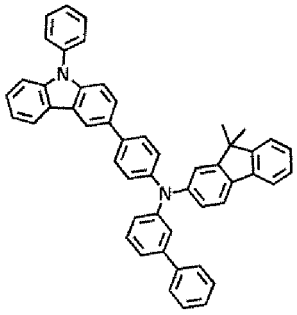
In Formulae 201A, 201A(1), 201A-1, 202A, and 202A-1,

L_{201} to L_{203}, xa1 to xa3, xa5, and R_{202} to R_{204} may independently be the same as described herein above,
R_{211} and R_{212} may be understood by referring to the description provided herein in connection with R_{203}, and
R_{213} to R_{217} may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1-C_{10} alkyl group, a phenyl group substituted with -F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group.

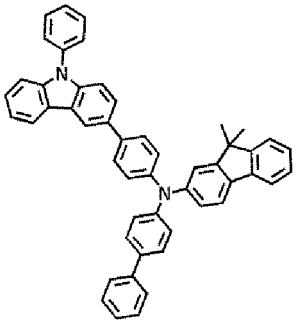
[0090] The hole transport region may include at least one compound selected from Compounds HT1 to HT39, but embodiments of the present disclosure are not limited thereto:



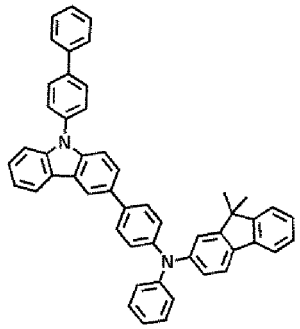
HT1



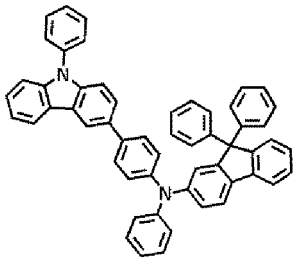
HT2



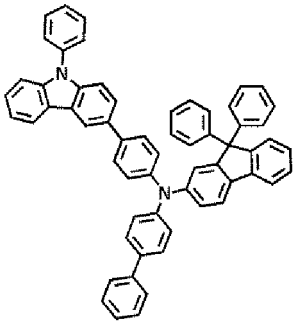
HT3



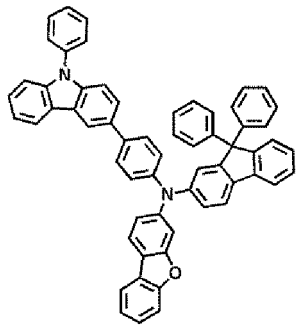
HT4



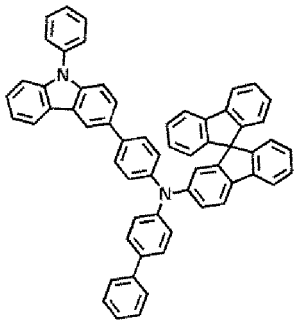
HT5



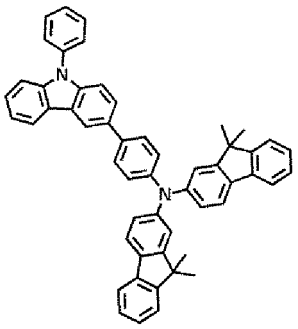
HT6



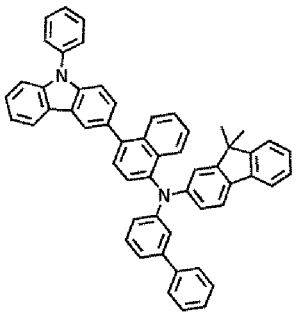
HT7



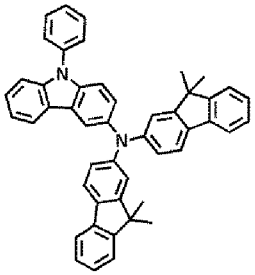
HT8



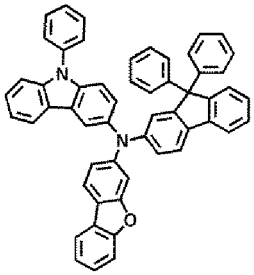
HT9



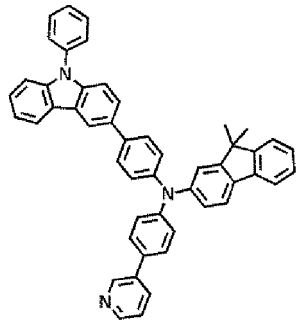
HT10



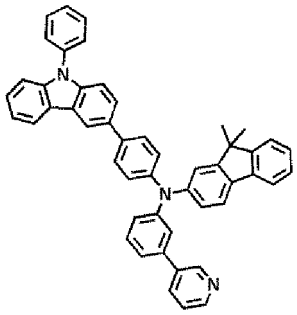
HT11



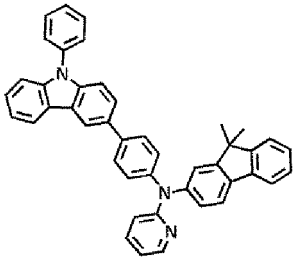
HT12



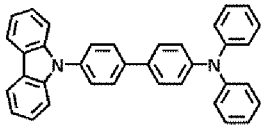
HT13



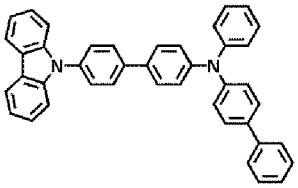
HT14



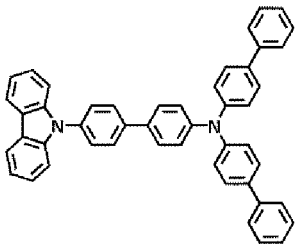
HT15



HT16



HT17



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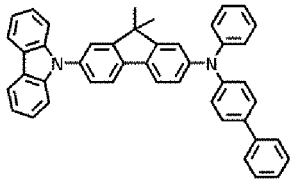
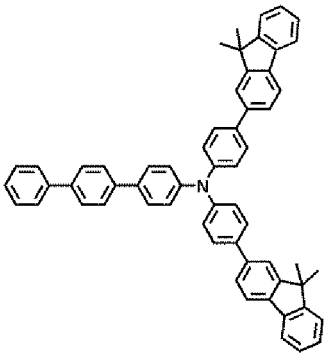
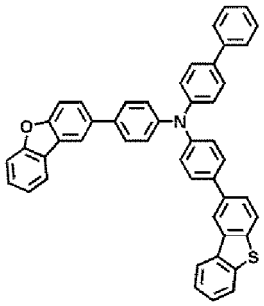


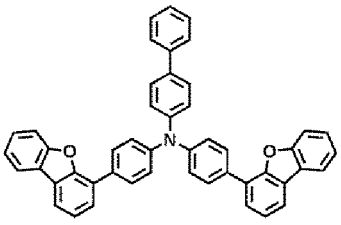
HT19



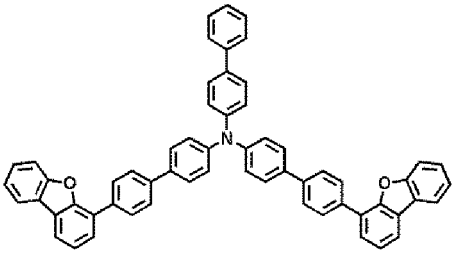
HT20



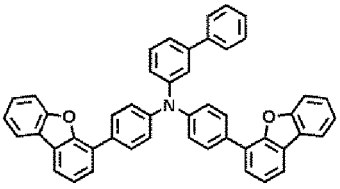
HT21



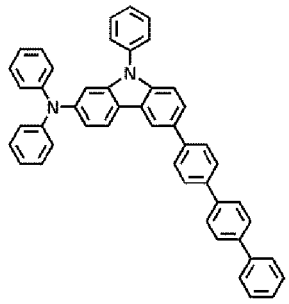
HT22



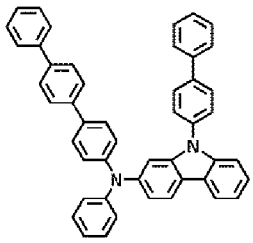
HT23



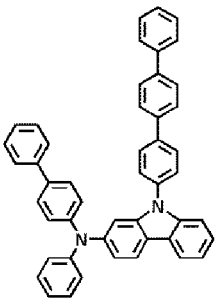
HT24



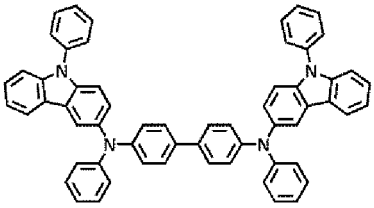
HT25



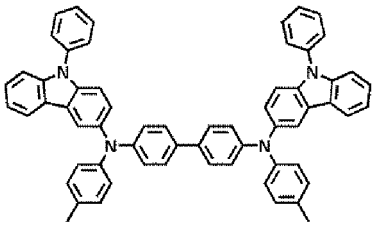
HT26



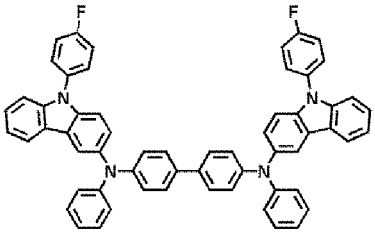
HT27



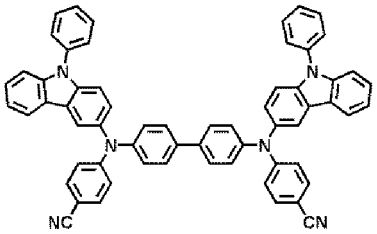
HT28



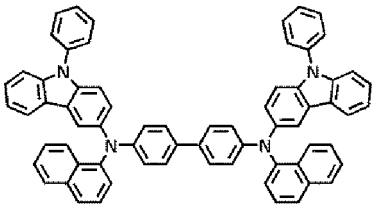
HT29



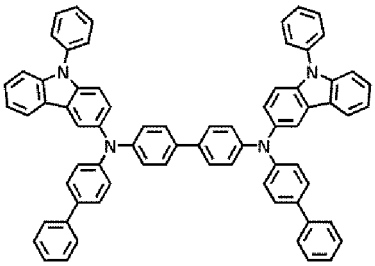
HT30



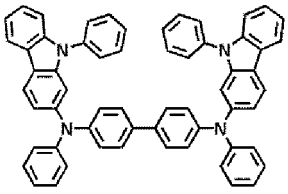
HT31



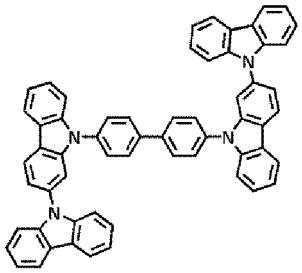
HT32



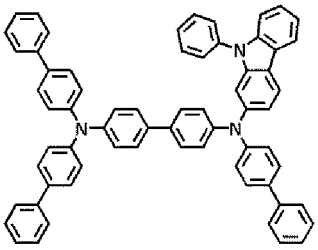
HT33



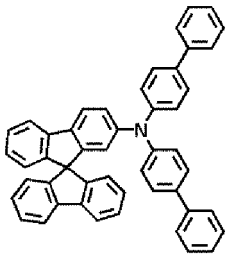
HT34



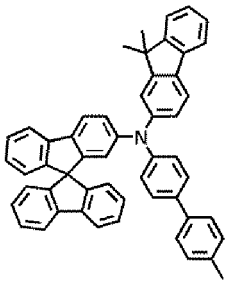
HT35



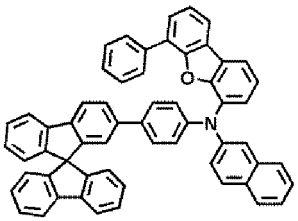
HT36



HT37



HT38



HT39

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[0091] A thickness of the hole transport region may be in a range of about 100 Å to about 10,000 Å , for example, about 100 Å to about 7000 Å, about 100 Å to about 5000 Å, about 100 Å to about 3000 Å, about 100 Å to about 1,000 Å. When the hole transport region includes at least one selected from a hole injection layer and a hole transport layer, the thickness of the hole injection layer may be in a range of about 100 Å to about 9,000 Å , and for example, about 100 Å to about 7,000 Å, about 100 Å to about 5,000 Å, about 100 Å to about 3,000 Å, about 100 Å to about 2,000 Å, about 100 Å to about 1,000 Å, or about 200 Å to about 400 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, or about 150 Å to about 250 Å. When the thicknesses of the hole transport region, the hole injection layer, and the hole transport layer are within these ranges, suitable or satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

[0092] The emission auxiliary layer may increase light-emission efficiency by compensating for an optical resonance distance according to the wavelength of light emitted by an emission layer (e.g., by adjusting the optical resonance distance to match the wavelength of light emitted from the emission layer), and the electron blocking layer may block or reduce the flow of electrons from an electron transport region (e.g., from flowing further into the hole transport region). The emission auxiliary layer and the electron blocking layer may each include or be formed of materials as described herein above.

p-dopant

[0093] The hole transport region may further include, in addition to these materials, a charge-generation material for the improvement of conductive properties. The charge-generation material may be homogeneously or non-homogeneously dispersed in the hole transport region.

[0094] The charge-generation material may be, for example, a p-dopant.

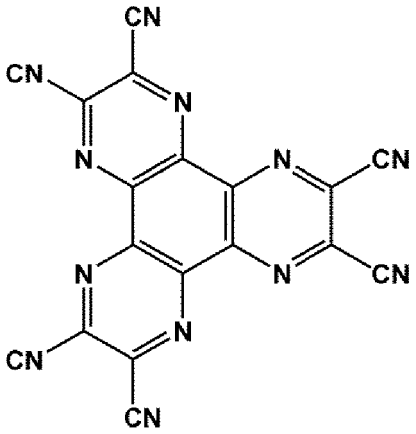
[0095] In one embodiment, the p-dopant may have a LUMO energy level of about - 3.5 eV or less.

[0096] The p-dopant may include at least one selected from a quinone derivative, a metal oxide, and a cyano group-containing compound, but embodiments of the present disclosure are not limited thereto.

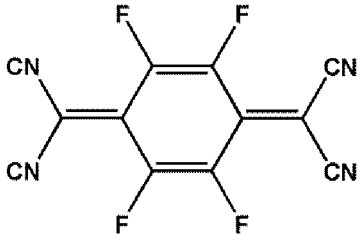
[0097] In one embodiment, the p-dopant may include at least one selected from:

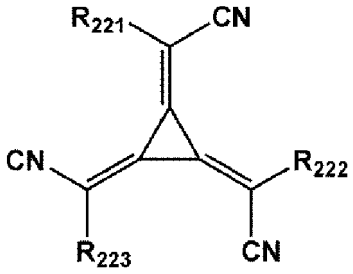
a quinone derivative, such as tetracyanoquinodimethane (TCNQ) and/or 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ);
a metal oxide, such as tungsten oxide and/or molybdenum oxide;
1,4,5,8,9,11 -Hexaazatriphenylene-hexacarbonitrile (HAT-CN); and
a compound represented by Formula 221,
but embodiments of the present disclosure are not limited thereto:

HAT-CN



F4-TCNQ





Formula 221

[0098] In Formula 221,

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

Emission layer in organic layer 150

[0099] When the organic light-emitting device 10 is a full-color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, or a blue emission layer, according to a sub-pixel. In one or more embodiments, the emission layer may have a stacked structure of two or more layers selected from a red emission layer, a green emission layer, and a blue emission layer, in which the two or more layers may contact each other or may be separated from each other. In one or more embodiments, the emission layer may include two or more materials selected from a red light-emitting material, a green light-emitting material, and a blue light-emitting material, in which the two or more materials are mixed with each other in a single layer to emit white light.

[0100] The host may include the heterocyclic compound represented by Formula 1.

[0101] The emission layer may include a host and a dopant. The dopant may include at least one selected from a phosphorescent dopant and a fluorescent dopant.

[0102] In the emission layer, an amount of the dopant may be in a range of about 0.01 parts by weight to about 15 parts by weight based on 100 parts by weight of the host, but embodiments of the present disclosure are not limited thereto.

[0103] A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, for example, about 100 Å to about 800 Å, about 150 Å to about 800 Å, about 150 Å to about 700 Å, about 150 Å to about 650 Å, about 200 Å to about 600 Å or about 200 Å to about 300 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.

Host in emission layer

[0104] The host may include the heterocyclic compound represented by Formula 1.

[0105] In one or more embodiments, the host may further include a compound represented by Formula 301 below:

Formula 301 $[Ar_{301}]_{xb11}-[(L_{301})_{xb1}-R_{301}]_{xb21}$.

In Formula 301,

Ar_{301} may be a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
xb11 may be 0, 1, 2, or 3;
L_{301} may be selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,
xb1 may be an integer from 0 to 5,
R_{301} may be selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, - $Si(Q_{301})(Q_{302})(Q_{303})$, -$N(Q_{301})(Q_{302})$, -$B(Q_{301})(Q_{302})$, -$C(=O)(Q_{301})$, -$S(=O)_2(Q_{301})$, and - $P(=O)(Q_{301})(Q_{302})$,
xb21 may be an integer from 1 to 5, and
Q_{301} to Q_{303} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group, but embodiments of the present disclosure are not limited thereto.

[0106] For example, Ar_{301} may be a substituted or unsubstituted C_6-C_{32} carbocyclic group or a substituted or unsubstituted C_1-C_{12} heterocyclic group, but embodiments are not limited thereto.

[0107] In one embodiment, Ar_{301} in Formula 301 may be selected from:

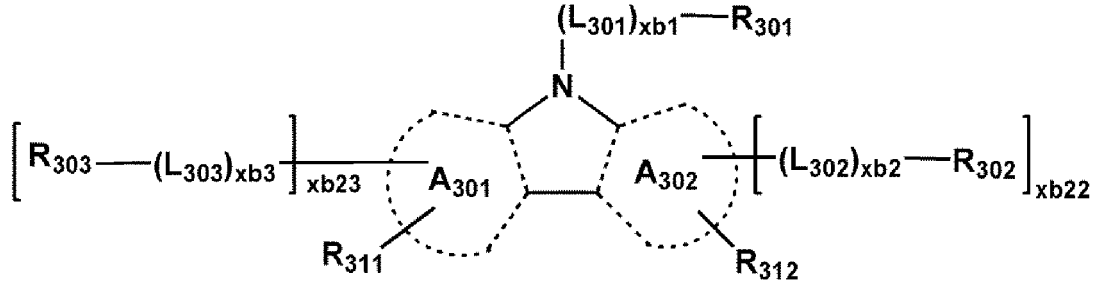
a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, and a dibenzothiophene group; and
a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, and a dibenzothiophene group, each substituted with at least one selected from deuterium, - F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, - $Si(Q_{31})(Q_{32})(Q_{33})$, -$N(Q_{31})(Q_{32})$, -$B(Q_{31})(Q_{32})$, -$C(=O)(Q_{31})$, -$S(=O)_2(Q_{31})$, and - $P(=O)(Q_{31})(Q_{32})$,

[0108] Q_{31} to Q_{33} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group, but embodiments of the present disclosure are not limited thereto.

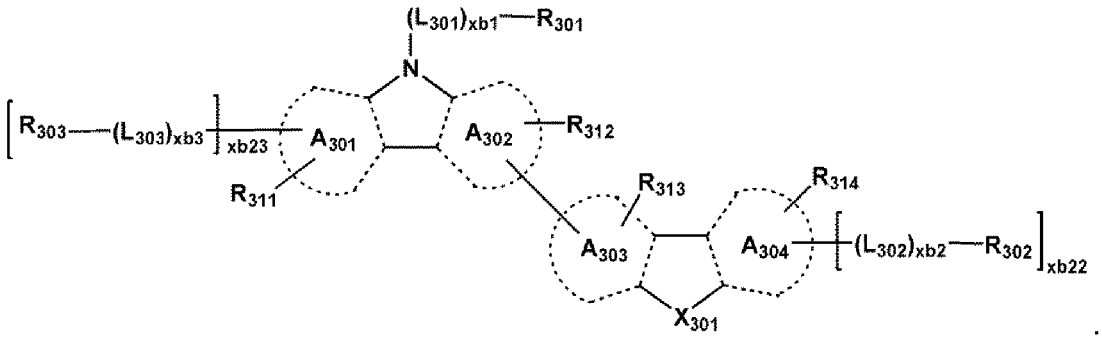
[0109] When xb11 in Formula 301 is 2 or more, two or more Ar_{301}(s) may be linked via a single bond.

[0110] In one or more embodiments, the compound represented by Formula 301 may be represented by Formula 301-1 or 301-2:

Formula 301-1



Formula 301-2



In Formulae 301-1 to 301-2,

ring A_{301} to ring A_{304} may each independently be selected from a benzene ring, a naphthalene ring, a phenanthrene ring, a fluoranthene ring, a triphenylene ring, a pyrene ring, a chrysene ring, a pyridine ring, a pyrimidine ring, an indene ring, a fluorene ring, a spiro-bifluorene ring, a benzofluorene ring, a dibenzofluorene ring, an indole ring, a carbazole ring, a benzocarbazole ring, a dibenzocarbazole ring, a furan ring, a benzofuran ring, a dibenzofuran ring, a naphthofuran ring, a benzonaphthofuran ring, a dinaphthofuran ring, a thiophene ring, a benzothiophene ring, a dibenzothiophene ring, a naphthothiophene ring, a benzonaphthothiophene ring, and a dinaphthothiophene ring,
X_{301} may be O, S, or N-[$(L_{304})_{xb4}$-R_{304}],
R_{311} to R_{314} may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group -$Si(Q_{31})(Q_{32})(Q_{33})$, -$N(Q_{31})(Q_{32})$, -$B(Q_{31})(Q_{32})$, -$C(=O)(Q_{31})$, -$S(=O)_2(Q_{31})$, and -$P(=O)(Q_{31})(Q_{32})$,
xb22 and xb23 may each independently be 0, 1, or 2,
L_{301}, xb1, R_{301}, and Q_{31} to Q_{33} may each independently be the same as described herein above,
L_{302} to L_{304} may each independently be the same as described in connection with L_{301},
xb2 to xb4 may each independently be the same as described in connection with xb1, and
R_{302} to R_{304} may each independently be the same as described in connection with R_{301}.

[0111] For example, L_{301} to L_{304} in Formulae 301, 301-1, and 301-2 may each independently be selected from:

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, an isobenzothiazolylene

group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene group; and
a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an azacarbazolyl group, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$, and $-P(=O)(Q_{31})(Q_{32})$, and
Q_{31} to Q_{33} may each independently be the same as described herein above.

[0112] As another example, R_{301} to R_{304} in Formulae 301, 301-1, and 301-2 may each independently be selected from: deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{60} (e.g. C_1-C_{10}) alkyl group, a substituted or unsubstituted C_2-C_{60} (e.g. C_2-C_{10}) alkenyl group, a substituted or unsubstituted C_2-C_{60} *(e.g.* C_2-C_{10}) alkynyl group, a substituted or unsubstituted C_1-C_{60} (*e.g.* C_1-C_{10}) alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{30} aryl group, a substituted or unsubstituted C_6-C_{30} aryloxy group, a substituted or unsubstituted C_6-C_{30} arylthio group, a substituted or unsubstituted C_1-C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_{301})(Q_{302})(Q_{303})$, $-N(Q_{301})(Q_{302})$, $-B(Q_{301})(Q_{302})$, $-C(=O)(Q_{301})$, $-S(=O)_2(Q_{301})$, and $-P(=O)(Q_{301})(Q_{302})$, but embodiments are not limited thereto.

[0113] In one embodiment, R_{301} to R_{304} in Formulae 301, 301-1, and 301-2 may each independently be selected from:

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

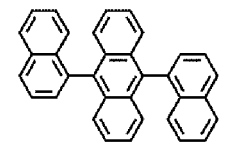
group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group; and

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, an azacarbazolyl group, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$, and $-P(=O)(Q_{31})(Q_{32})$, and

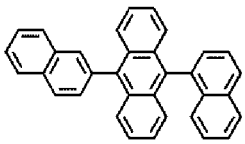
Q_{31} to Q_{33} may each independently be the same as described herein above.

[0114] In one embodiment, the host may include an alkaline earth metal complex. For example, the host may include a complex selected from a Be complex (for example, Compound H55), a Mg complex, and a Zn complex. For example, the host may be selected from a Be complex (for example, Compound H55), a Mg complex, and a Zn complex.

[0115] The host may include at least one selected from 9,10-di(2-naphthyl)anthracene (ADN), 2-methyl-9,10-bis(naphthalen-2-yl)anthracene (MADN), 9,10-di-(2-naphthyl)-2-t-butyl-anthracene (TBADN), 4,4'-bis(N-carbazolyl)-1,1'-biphenyl (CBP), 1,3-di-9-carbazolylbenzene (mCP), 1,3,5-tri(carbazol-9-yl)benzene (TCP), and Compounds H1 to H55, but embodiments of the present disclosure are not limited thereto:



H1



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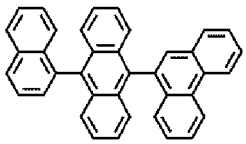

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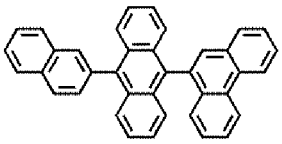

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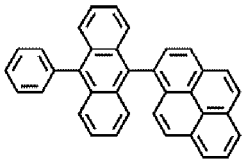

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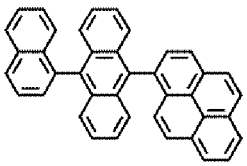

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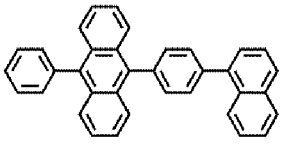
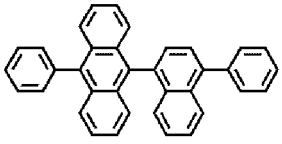


H7



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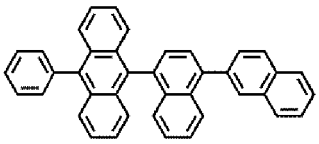

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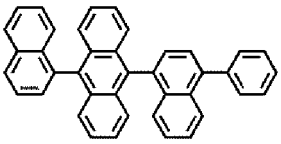

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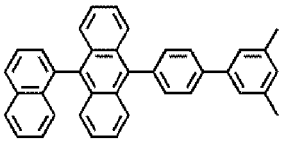

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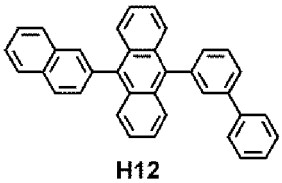

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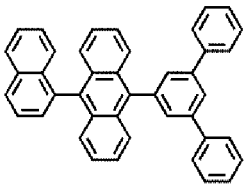

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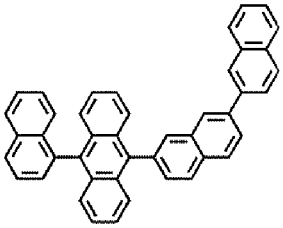

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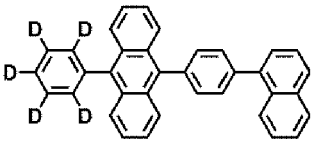

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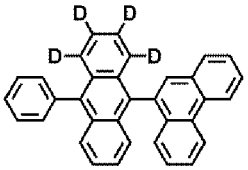

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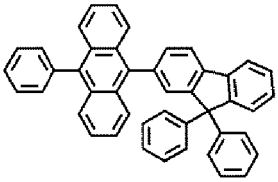

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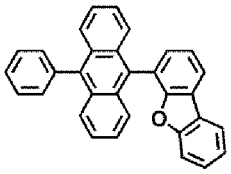

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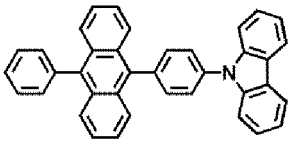

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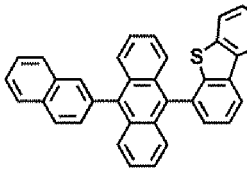

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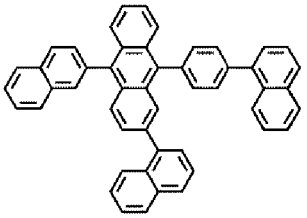

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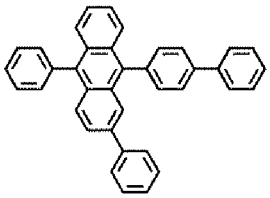

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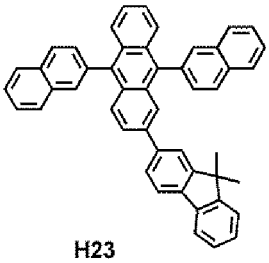

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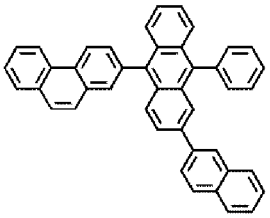

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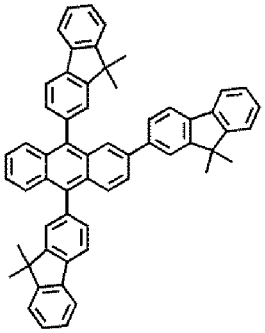

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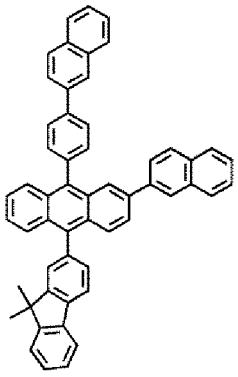

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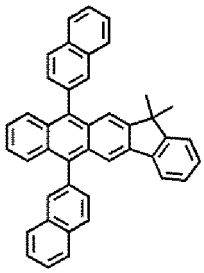

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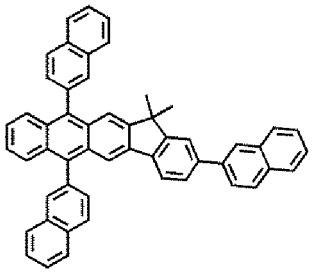

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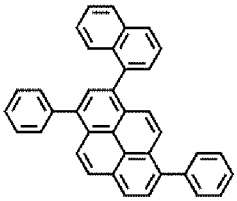

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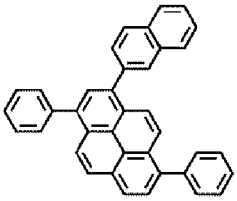

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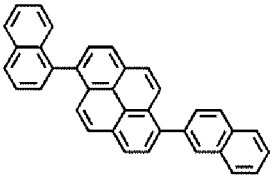

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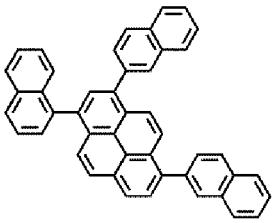

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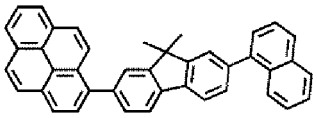

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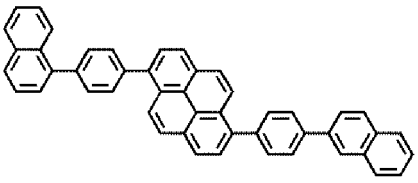

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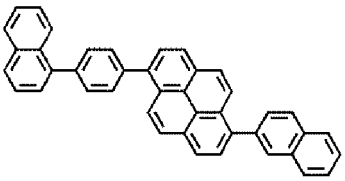

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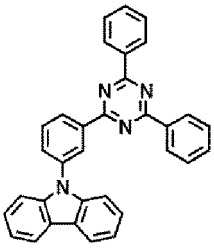

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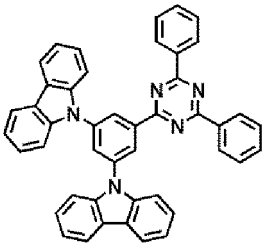

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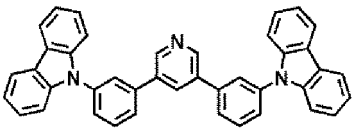

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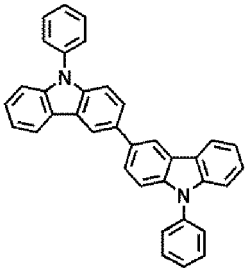

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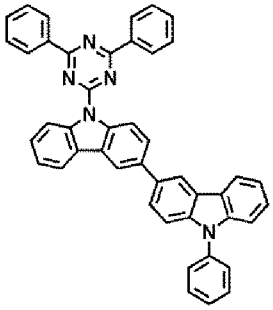

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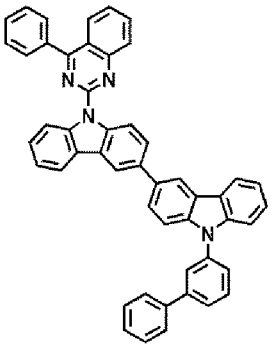

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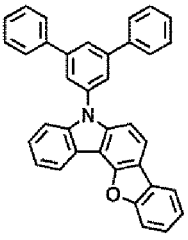

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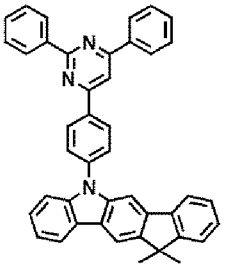

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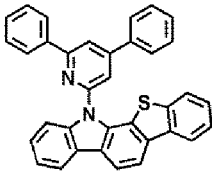

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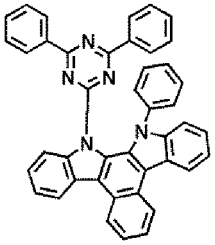

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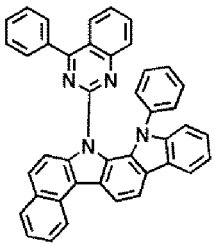

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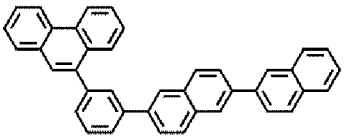

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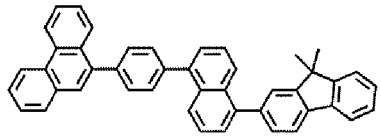

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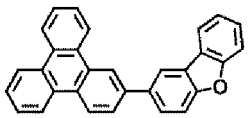

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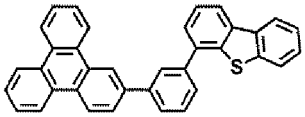
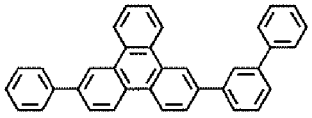


H50



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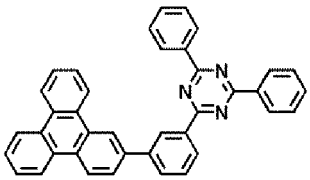

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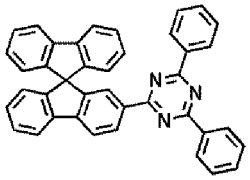
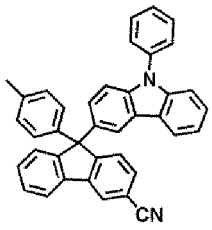
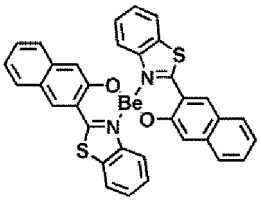


H53



H54



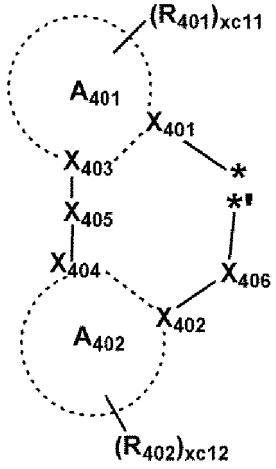
H55

Phosphorescent dopant included in emission layer in organic layer 150

[0116] The phosphorescent dopant may include an organometallic complex represented by Formula 401 below:

Formula 401 $M(L_{401})_{xc1}(L402)_{xc2}$

Formula 402



In Formulae 401 and 402,

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

L_{401} may be selected from ligands represented by Formula 402, and xc1 may be 1, 2, or 3, wherein, when xc1 is two or more, two or more L_{401}(s) may be identical to or different from each other,
L_{402} may be an organic ligand, and xc2 may be an integer from 0 to 4, wherein, when xc2 is two or more, two or more L_{402}(s) may be identical to or different from each other,
X_{401} to X_{404} may each independently be nitrogen or carbon,
X_{401} and X_{403} may be linked via a single bond or a double bond, and X_{402} and X_{404} may be linked via a single bond or a double bond,
A_{401} and A_{402} may each independently be selected from a C_5-C_{60} (e.g. C_5-C30) carbocyclic group or a C_1-C_{60} (e.g. C_1-C_{20}) heterocyclic group,
X_{405} may be a single bond, *-O-*', *-S-*', *-C(=O)-*', *-N(Q_{411})-*', *-C(O_{411})(Q_{412})-*', *-C(Q_{411})=C(Q_{412})-*', *-C(Q_{411})=*', or *=C=*', wherein Q_{411} and Q_{412} may each independently be hydrogen, deuterium, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group,
X_{406} may be a single bond, O, or S,
R_{401} and R_{402} may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{20} alkyl group, a substituted or unsubstituted C_1-C_{20} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{30}) aryl group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{30}) aryloxy group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{30}) arylthio group, a substituted or unsubstituted C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, -Si(Q_{401})(Q_{402})(Q_{403}), -N(Q_{401})(Q_{402}), -B(Q_{401})(Q_{402}), -C(=O)(Q_{401}), -S(=O)$_2$(Q_{401}), and -P(=O)(Q_{401})(Q_{402}), wherein Q_{401} to Q_{403} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a C_6-C_{20} aryl group, and a C_1-C_{20} heteroaryl group,
xc11 and xc12 may each independently be an integer from 0 to 10, and
* and *'in Formula 402 each indicate a binding site to M in Formula 401.

[0117] In one embodiment, A_{401} and A_{402} in Formula 402 may each independently be selected from a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, an indene group, a pyrrole group, a thiophene group, a furan group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a quinoxaline group, a quinazoline group, a carbazole group, a benzimidazole group, a benzofuran group, a benzothiophene group, an isobenzothiophene group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a dibenzofuran group, and a dibenzothiophene group.

[0118] In one or more embodiments, in Formula 402, i) X_{401} may be nitrogen, and X402 may be carbon, or ii) X_{401} and X_{402} may each be nitrogen at the same time.

[0119] In one or more embodiments, R_{401} and R_{402} in Formula 402 may each independently be selected from:

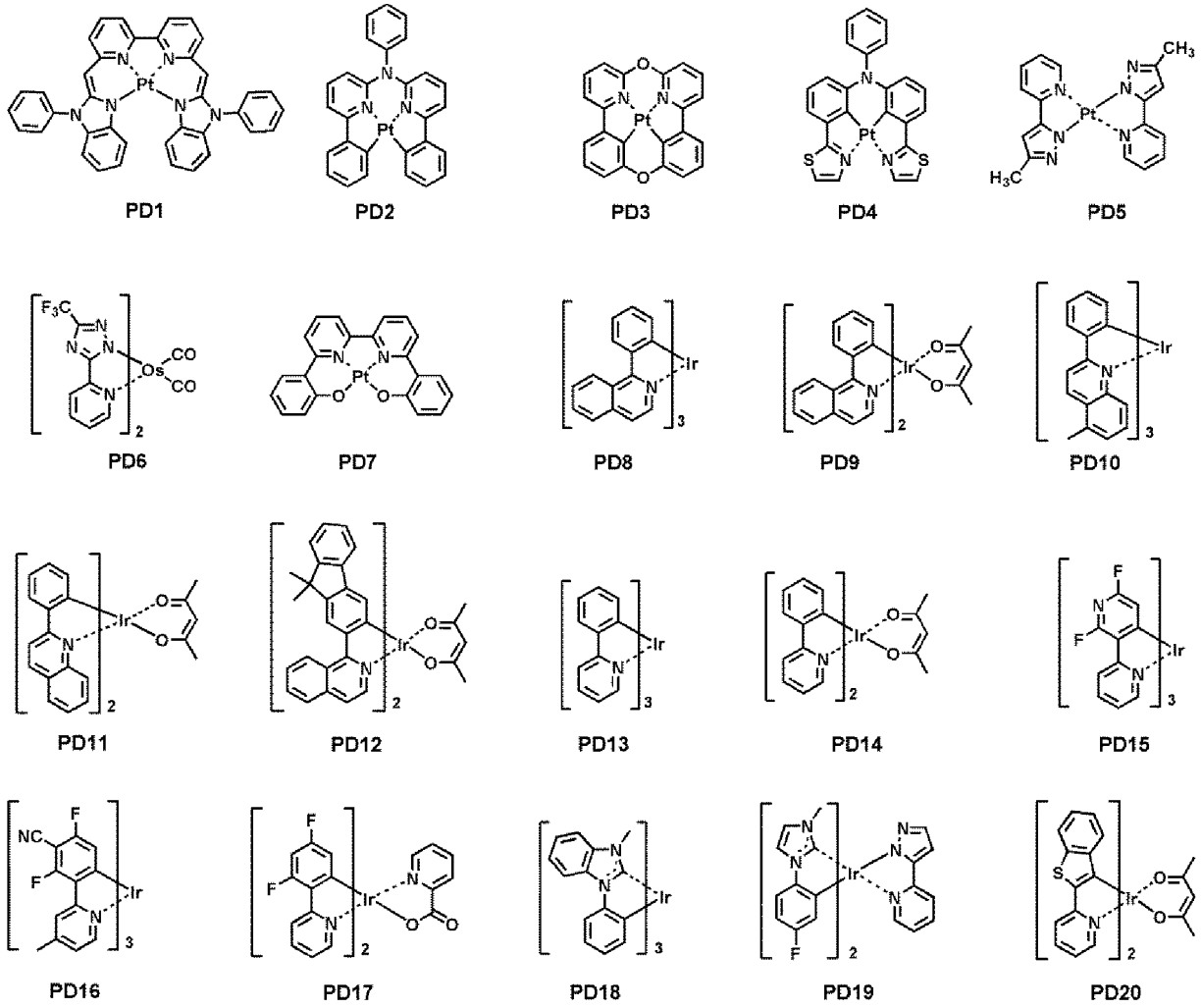
hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, and a C_1-C_{20} alkoxy group;
a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one selected from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

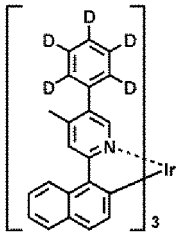
group, a quinazolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group; and $-Si(Q_{401})(Q_{402})(Q_{403})$, $-N(Q_{401})(Q_{402})$, $-B(Q_{401})(Q_{402})$, $-C(=O)(Q_{401})$, $-S(=O)_2(Q_{401})$, and $-P(=O)(Q_{401})(Q_{402})$, and Q_{401} to Q_{403} may each independently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

[0120] In one or more embodiments, in Formula 401, when xc1 is 2 or more, two A_{401}(s) in two or more L_{401}(s) may optionally be linked via X407, which is a linking group, or when xc1 is 2 or more, two A_{402}(s) in two or more L_{401}(s) may optionally be linked via X_{408}, which is a linking group (see Compounds PD1 to PD4 and PD7). X407 and X_{408} may each independently be a single bond, *-O-*', *-S-*', *-C(=O)-*', *-N(Q_{413})-*', *-C(Q_{413})(Q_{414})-*', or *-C(Q_{413})=C(Q_{414})-*' (wherein Q_{413} and Q_{414} may each independently be hydrogen, deuterium, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group), but embodiments of the present disclosure are not limited thereto.

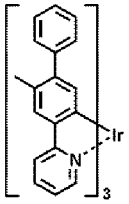
[0121] L_{402} in Formula 401 may be a monovalent, divalent, or trivalent organic ligand. For example, L_{402} may be selected from halogen, diketone (for example, acetylacetonate), carboxylic acid (for example, picolinate), -C(=O), isonitrile, -CN, and a phosphorus-containing material (for example, phosphine, or phosphite), but embodiments of the present disclosure are not limited thereto.

[0122] In one or more embodiments, the phosphorescent dopant may be selected from, for example, Compounds PD1 to PD26, but embodiments of the present disclosure are not limited thereto:

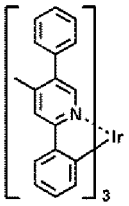




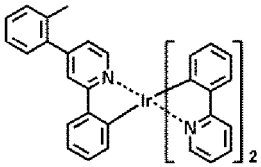
PD21



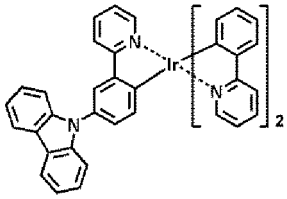
PD22



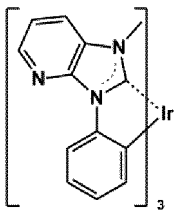
PD23



PD24



PD25



PD26

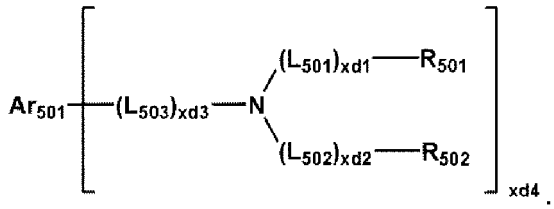
Fluorescent dopant in emission layer

[0123] The fluorescent dopant may include the heterocyclic compound represented by Formula 1.

[0124] In one embodiment, the fluorescent dopant may include an arylamine compound or a styrylamine compound.

[0125] The fluorescent dopant may include a compound represented by Formula 501 below:

Formula 501



In Formula 501,

Ar_{501} may be a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,

L_{501} to L_{503} 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} (*e.g.* C_6-C_{30}) arylene group, a substituted or unsubstituted C_1-C_{60} (e.g. C_1-C_{20}) heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

xd1 to xd3 may each independently be an integer from 0 to 3,

R_{501} and R_{502} may each independently be selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{30}) aryl group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{30}) aryloxy group, a substituted or unsubstituted C_6-C_{60} (*e.g.* C_6-C_{30}) arylthio group, a substituted or unsubstituted C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, and

xd4 may be an integer from 1 to 6.

[0126] For example, Ar_{501} may be a substituted or unsubstituted C_5-C_{30} carbocyclic group or a substituted or unsubstituted C_1-C_{20} heterocyclic group, but embodiments are not limited thereto.

[0127] In one embodiment, Ar_{501} in Formula 501 may be selected from:

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

a naphthalene group, a heptalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, and an indenophenanthrene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0128] In one or more embodiments, L_{501} to L_{503} in Formula 501 may each independently be selected from:

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, and a pyridinylene group; and

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, and a pyridinylene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group.

[0129] In one or more embodiments, R_{501} and R_{502} in Formula 501 may each independently be selected from:

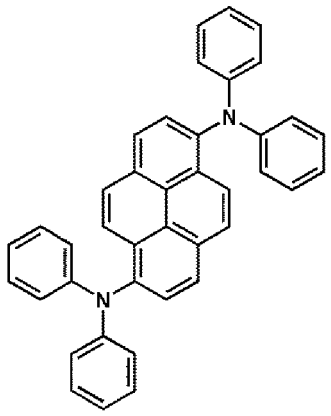
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group; and

a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a

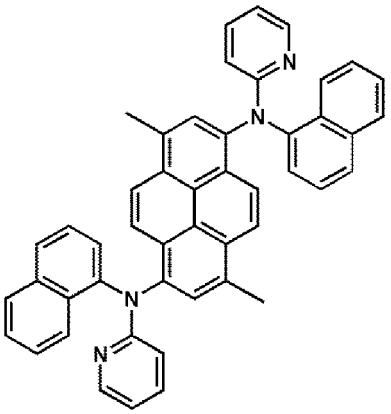
dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, and - $Si(Q_{31})(Q_{32})(Q_{33})$, and
Q_{31} to Q_{33} may each independently be a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0130] In one or more embodiments, xd4 in Formula 501 may be 2, but embodiments of the present disclosure are not limited thereto.

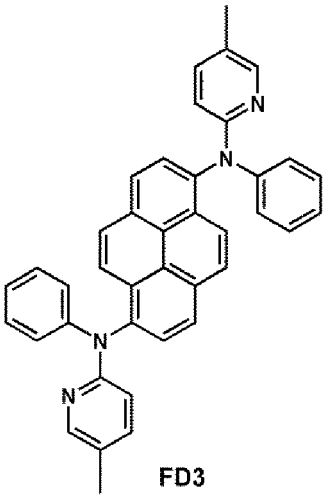
[0131] For example, the fluorescent dopant may be selected from Compounds FD1 to FD22:



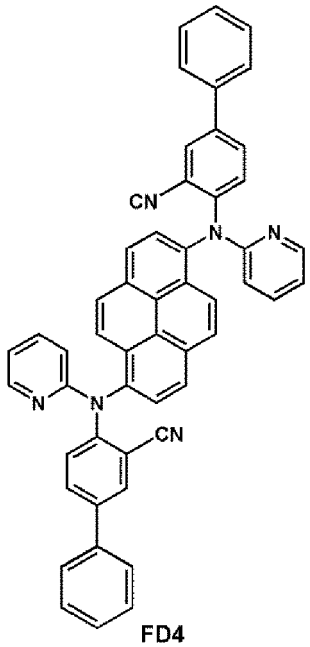
FD1



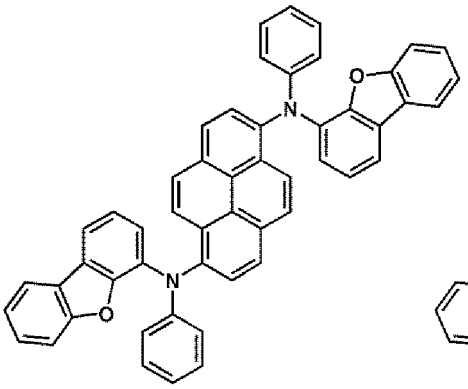
FD2



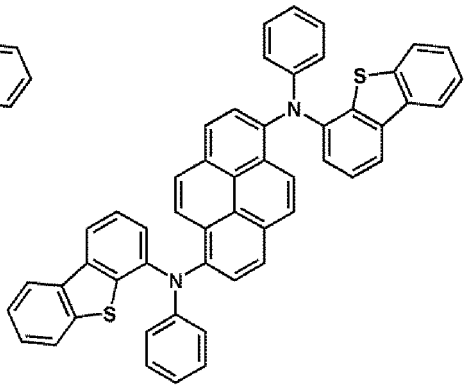
FD3



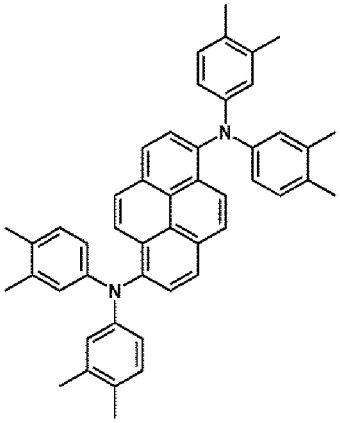
FD4



FD5



FD6



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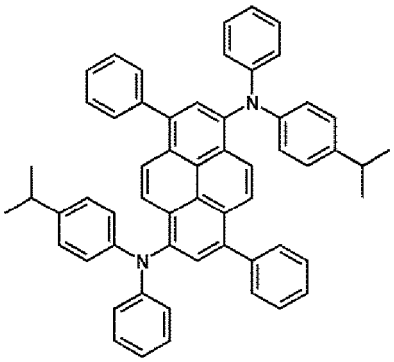

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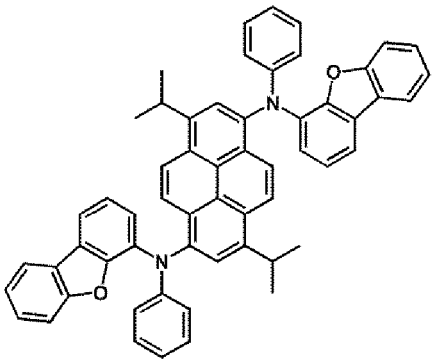

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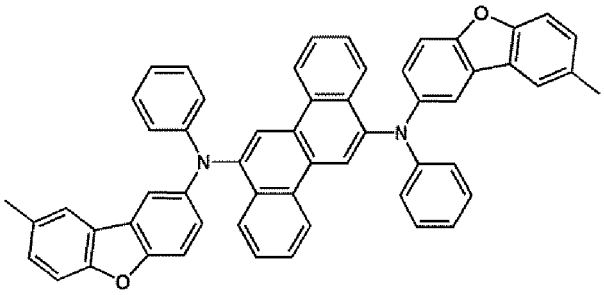

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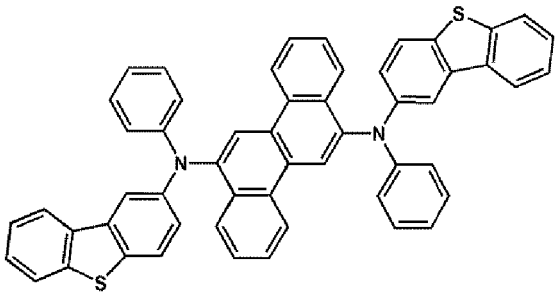

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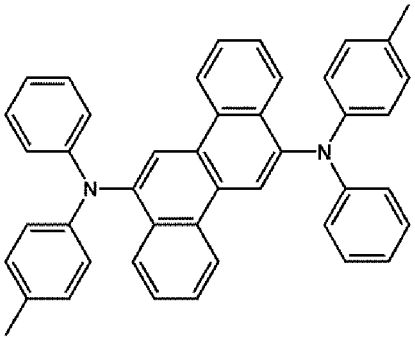

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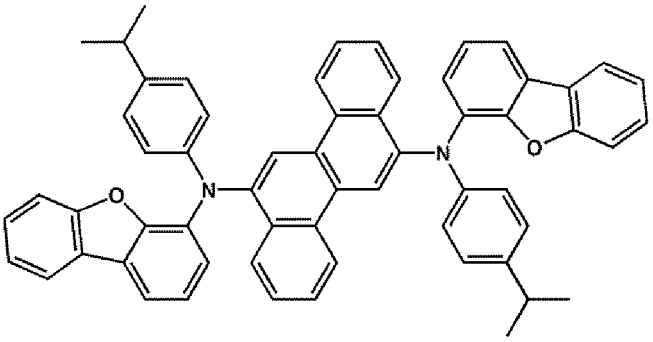

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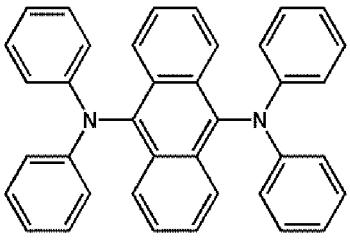

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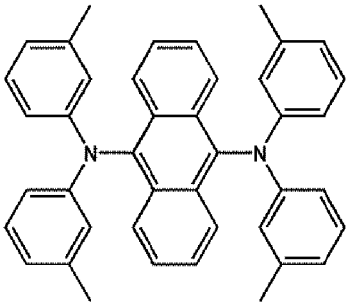

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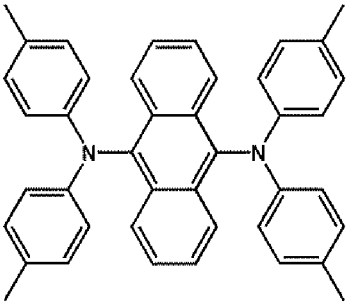

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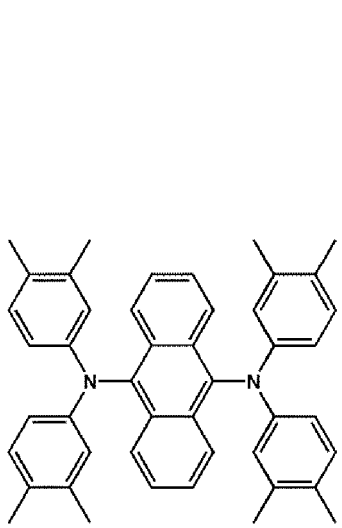

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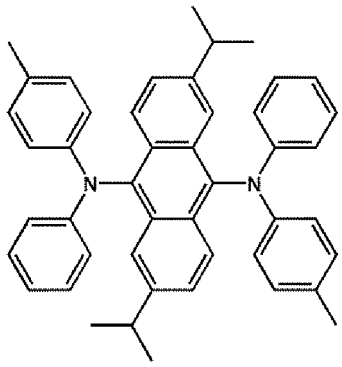

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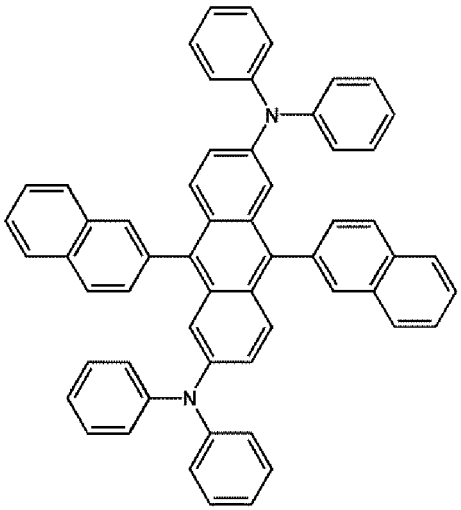

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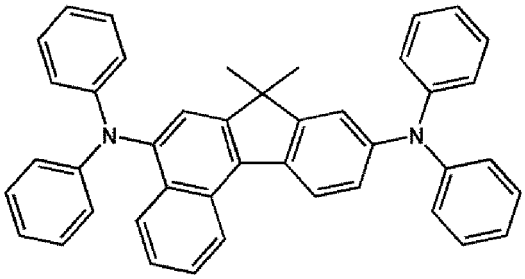

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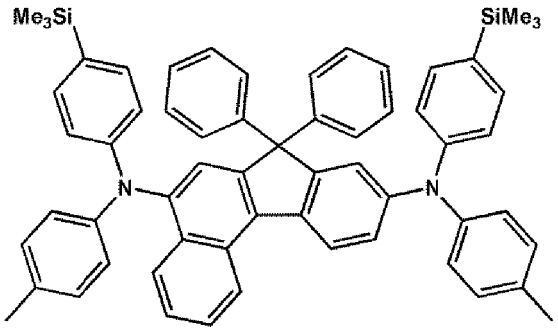

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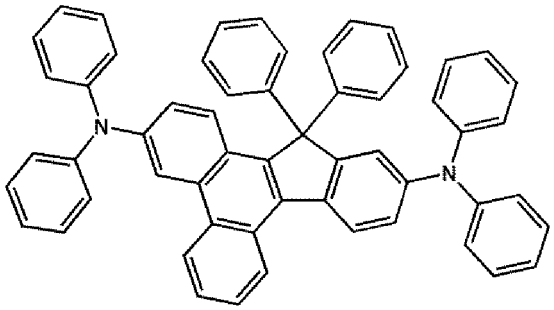
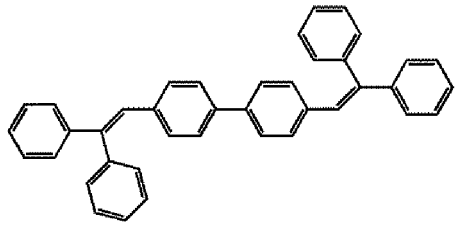
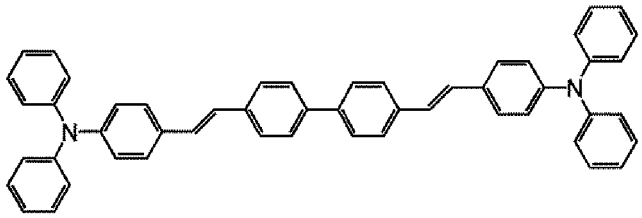


FD22

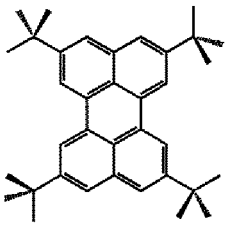
[0132] In one or more embodiments, the fluorescent dopant may be selected from the following compounds, but embodiments of the present disclosure are not limited thereto:



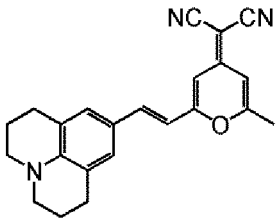
DPVBi



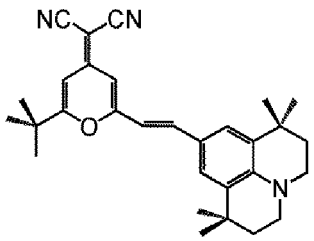
DPAVBi



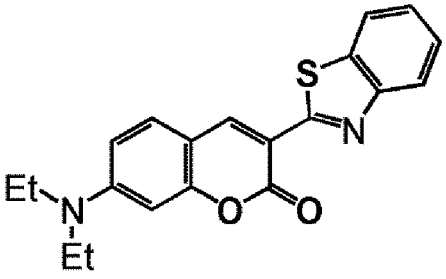
TBPe



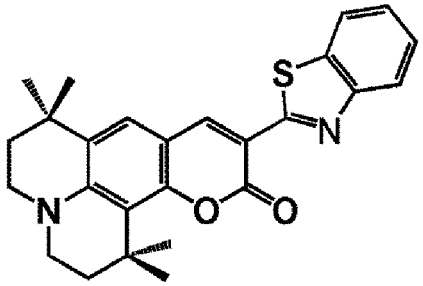
DCM



DCJTB



Coumarin 6



C545T

Electron transport region in organic layer 150

[0133] The electron transport region may have: i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

[0134] The electron transport region may include at least one selected from a buffer layer, a hole blocking layer, an electron control layer, an electron transport layer, and an electron injection layer, but embodiments of the present disclosure are not limited thereto.

[0135] For example, the electron transport region may have an electron transport layer/electron injection layer structure, a hole blocking layer/electron transport layer/electron injection layer structure, an electron control layer/electron transport layer/electron injection layer structure, or a buffer layer/electron transport layer/electron injection layer structure, wherein the constituting layers of each structures are sequentially stacked from the emission layer. However, embodiments of the structure of the electron transport region are not limited thereto.

[0136] The electron transport region (for example, a buffer layer, a hole blocking layer, an electron control layer, and/or an electron transport layer in the electron transport region) may include a metal-free compound containing at least one π electron-depleted nitrogen-containing ring.

[0137] The term "π electron-depleted nitrogen-containing ring," as used herein, refers to a C_1-C_{60} (*e.g.* a C_1-C_{30}) heterocyclic group having at least one *-N=*' moiety as a ring-forming moiety.

[0138] For example, the "π electron-depleted nitrogen-containing ring" may be i) a 5- to 7-membered heteromonocyclic group having at least one *-N=*' moiety, ii) a heteropolycyclic group in which two or more 5- to 7-membered heteromonocyclic groups each having at least one *-N=*' moiety are condensed with each other, or iii) a heteropolycyclic group in which at least one of 5- to 7-membered heteromonocyclic group having at least one *-N=*' moiety, is condensed with at least one C_5-C_{60} (*e.g.* a C_5-C_{30}) carbocyclic group.

[0139] Non-limiting examples of the π electron-depleted nitrogen-containing ring include an imidazole, a pyrazole, a

thiazole, an isothiazole, an oxazole, an isoxazole, a pyridine, a pyrazine, a pyrimidine, a pyridazine, an indazole, a purine, a quinoline, an isoquinoline, a benzoquinoline, a phthalazine, a naphthyridine, a quinoxaline, a quinazoline, a cinnoline, a phenanthridine, an acridine, a phenanthroline, a phenazine, a benzimidazole, an isobenzothiazole, a benzoxazole, an isobenzoxazole, a triazole, a tetrazole, an oxadiazole, a triazine, a thiadiazole, an imidazopyridine, an imidazopyrimidine, and an azacarbazole.

[0140] For example, the electron transport region may include a compound represented by Formula 601:

Formula 601 $$[Ar_{601}]_{xe11}\text{-}[(L_{601})_{xe1}\text{-}R_{601}]_{xe21}.$$

In Formula 601,

Ar_{601} may be a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
xe11 may be 0, 1, 2, or 3,
L_{601} may be selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3-C_{10} cycloalkenylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6-C_{60} arylene group, a substituted or unsubstituted C_1-C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,
xe1 may be an integer from 0 to 5,
R_{601} may be selected from a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, - $Si(Q_{601})(Q_{602})(Q_{603})$, $-C(=O)(Q_{601})$, $-S(=O)_2(Q_{601})$, and $-P(=O)(Q_{601})(Q_{602})$,
Q_{601} to Q_{603} may each independently be a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group, and
xe21 may be an integer from 1 to 5.

[0141] In one embodiment, at least one of Ar_{601}(s) in the number of xe11 and R_{601}(s) in the number of xe21 may include the π electron-depleted nitrogen-containing ring.

[0142] For example, Ar_{601} may be a substituted or unsubstituted C_5-C_{30} carbocyclic group or a substituted or unsubstituted C_1-C_{20} heterocyclic group, but embodiments are not limited thereto.

[0143] In one embodiment, Ar_{601} in Formula 601 may be selected from:

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

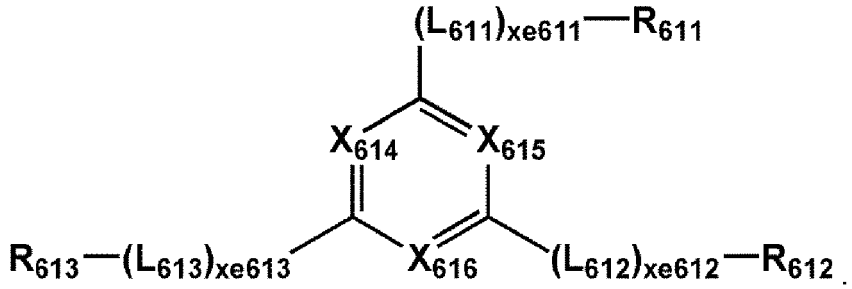
an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-S(=O)_2(Q_{31})$, and $-P(=O)(Q_{31})(Q_{32})$, and
Q_{31} to Q_{33} may each independently be selected from a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0144] When xe11 in Formula 601 is 2 or more, two or more Ar_{601}(s) may be linked via a single bond.

[0145] In one or more embodiments, Ar_{601} in Formula 601 may be an anthracene group.

[0146] In one or more embodiments, the compound represented by Formula 601 may be represented by Formula 601-1 :

Formula 601-1



In Formula 601-1,

X_{614} may be N or $C(R_{614})$, X_{615} may be N or $C(R_{615})$, X_{616} may be N or $C(R_{616})$, and at least one selected from X_{614} to X_{616} may be N,
L_{611} to L_{613} may each independently be the same as described in connection with L_{601},
xe_{611} to xe_{613} may each independently be defined the same as described in connection with xe1,
R_{611} to R_{613} may each independently be the same as described in connection with R_{601}, and
R_{614} to R_{616} may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0147] For example, L_{601} and L_{611} to L_{613} in Formulae 601 and 601-1 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_{30} arylene group, a substituted or unsubstituted C_1-C_{20} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group, but embodiments are not limited thereto.

[0148] In one embodiment, L_{601} and L_{611} to L_{613} in Formulae 601 and 601-1 may each independently be selected from:

a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene group; and
a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene

group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a thiophenylene group, a furanylene group, a carbazolylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a dibenzosilolylene group, a pyridinylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a thiadiazolylene group, an oxadiazolylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, a triazinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, and an azacarbazolylene group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group,
but embodiments of the present disclosure are not limited thereto.

[0149] In one or more embodiments, xe_1 and xe_{611} to xe_{613} in Formulae 601 and 601-1 may each independently be 0, 1, or 2.

[0150] For example, R_{601} and R_{611} to R_{613} in Formulae 601 and 601-1 may each independently be selected from: a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{30} aryl group, a substituted or unsubstituted C_6-C_{30} aryloxy group, a substituted or unsubstituted C_6-C_{30} arylthio group, a substituted or unsubstituted C_1-C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, - $Si(Q_{601})(Q_{602})(Q_{603})$, $-C(=O)(Q_{601})$, $-S(=O)_2(Q_{601})$, and $-P(=O)(Q_{601})(Q_{602})$.

[0151] In one or more embodiments, R_{601} and R_{611} to R_{613} in Formulae 601 and 601-1 may each independently be selected from:

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

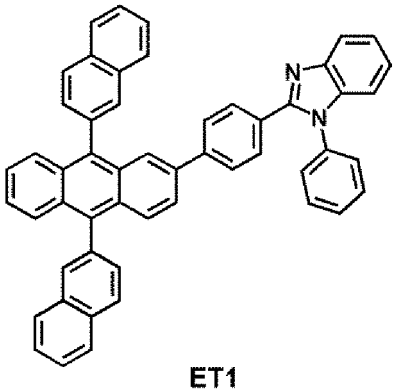
a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl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

group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group; and

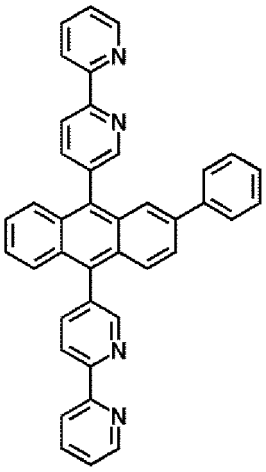
$-S(=O)_2(Q_{601})$ and $-P(=O)(O_{601})(O_{602})$, and

Q_{601} and Q_{602} may each independently be the same as described herein above.

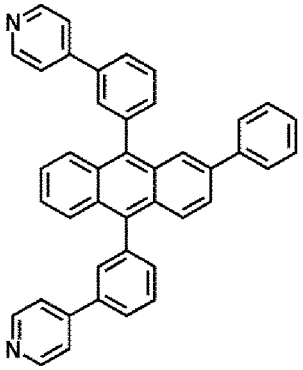
[0152] The electron transport region may include at least one compound selected from Compounds ET1 to ET36, but embodiments of the present disclosure are not limited thereto:



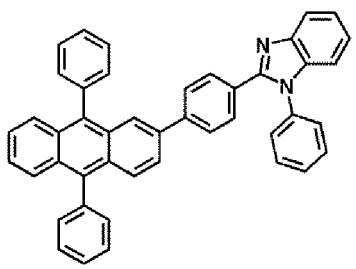
ET1



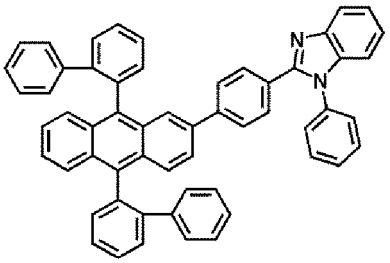
ET2



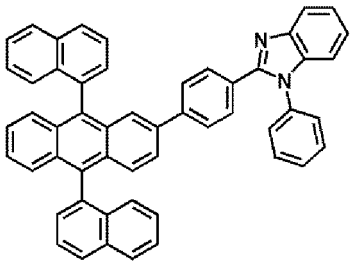
ET3



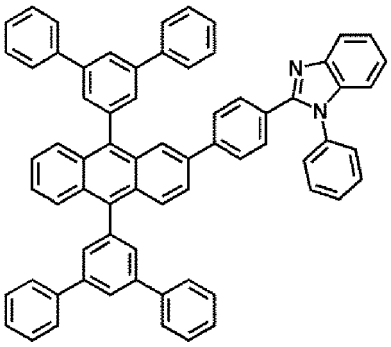
ET4



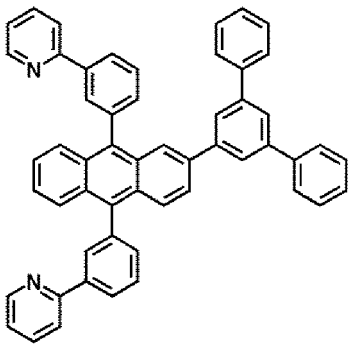
ET5



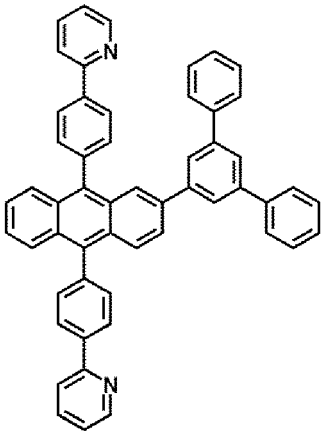
ET6



ET7



ET8



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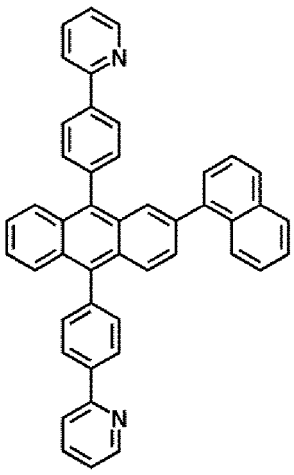

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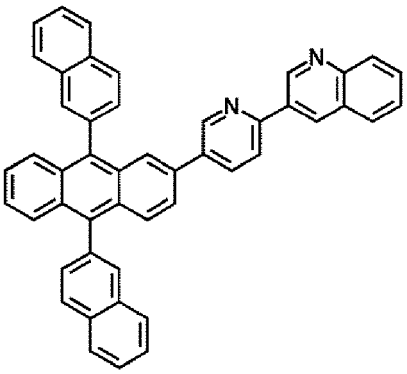

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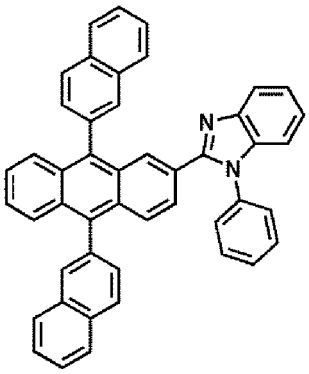

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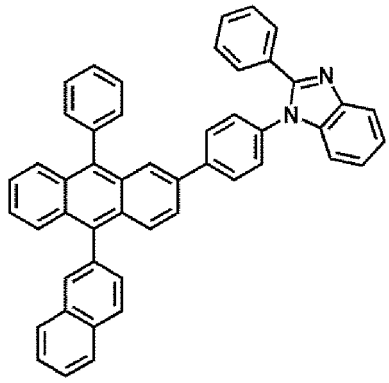

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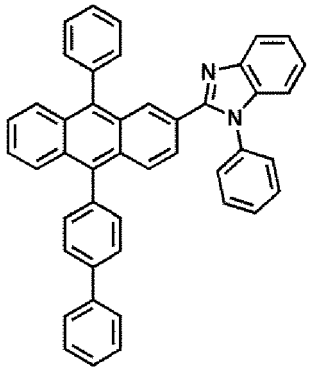

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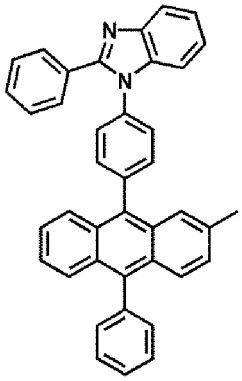

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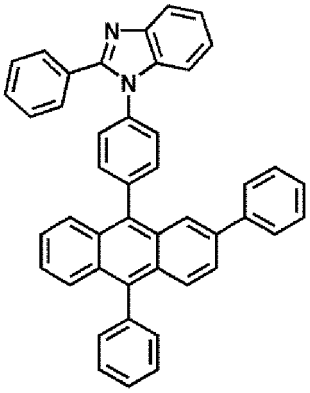

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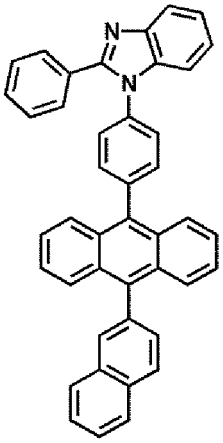

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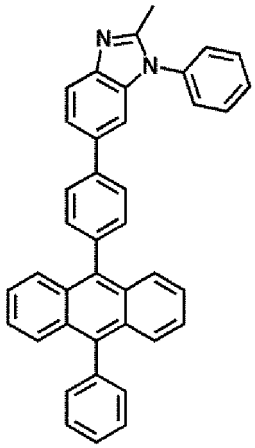

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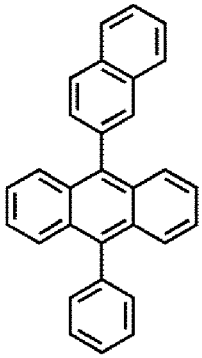

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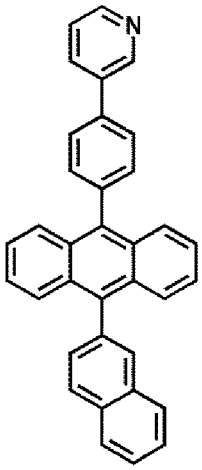
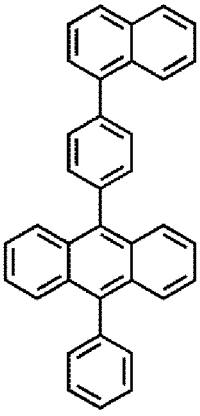


ET20



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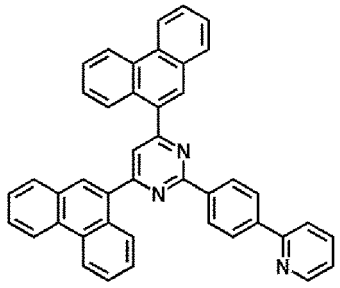

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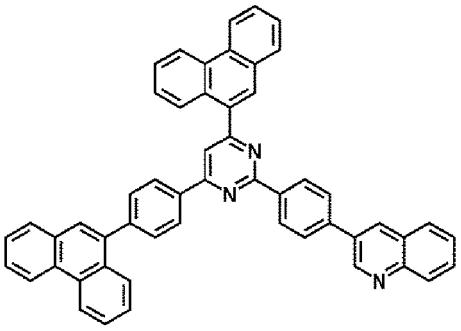
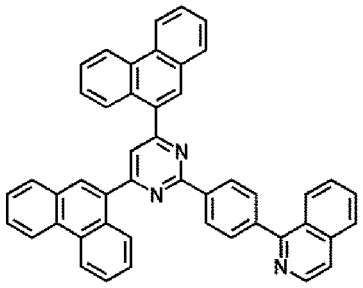


ET23



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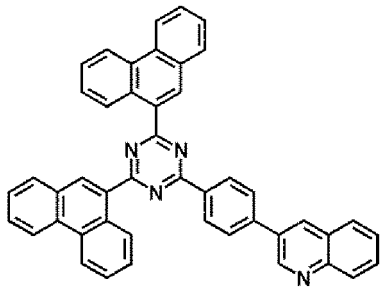

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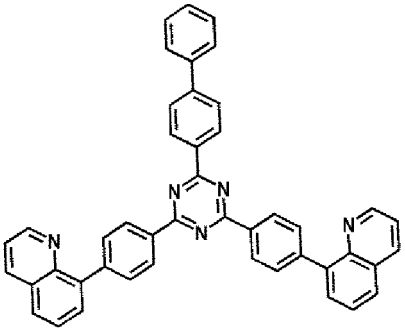
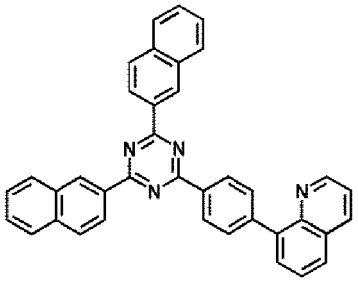
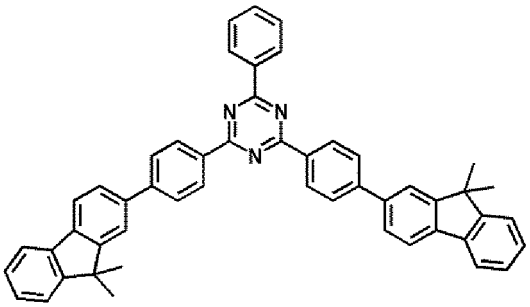


ET26



ET27



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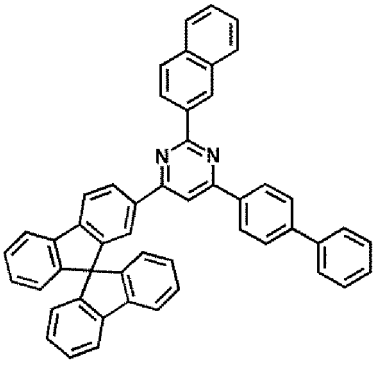

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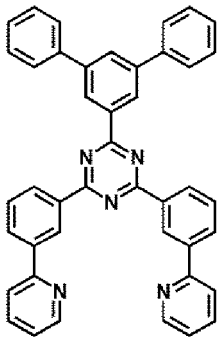
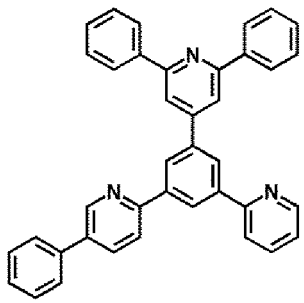
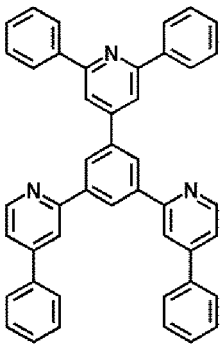


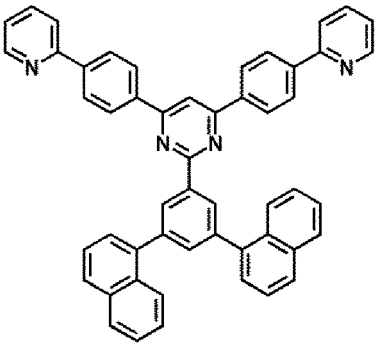
ET30



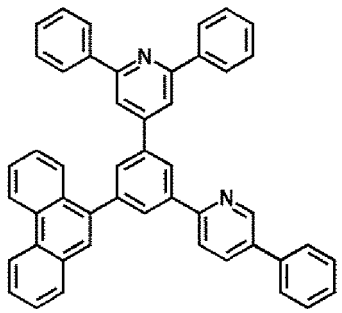
ET31



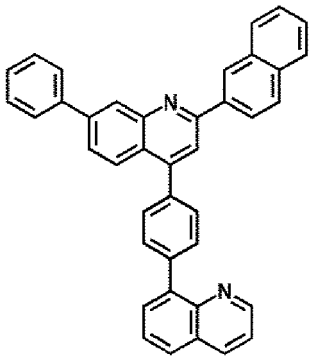
ET32



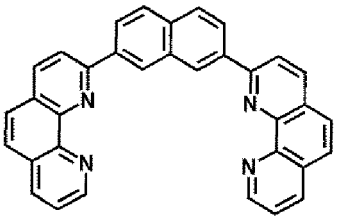
ET33



ET34

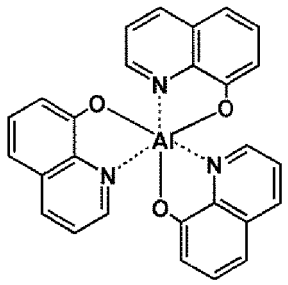


ET35

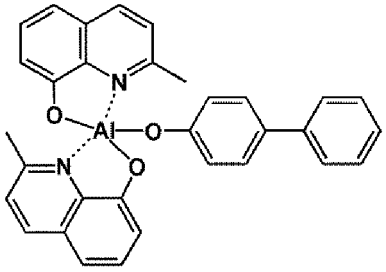


ET36

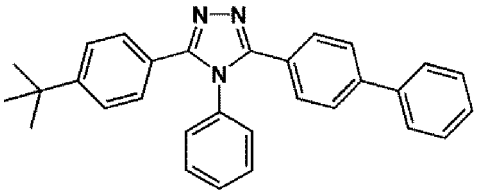
[0153] In one or more embodiments, the electron transport region may include at least one selected from 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), Alq_3, BAlq, 3-(biphenyl-4-yl)-5-(4-tert-butylphenyl)-4-phenyl-4H-1,2,4-triazole (TAZ), and NTAZ:



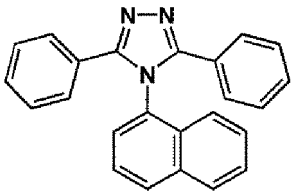
Alq_3



BAlq



TAZ



NTAZ

[0154] Thicknesses of the buffer layer, the hole blocking layer, and the electron control layer may each be in a range of about 20 Å to about 1,000 Å, for example, about 20 Å to about 700 Å, about 20 Å to about 500 Å, about 20 Å to about 400 Å, about 30 Å to about 400 Å or about 30 Å to about 300 Å. When the thicknesses of the buffer layer, the hole blocking layer, and the electron control layer are each within these ranges, the hole blocking layer and/or the electron control layer may have excellent hole blocking characteristics and/or electron control characteristics without a substantial increase in driving voltage.

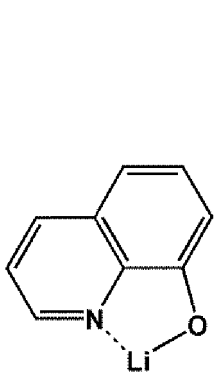
[0155] A thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, for example, about 100 Å to about 700 Å, about 100 Å to about 600 Å, about 150 Å to about 600 Å, about 150 Å to about 500 Å or about 150 Å to about 250 Å. When the thickness of the electron transport layer is within the range described herein above, the electron transport layer may have suitable or satisfactory electron transport characteristics without a substantial increase in driving voltage.

[0156] The electron transport region (for example, the electron transport layer in the electron transport region) may further include, in addition to the materials described herein above, a metal-containing material.

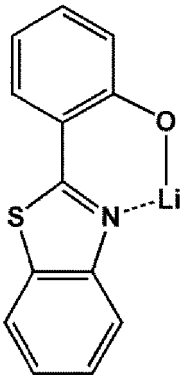
[0157] The metal-containing material may include at least one selected from an alkali metal complex and an alkaline earth-metal complex. The alkali metal complex may include a metal ion selected from a Li ion, a Na ion, a K ion, a Rb ion, and a Cs ion, and the alkaline earth-metal complex may include a metal ion selected from a Be ion, a Mg ion, a Ca ion, a Sr ion, and a Ba ion. A ligand coordinated with the metal ion of the alkali metal complex or the alkaline earth-metal complex may be selected from a hydroxy quinoline, a hydroxy isoquinoline, a hydroxy benzoquinoline, a hydroxy acridine, a hydroxy phenanthridine, a hydroxy phenyloxazole, a hydroxy phenylthiazole, a hydroxy diphenyloxadiazole, a hydroxy

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

[0158] For example, the metal-containing material may include a Li complex. The Li complex may include, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2:



ET-D1



ET-D2

[0159] The electron transport region may include an electron injection layer that facilitates electron injection from the second electrode 190. The electron injection layer may directly contact the second electrode 190.

[0160] The electron injection layer may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

[0161] The electron injection layer may include an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare earth metal complex, or any combination thereof.

[0162] The alkali metal may be selected from Li, Na, K, Rb, and Cs. In one embodiment, the alkali metal may be Li, Na, or Cs. In one or more embodiments, the alkali metal may be Li or Cs, but embodiments of the present disclosure are not limited thereto.

[0163] The alkaline earth metal may be selected from Mg, Ca, Sr, and Ba.

[0164] The rare earth metal may be selected from Sc, Y, Ce, Tb, Yb, and Gd.

[0165] The alkali metal compound, the alkaline earth-metal compound, and the rare earth metal compound may be selected from oxides and halides (for example, fluorides, chlorides, bromides, or iodides) of the alkali metal, the alkaline earth-metal, and the rare earth metal.

[0166] The alkali metal compound may be selected from alkali metal oxides, such as Li_2O, Cs_2O, and/or K_2O, and alkali metal halides, such as LiF, NaF, CsF, KF, LiI, NaI, CsI, and/or KI. In one embodiment, the alkali metal compound may be selected from LiF, Li_2O, NaF, LiI, NaI, CsI, and KI, but embodiments of the present disclosure are not limited thereto.

[0167] The alkaline earth-metal compound may be selected from alkaline earth-metal oxides, such as BaO, SrO, CaO, $Ba_xSr_{1-x}O$ ($0<x<1$), and/or $Ba_xCa_{1-x}O$ ($0<x<1$). In one embodiment, the alkaline earth-metal compound may be selected from BaO, SrO, and CaO, but embodiments of the present disclosure are not limited thereto.

[0168] The rare earth metal compound may be selected from YbF_3, ScF_3, Sc_2O_3, Y_2O_3, Ce_2O_3, GdF_3, and TbF_3. In one embodiment, the rare earth metal compound may be selected from YbF_3, ScF_3, TbF_3, YbI_3, ScI_3, and TbI_3, but embodiments of the present disclosure are not limited thereto.

[0169] The alkali metal complex, the alkaline earth-metal complex, and the rare earth metal complex may include an ion of alkali metal, alkaline earth-metal, and rare earth metal as described herein above, and a ligand coordinated with the metal ion of the alkali metal complex, the alkaline earth-metal complex, or the rare earth metal complex may be selected from hydroxy quinoline, hydroxy isoquinoline, hydroxy benzoquinoline, hydroxy acridine, hydroxy phenanthridine, hydroxy phenyloxazole, hydroxy phenylthiazole, hydroxy diphenyloxadiazole, hydroxy diphenylthiadiazole, hydroxy phenylpyridine, hydroxy phenylbenzimidazole, hydroxy phenylbenzothiazole, bipyridine, phenanthroline, and cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

[0170] The electron injection layer may include (e.g., consist of) an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare earth metal complex, or any combination thereof, as described herein above. In one or more embodiments, the electron injection layer may further include an organic material. When the electron injection layer further includes an organic material, an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare earth metal compound, an alkali metal complex,

an alkaline earth-metal complex, a rare earth metal complex, or any combination thereof may be homogeneously or non-homogeneously dispersed in a matrix including the organic material.

[0171] A thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, for example, about 3 Å to about 90 Å or about 3 Å to about 20 Å. When the thickness of the electron injection layer is within the range described herein above, the electron injection layer may have suitable or satisfactory electron injection characteristics without a substantial increase in driving voltage.

Second electrode 190

[0172] The second electrode 190 may be on the organic layer 150 having such a structure. The second electrode 190 may be a cathode which is an electron injection electrode, and in this regard, a material for forming the second electrode 190 may be selected from metal, an alloy, an electrically conductive compound, and a combination thereof, which have a relatively low work function.

[0173] The second electrode 190 may include at least one selected from lithium (Li), silver (Ag), magnesium (Mg), aluminium (Al), aluminium-lithium (Al-Li), calcium (Ca), magnesium-indium (Mg-In), magnesium-silver (Mg-Ag), ITO, and IZO, but embodiments of the present disclosure are not limited thereto. The second electrode 190 may be a transmissive electrode, a semi-transmissive electrode, or a reflective electrode.

[0174] The second electrode 190 may have a single-layered structure, or a multi-layered structure including two or more layers.

Description of FIGS. 2 to 4

[0175] FIG. 2 is a schematic view of an organic light-emitting device 20 according to an embodiment of the present disclosure. The organic light-emitting device 20 includes a first capping layer 210, the first electrode 110, the organic layer 150, and the second electrode 190, which are sequentially stacked in this stated order. FIG. 3 is a schematic view of an organic light-emitting device 30 according to an embodiment of the present disclosure. The organic light-emitting device 30 includes the first electrode 110, the organic layer 150, the second electrode 190, and a second capping layer 220, which are sequentially stacked in this stated order. FIG. 4 is a schematic view of an organic light-emitting device 40 according to an embodiment of the present disclosure. The organic light-emitting device 40 includes the first capping layer 210, the first electrode 110, the organic layer 150, the second electrode 190, and the second capping layer 220, which are sequentially stacked in this stated order.

[0176] Regarding FIGS. 2 to 4, the first electrode 110, the organic layer 150, and the second electrode 190 may be understood by referring to the descriptions presented in connection with FIG. 1.

[0177] 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 and the first capping layer 210 toward the outside, wherein the first electrode 110 may be a semi-transmissive electrode or a transmissive electrode. 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 and the second capping layer 220 toward the outside, wherein the second electrode 190 may be a semi-transmissive electrode or a transmissive electrode.

[0178] The first capping layer 210 and the second capping layer 220 may increase external luminescence efficiency according to the principle of constructive interference.

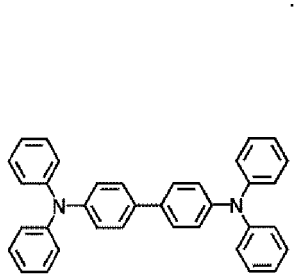
[0179] The first capping layer 210 and the second capping layer 220 may each independently be an organic capping layer including an organic material, an inorganic capping layer including an inorganic material, or a composite capping layer including an organic material and an inorganic material.

[0180] At least one selected from the first capping layer 210 and the second capping layer 220 may each independently include at least one material selected from carbocyclic compounds, heterocyclic compounds, amine-based compounds, porphyrin derivatives, phthalocyanine derivatives, a naphthalocyanine derivatives, alkali metal complexes, and alkaline earth-metal complexes. The carbocyclic compound, the heterocyclic compound, and the amine-based compound may be optionally substituted with a substituent containing at least one element selected from O, N, S, Se, Si, F, Cl, Br, and I.

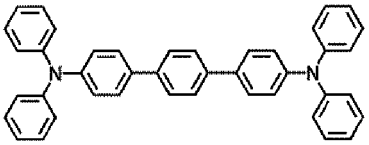
[0181] In one embodiment, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently include an amine-based compound.

[0182] In one embodiment, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently include the compound represented by Formula 201 or the compound represented by Formula 202.

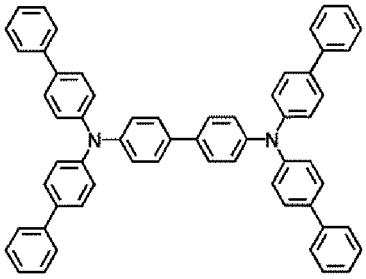
[0183] In one or more embodiments, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently include a compound selected from Compounds HT28 to HT33 and Compounds CP1 to CP5, but embodiments of the present disclosure are not limited thereto:



CP1



CP2



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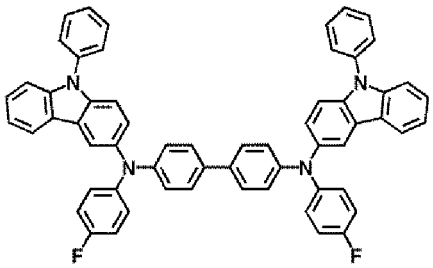

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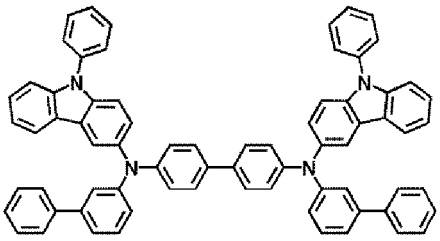


CP5

[0184] Hereinbefore, the organic light-emitting device according to an embodiment of the present disclosure has been described in connection with FIGS. 1 to 4, but embodiments of the present disclosure are not limited thereto.

[0185] The layers constituting the hole transport region, the emission layer, and the layers constituting the electron transport region may be formed in a certain (set or predetermined) region using one or more suitable methods selected from vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, ink-jet printing, laser-printing, and laser-induced thermal imaging.

[0186] When the layers constituting the hole transport region, the emission layer, and the layers constituting the electron transport region are formed by vacuum deposition, the deposition may be performed at a deposition temperature of about 100 °C to about 500 °C, a vacuum degree of about 10^{-8} torr to about 10^{-3} torr, and a deposition speed of about 0.01 Å/sec to about 100 Å/sec by taking into account a material to be included in a layer to be formed, and the structure of a layer to be formed.

[0187] When the layers constituting the hole transport region, the emission layer, and the layers constituting the electron transport region are formed by spin coating, the spin coating may be performed at a coating speed of about 2,000 rpm to about 5,000 rpm and at a heat treatment temperature of about 80 °C to 200 °C by taking into account a material to be included in a layer to be formed, and the structure of a layer to be formed.

General definition of at least some of the substituents

[0188] The term "C_1-C_{60} alkyl group," as used herein, refers to a linear or branched aliphatic saturated hydrocarbon monovalent group having 1 to 60 carbon atoms, and non-limiting examples thereof include a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an isoamyl group, and a hexyl group. The term "C_1-C_{60} alkylene group," as used herein, refers to a divalent group having substantially the same structure as the C_1-C_{60} alkyl group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkyl/alkylene group.

[0189] The term "C_2-C_{60} alkenyl group," as used herein, refers to a hydrocarbon group having at least one carbon-carbon double bond at a main chain (e.g., in the middle) or at a terminal end (e.g., the terminus) of the C_2-C_{60} alkyl group, and non-limiting examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term "C_2-C_{60} alkenylene group," as used herein, refers to a divalent group having substantially the same structure as the C_2-C_{60} alkenyl group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkenyl/alkenylene group.

[0190] The term "C_2-C_{60} alkynyl group," as used herein, refers to a hydrocarbon group having at least one carbon-carbon triple bond at a main chain (e.g., in the middle) or at a terminal end (e.g., the terminus) of the C_2-C_{60} alkyl group, and non-limiting examples thereof include an ethynyl group, and a propynyl group. The term "C_2-C_{60} alkynylene group," as used herein, refers to a divalent group having substantially the same structure as the C_2-C_{60} alkynyl group. Corresponding definitions apply to other ranges given for the number of carbon atoms in an alkynyl/alkynylene group.

[0191] The term "C_1-C_{60} alkoxy group," as used herein, refers to a monovalent group represented by -OA_{101} (wherein A_{101} is a C_1-C_{60} alkyl group), and non-limiting examples thereof include a methoxy group, an ethoxy group, and an isopropyloxy group.

[0192] The term "C_3-C_{10} cycloalkyl group," as used herein, refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and non-limiting examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term "C_3-C_{10} cycloalkylene group," as used herein, refers to a divalent group having substantially the same structure as the C_3-C_{10} cycloalkyl group.

[0193] The term "C_1-C_{10} heterocycloalkyl group," as used herein, refers to a monovalent monocyclic group having at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom and 1 to 10 carbon atoms, and non-limiting examples thereof include a 1,2,3,4-oxatriazolidinyl group, a tetrahydrofuranyl group, and a tetrahydrothiophenyl group. The term "C_1-C_{10} heterocycloalkylene group," as used herein, refers to a divalent group having substantially the same structure as the C_1-C_{10} heterocycloalkyl group.

[0194] The term "C_3-C_{10} cycloalkenyl group," as used herein, refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one carbon-carbon double bond in the ring thereof and no aromaticity (e.g., is not aromatic), and non-limiting examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term "C_3-C_{10} cycloalkenylene group," as used herein, refers to a divalent group having substantially the same structure as the C_3-C_{10} cycloalkenyl group.

[0195] The term "C_1-C_{10} heterocycloalkenyl group," as used herein, refers to a monovalent monocyclic group that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, 1 to 10 carbon atoms, and at least one carbon-carbon double bond in its ring. Non-limiting examples of the C_1-C_{10} heterocycloalkenyl group include a 4,5-dihydro-1,2,3,4-oxatriazolyl group, a 2,3-dihydrofuranyl group, and a 2,3-dihydrothiophenyl group. The term "C_1-C_{10} heterocycloalkenylene group," as used herein, refers to a divalent group having substantially the same structure as the C_1-C_{10} heterocycloalkenyl group.

[0196] The term "C_6-C_{60} aryl group," as 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. Non-limiting examples of the C_6-C_{60} aryl group include a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C_6-C_{60} aryl group and the C_6-C_{60} arylene group each include two or more rings, the rings may be fused to each other (e.g., combined together). Corresponding definitions apply to other ranges given for the number of carbon atoms in an aryl/arylene group.

[0197] The term "C_1-C_{60} heteroaryl group," as used herein, refers to a monovalent group having a carbocyclic aromatic system that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 60 carbon atoms. The term "C_1-C_{60} heteroarylene group," as used herein, refers to a divalent group having a carbocyclic aromatic system that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 60 carbon atoms. Non-limiting examples of the C_1-C_{60} heteroaryl group include a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_1-C_{60} heteroaryl group and the C_1-C_{60} heteroarylene group each include two or more rings, the rings may be condensed with each other (e.g., combined together). Corresponding definitions apply to other ranges given for the number of carbon atoms in an heteroaryl/heteroarylene group.

[0198] The term "C_6-C_{60} aryloxy group," as used herein, refers to -OA_{102} (wherein A_{102} is a C_6-C_{60} aryl group), and the term "C_6-C_{60} arylthio group," as used herein, refers to -SA_{103} (wherein A_{103} is a C_6-C_{60} aryl group). Corresponding definitions apply to other ranges given for the number of carbon atoms in an aryloxy group and an arylthio group.

[0199] The term "monovalent non-aromatic condensed polycyclic group," as used herein, refers to a monovalent group (for example, having 8 to 60 carbon atoms) having two or more rings condensed with each other (e.g., combined together), only carbon atoms as ring-forming atoms, and no aromaticity in its entire molecular structure (e.g., the entire molecular structure is not aromatic). A non-limiting example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. The term "divalent non-aromatic condensed polycyclic group," as used herein, refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed polycyclic group.

[0200] The term "monovalent non-aromatic condensed heteropolycyclic group," as used herein, refers to a monovalent group (for example, having 1 to 60 carbon atoms) having two or more rings condensed to each other (e.g., combined together), at least one heteroatom selected from N, O, Si, P, and S, other than carbon atoms, as a ring-forming atom, and no aromaticity in its entire molecular structure (e.g., the entire molecular structure is not aromatic). A non-limiting example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. The term "divalent non-aromatic condensed heteropolycyclic group," as used herein, refers to a divalent group having substantially the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0201] The term "C_5-C_{60} carbocyclic group," as used herein, refers to a monocyclic or polycyclic group having 5 to 60 carbon atoms in which a ring-forming atom is a carbon atom only. The term "C_5-C_{60} carbocyclic group," as used herein, refers to an aromatic carbocyclic group or a non-aromatic carbocyclic group. The C_5-C_{60} carbocyclic group may be a

ring, such as benzene, a monovalent group, such as a phenyl group, or a divalent group, such as a phenylene group. In one or more embodiments, depending on the number of substituents connected to the C_5-C_{60} carbocyclic group, the C_5-C_{60} carbocyclic group may be a trivalent group or a quadrivalent group. Corresponding definitions apply to other ranges given for the number of carbon atoms in a carbocyclic group.

[0202] The term "C_1-C_{60} heterocyclic group," as used herein, refers to a group having substantially the same structure as the C_5-C_{60} carbocyclic group, except that at least one heteroatom selected from N, O, Si, P, and S is used as a ring-forming atom, in addition to carbon (the number of carbon atoms may be 1 to 60). Corresponding definitions apply to other ranges given for the number of carbon atoms in a heterocyclic group.

[0203] In the specification, at least one substituent of the substituted C_5-C_{60} (*e.g.* C_5-C_{30}) carbocyclic group, the substituted C_1-C_{60} (*e.g.* C_1-C_{20}) heterocyclic group, the substituted C_3-C_{10} cycloalkylene group, the substituted C_1-C_{10} heterocycloalkylene group, the substituted C_3-C_{10} cycloalkenylene group, the substituted C_1-C_{10} heterocycloalkenylene group, the substituted C_6-C_{60} (*e.g.* C_6-C_{30}) arylene group, the substituted C_1-C_{60} (*e.g.* C_1-C_{20}) heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C_1-C_{60} (*e.g.* C_1-C_{20}) alkyl group, the substituted C_2-C_{60} (*e.g.* C_2-C_{20}) alkenyl group, the substituted C_2-C_{60} (*e.g.* C_2-C_{20}) alkynyl group, the substituted C_1-C_{60} (*e.g.* C_1-C_{20}) alkoxy group, the substituted C_3-C_{10} cycloalkyl group, the substituted C_1-C_{10} heterocycloalkyl group, the substituted C_3-C_{10} cycloalkenyl group, the substituted C_1-C_{10} heterocycloalkenyl group, the substituted C_6-C_{60} (*e.g.* C_6-C_{30}) aryl group, the substituted C_6-C_{60} (*e.g.* C_6-C_{30}) aryloxy group, the substituted C_6-C_{60} (*e.g.* C_6-C_{30}) arylthio group, the substituted C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may each independently be selected from:

deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} (*e.g.* C_1-C_{20}) alkyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkenyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkynyl group, and a C1-C60 (*e.g.* C_1-C_{20}) alkoxy group;

a C_1-C_{60} (*e.g.* C_1-C_{20}) alkyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkenyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkynyl group, and a C_1-C_{60} (*e.g.* C_1-C_{20}) alkoxy group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryloxy group, a C_6-C_{60} (*e.g.* C_6-C_{30}) arylthio group, a C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_{11})(Q_{12})(Q_{13})$, $-N(Q_{11})(Q_{12})$, $-B(Q_{11})(Q_{12})$, $-C(=O)(Q_{11})$, $-S(=O)_2(Q_{11})$, and $-P(=O)(Q_{11})(Q_{12})$;

a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryloxy group, a C_6-C_{60} (*e.g.* C_6-C_{30}) arylthio group, a C_1-C_{60} (*e.g.* C_1-C_{20}) 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} (*e.g.* C_6-C_{30}) aryl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryloxy group, a C_6-C_{60} (*e.g.* C_6-C_{30}) arylthio group, a C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} (*e.g.* C_1-C_{20}) alkyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkenyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkynyl group, a C_1-C_{60} (*e.g.* C_1-C_{20}) alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryloxy group, a C_6-C_{60} (*e.g.* C_6-C_{30}) arylthio group, a C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_{21})(Q_{22})(Q_{23})$, $-N(Q_{21})(Q_{22})$, $-B(Q_{21})(Q_{22})$, $-C(=O)(Q_{21})$, $-S(=O)_2(Q_{21})$, and $-P(=O)(Q_{21})(Q_{22})$; and

$-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$, and $-P(=O)(Q_{31})(Q_{32})$, and

Q_{11} to Q_{13}, Q_{21} to Q_{23}, and Q_{31} to Q_{33} may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} (*e.g.* C_1-C_{20}) alkyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkenyl group, a C_2-C_{60} (*e.g.* C_2-C_{20}) alkynyl group, a C1-C60 (*e.g.* C_1-C_{20}) alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} (*e.g.* C_6-C_{30}) aryl group, a C_1-C_{60} (*e.g.* C_1-C_{20}) heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group.

[0204] The term "Ph," as used herein, refers to a phenyl group, the term "Me," as used herein, refers to a methyl group, the term "Et," as used herein, refers to an ethyl group, the terms "ter-Bu" and "Bu^t," as used herein, refer to a tert-butyl

group, and the term "OMe," as used herein, refers to a methoxy group.

[0205] The term "biphenyl group," as used herein, refers to "a phenyl group substituted with a phenyl group." For example, the "biphenyl group" is a substituted phenyl group having a C_6-C_{60} aryl group as a substituent.

[0206] The term "terphenyl group," as used herein, refers to "a phenyl group substituted with a biphenyl group." For example, the "terphenyl group" is a phenyl group having, as a substituent, a C_6-C_{60} aryl group substituted with a C_6-C_{60} aryl group.

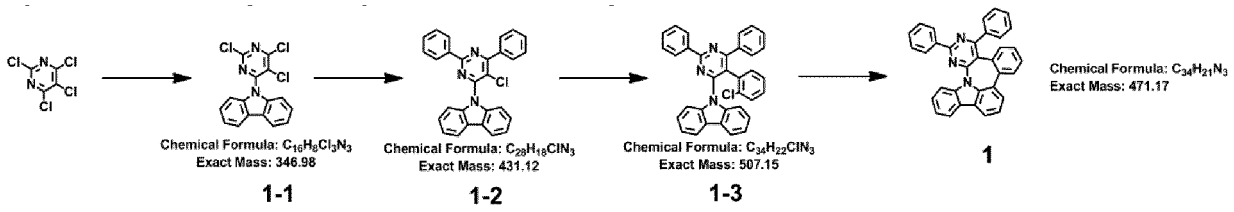
[0207] * and *', as used herein, unless defined otherwise, each refer to a binding site to a neighboring atom in a corresponding formula.

[0208] Hereinafter, compounds according to embodiments of the present disclosure and organic light-emitting devices according to embodiments of the present disclosure will be described in more detail with reference to Synthesis Examples and Examples. The wording "B was used instead of A" used in describing Synthesis Examples indicates that an identical molar equivalent of B was used in place of A.

Examples

Synthesis Example 1: Synthesis of Compound 1

[0209]



Synthesis of Intermediate 1-1

[0210] Carbazole was reacted with nBuLi and then was reacted with perchloropyrimidine to obtain Intermediate 1-1. Intermediate 1-1 was identified by LC/MS. $C_{16}H_8Cl_3N_3$ M+1: 347.72.

Synthesis of Intermediate 1-2

[0211] Intermediate 1-1 and phenyl boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 1-2. Intermediate 1-2 was identified by LC/MS. $C_{28}H_{18}ClN_3$ M+1: 432.21.

Synthesis of Intermediate 1-3

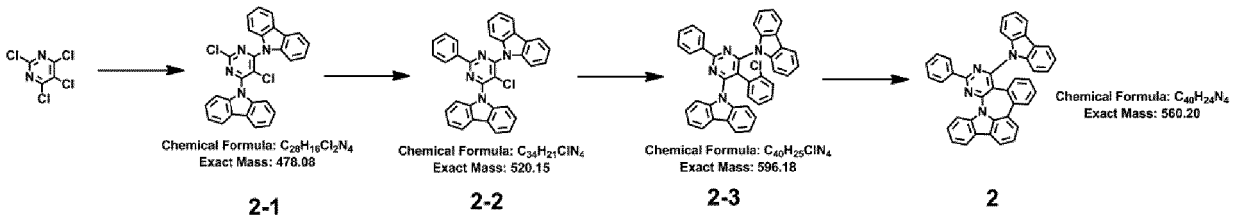
[0212] Intermediate 1-2 and 2-chlorophenyl boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 1-3. Intermediate 1-3 was identified by LC/MS. $C_{34}H_{22}ClN_3$ M+1: 508.17.

Synthesis of Compound 1

[0213] 2.8 g of Intermediate 1-3 was added to a reaction container, and 0.05 g of $Pd(OAc)_2$, 0.13 g of $Pd(tBu)_3HBF_4$, 4.5 g of Cs_2CO_3, and 30 mL of dimethylacetamide (DMA) were added dropwise thereto. The reaction temperature was raised to a temperature of 180 °C and the reaction mixture was refluxed for 12 hours. After the reaction was believed to be completed, the reaction solution was extracted therefrom by using ethyl acetate, and an organic layer was collected therefrom. The collected organic layer was dried utilizing magnesium sulfate, and a solvent was evaporated therefrom to obtain a residue. The residue was separated and purified by silica gel column chromatography to obtain 1.43 g (yield: 55 %) of Compound 1. Compound 1 was identified by LC-MS and ^{1}H-NMR.

Synthesis Example 2: Synthesis of Compound 2

[0214]



Synthesis of Intermediate 2-1

[0215] Carbazole was reacted with nBuLi and then was reacted with perchloropyrimidine to obtain Intermediate 2-1. Intermediate 2-1 was identified by LC/MS. $C_{28}H_{16}Cl_2N_4$ M+1: 479.12.

Synthesis of Intermediate 2-2

[0216] Intermediate 2-1 and phenyl boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 2-2. Intermediate 2-2 was identified by LC/MS. $C_{34}H_{21}ClN_4$ M+1: 521.13.

Synthesis of Intermediate 2-3

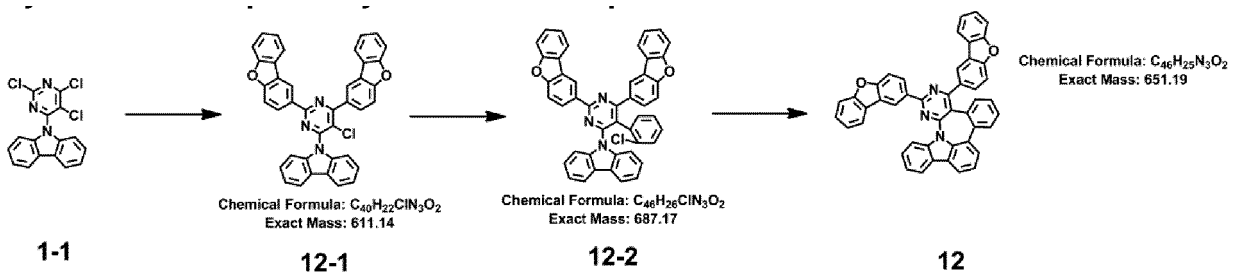
[0217] Intermediate 2-2 and 2-chlorophenyl boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 2-3. Intermediate 2-3 was identified by LC/MS. $C_{40}H_{25}ClN_4$ M+1: 597.23.

Synthesis of Compound 2

[0218] 3.1 g of Intermediate 2-3 was added to a reaction container, and 0.047 g of $Pd(OAc)_2$, 0.12 g of $Pd(tBu)_3HBF_4$, 4.2 g of Cs_2CO_3, and 30 mL of DMA were added dropwise thereto. The reaction temperature was raised to a temperature of 180 °C and the reaction mixture was refluxed for 12 hours. After the reaction was believed to be completed, the reaction solution was extracted therefrom by using ethyl acetate, and an organic layer was collected therefrom. The collected organic layer was dried utilizing magnesium sulfate, and a solvent was evaporated therefrom to obtain a residue. The residue was separated and purified by silica gel column chromatography to obtain 1.22 g (yield: 42 %) of Compound 2. Compound 2 was identified by LC-MS and ^{1}H -NMR.

Synthesis Example 3: Synthesis of Compound 12

[0219]



Synthesis of Intermediate 12-1

[0220] Intermediate 1-1 and dibenzofuran-2-boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 12-1. Intermediate 12-1 was identified by LC/MS. $C_{40}H_{22}ClN_3O_2$ M+1: 612.15.

Synthesis of Intermediate 12-2

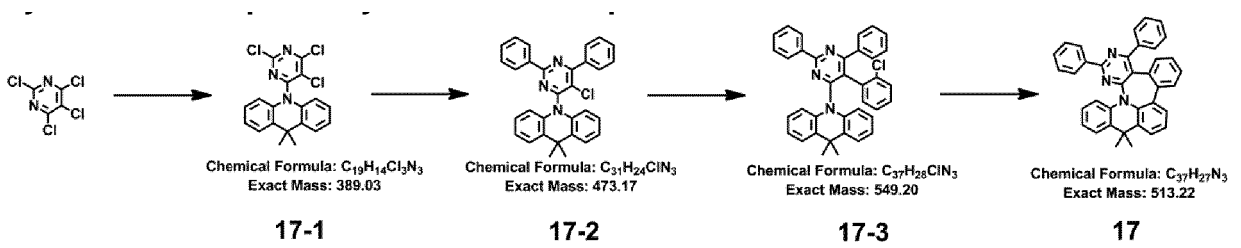
[0221] Intermediate 12-1 and 2-chlorophenyl boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 12-2. Intermediate 12-2 was identified by LC/MS. $C_{46}H_{26}ClN_3O_2$ M+1: 688.15.

Synthesis of Compound 12

[0222] 2.1 g of Intermediate 12-2 was added to a reaction container, and 0.027 g of $Pd(OAc)_2$, 0.071 g of $Pd(tBu)_3HBF_4$, 2.5 g of Cs_2CO_3, and 20 mL of DMA were added dropwise thereto. The reaction temperature was raised to a temperature of 180 °C and the reaction mixture was refluxed for 12 hours. After the reaction was believed to be completed, the reaction solution was extracted therefrom by using ethyl acetate, and an organic layer was collected therefrom. The collected organic layer was dried utilizing magnesium sulfate, and a solvent was evaporated therefrom to obtain a residue. The residue was separated and purified by silica gel column chromatography to obtain 0.74 g (yield: 37 %) of Compound 12. Compound 12 was identified by LC-MS and ^1H -NMR.

Synthesis Example 4: Synthesis of Compound 17

[0223]



Synthesis of Intermediate 17-1

[0224] 9,9-dimethyl-9,10-dihydroacridine was reacted with nBuLi and then was reacted with perchloropyrimidine to obtain Intermediate 17-1. Intermediate 17-1 was identified by LC/MS. $C_{19}H_{14}Cl_3N_3$ M+1: 390.02.

Synthesis of Intermediate 17-2

[0225] Intermediate 17-1 was reacted with phenyl boronic acid under a Suzuki coupling condition to obtain Intermediate 17-2. Intermediate 17-2 was identified by LC/MS. $C_{31}H_{24}ClN_3$ M+1: 474.18.

Synthesis of Intermediate 17-3

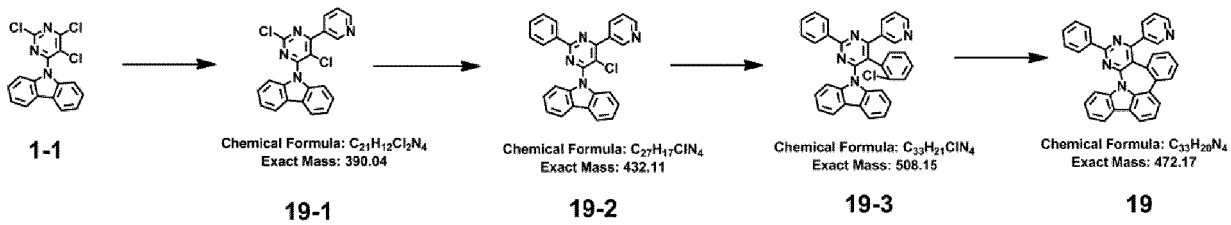
[0226] Intermediate 17-2 and 2-chlorophenyl boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 17-3. Intermediate 17-3 was identified by LC/MS. $C_{37}H_{28}ClN_3$ M+1: 550.21.

Synthesis of Compound 17

[0227] 4.1 g of Intermediate 17-3 was added to a reaction container, and 0.067 g of $Pd(OAc)_2$, 0.17 g of $Pd(tBu)_3HBF_4$, 6 g of Cs_2CO_3, and 40 mL of DMA were added dropwise thereto. The reaction temperature was raised to a temperature of 180 °C and the reaction mixture was refluxed for 12 hours. After the reaction was believed to be completed, the reaction solution was extracted therefrom by using ethyl acetate, and an organic layer was collected therefrom. The collected organic layer was dried utilizing magnesium sulfate, and a solvent was evaporated therefrom to obtain a residue. The residue was separated and purified by silica gel column chromatography to obtain 1.5 g (yield: 39 %) of Compound 17. Compound 17 was identified by LC-MS and ^1H -NMR.

Synthesis Example 5: Synthesis of Compound 19

[0228]



Synthesis of Intermediate 19-1

[0229] Intermediate 1-1 and pyridine-3-boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 19-1. Intermediate 19-1 was identified by LC/MS. $C_{21}H_{12}Cl_2N_4$ M+1: 391.03.

Synthesis of Intermediate 19-2

[0230] Intermediate 19-1 and phenylboronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 19-2. Intermediate 19-2 was identified by LC/MS. $C_{27}H_{17}ClN_4$ M+1: 433.12.

Synthesis of Intermediate 19-3

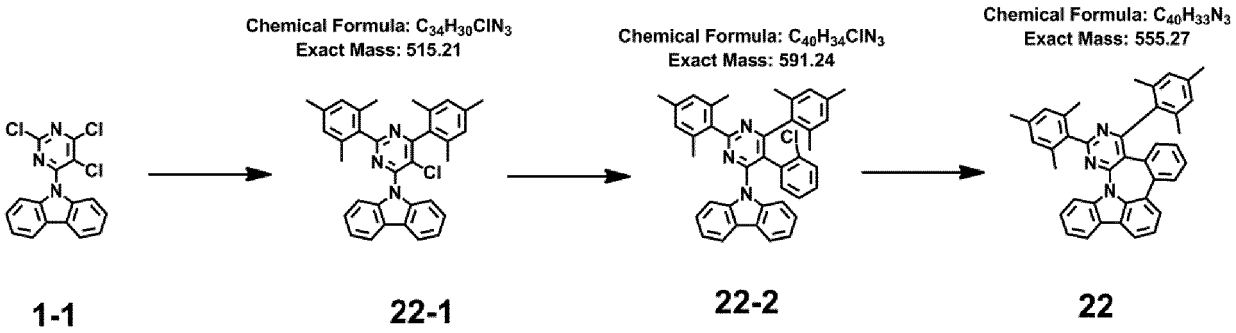
[0231] Intermediate 19-2 and 2-chlorophenyl boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 19-3. Intermediate 19-3 was identified by LC/MS. $C_{33}H_{21}ClN_4$ M+1: 508.15.

Synthesis of Compound 19

[0232] 4.3 g of Intermediate 19-3 was added to a reaction container, and 0.089 g of $Pd(OAc)_2$, 0.23 g of $Pd(tBu)_3HBF_4$, 8.1 g of Cs_2CO_3, and 50 mL of DMA were added dropwise thereto. The reaction temperature was raised to a temperature of 180 °C and the reaction mixture was refluxed for 12 hours. After the reaction was believed to be completed, the reaction solution was extracted therefrom by using ethyl acetate, and an organic layer was collected therefrom. The collected organic layer was dried utilizing magnesium sulfate, and a solvent was evaporated therefrom to obtain a residue. The residue was separated and purified by silica gel column chromatography to obtain 2.2 g (yield: 46 %) of Compound 19. Compound 19 was identified by LC-MS and ^{1}H -NMR.

Synthesis Example 6: Synthesis of Compound 22

[0233]



Synthesis of Intermediate 22-1

[0234] Intermediate 1-1 and mesitylboronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 22-1. Intermediate 22-1 was identified by LC/MS. $C_{34}H_{30}ClN_3$ M+1: 516.22.

Synthesis of Intermediate 22-2

[0235] Intermediate 22-1 and 2-chlorophenyl boronic acid were reacted with each other under a Suzuki coupling

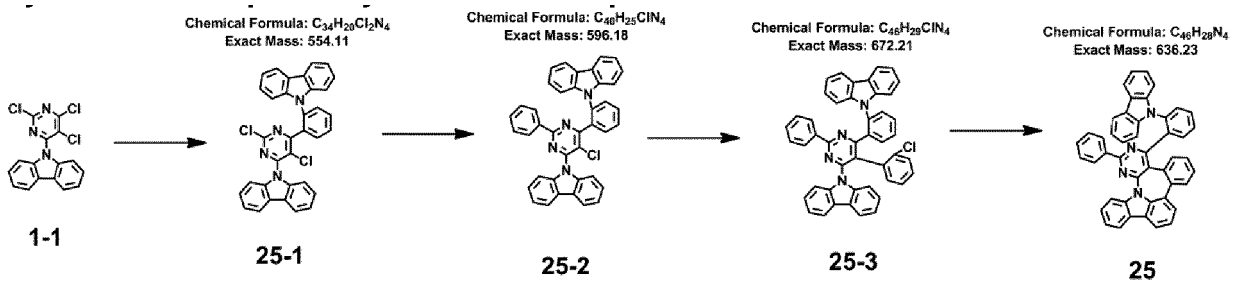
condition to obtain Intermediate 22-2. Intermediate 22-2 was identified by LC/MS. $C_{40}H_{34}ClN_3$ M+1: 592.31.

Synthesis of Compound 22

[0236] 2.3 g of Intermediate 22-2 was added to a reaction container, and 0.034 g of $Pd(OAc)_2$, 0.090 g of $Pd(tBu)_3HBF_4$, 3.17 g of Cs_2CO_3, and 20 mL of DMA were added dropwise thereto. The reaction temperature was raised to a temperature of 180 °C and the reaction mixture was refluxed for 12 hours. After the reaction was believed to be completed, the reaction solution was extracted therefrom by using ethyl acetate, and an organic layer was collected therefrom. The collected organic layer was dried utilizing magnesium sulfate, and a solvent was evaporated therefrom to obtain a residue. The residue was separated and purified by silica gel column chromatography to obtain 0.67 g (yield: 31 %) of Compound 22. Compound 22 was identified by LC-MS and ^{1}H -NMR.

Synthesis Example 7: Synthesis of Compound 25

[0237]



Synthesis of Intermediate 25-1

[0238] Intermediate 1-1 and (2-(9H-carbazol-9-yl)phenyl)boronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 25-1. Intermediate 25-1 was identified by LC/MS. $C_{34}H_{20}Cl_2N_4$ M+1: 555.22.

Synthesis of Intermediate 25-2

[0239] Intermediate 25-1 and phenylboronic acid reacted were with each other under a Suzuki coupling condition to obtain Intermediate 25-2. Intermediate 25-2 was identified by LC/MS. $C_{40}H_{25}ClN_4$ M+1: 597.18.

Synthesis of Intermediate 25-3

[0240] Intermediate 25-2 and phenylboronic acid were reacted with each other under a Suzuki coupling condition to obtain Intermediate 25-3. Intermediate 25-3 was identified by LC/MS. $C_{46}H_{29}ClN_4$ M+1: 673.21.

Synthesis of Compound 25

[0241] 2.5 g of Intermediate 25-3 was added to a reaction container, and 0.033 g of $Pd(OAc)_2$, 0.086 g of $Pd(tBu)_3HBF_4$, 3 g of Cs_2CO_3, and 20 mL of DMA were added dropwise thereto. The reaction temperature was raised to a temperature of 180 °C and the reaction mixture was refluxed for 12 hours. After the reaction was believed to be completed, the reaction solution was extracted therefrom by using ethyl acetate, and an organic layer was collected therefrom. The collected organic layer was dried utilizing magnesium sulfate, and a solvent was evaporated therefrom to obtain a residue. The residue was separated and purified by silica gel column chromatography to obtain 0.97 g (yield: 41 %) of Compound 25. Compound 25 was identified by LC-MS and ^{1}H -NMR.

[0242] ^{1}H NMR and MS/FAB of Compounds synthesized according to Synthesis Examples 1 to 7 are shown in Table 1.

[0243] Synthesis methods of compounds other than the Compounds shown in Table 1 may also be easily recognized by those of ordinary skill in the art by referring to the synthesis mechanisms and source materials described herein above.

Table 1

Compound	^{1}H NMR ($CDCl_3$, 400 MHz)	MS/FAB	
		found	calc.
1	8.42 (d, 2H), 8.20-8.10 (m, 4H), 8.12 (t, 2H), 7.80 (m, 2H), 7.72 (m, 2H), 7.75 (d, 1H), 7.52-7.47 (t, 7H), 7.28 (t, 1H), 7.2 (t, 1H)	472.21	471.17
2	8.56 (d, 1H), 8.41 (d, 2H), 7.35 (d, 3H), 8.22-8.17 (d, 3H), 8.11 (t, 2H), 7.93 (d, 1H), 7.70 (d, 1H), 7.58 (d, 2H), 7.53-7.49 (m, 2H), 7.51 (t, 2H), 7.35 (t, 1H), 7.28 (t, 1H), 7.22-7.18 (t, 2H), 7.15 (t, 1H)	561.23	560.20
12	8.42 (d, 2H), 8.18 (d, 1H), 8.09 (t, 2H), 8.02-7.75 (m, 8H), 7.72 (d, 1H), 7.58 (d, 1H), 7.56-7.50 (m, 3H), 7.39-7.28 (m, 5H), 7.18 (t, 1H)	652.17	651.19
17	8.36 (d, 2H), 8.01 (d, 1H), 7.98 (d, 2H), 7.80 (d, 2H), 7.64 (m, 2H), 7.61 (t, 2H), 7.50-7.48 (m, 4H), 7.23 (d, 1H), 7.20-7.12 (m, 4H), 6.94 (t, 1H), 1.68 (s, 6H)	514.25	513.22
19	9.23 (s, 1H), 8.71 (d, 1H), 8.44-8.38 (d, 4H), 8.11 (t, 2H), 7.72 (d, 1H), 7.60-7.55 (m, 2H), 7.49-7.45 (m, 4H), 7.29 (t, 1H), 7.19 (d, 1H)	473.21	472.17
22	8.41 (d, 2H), 8.19 (d, 2H), 8.11 (t, 2H), 7.71 (d, 1H), 7.59 (d, 1H), 7.48 (t, 1H), 7.28 (t, 1H), 7.2 (t, 1H), 7.01 (s, 4H), 2.57 (s, 12H), 2.46 (s, 6H)	556.23	555.27
25	8.54 (d, 1H), 8.42 (d, 2H), 8.22-8.17 (d, 5H), 8.10 (t, 2H), 7.96-7.90 (m, 3H), 7.80 (t, 1H), 7.70 (d, 1H), 7.60-54 (d, 2H), 7.50-7.46 (m, 6H), 7.35 (t, 1H), 7.28 (t, 1H), 7.19 (t, 2H), 7.15 (t, 1H)	637.25	636.23

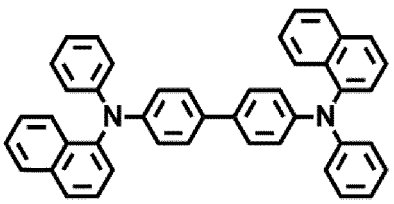
Example 1

[0244] As an anode, a 15 Ω/cm^2 (1,200 Å) ITO glass substrate from Corning was cut to a size of 50 mm x 50 mm x 0.5 mm, sonicated with isopropyl alcohol and pure water each for 5 minutes, and then cleaned by exposure to ultraviolet rays and ozone for 30 minutes. Then, the ITO glass substrate was provided to a vacuum deposition apparatus.

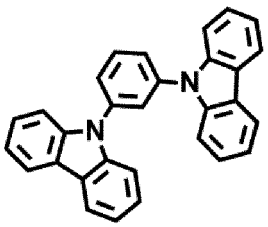
[0245] N,N'-di(1-naphthyl)-N,N'-diphenylbenzidine (NPB) was vacuum-deposited on the ITO glass substrate to form a hole injection layer having a thickness of 300 Å, and a hole transport material mCP was vacuum-deposited on the hole injection layer to form a hole transport layer having a thickness of 200 Å.

[0246] Compound 1 (host) and a phosphorescent dopant PD26 were co-deposited on the hole transport layer to a weight ratio of 92:8 to form an emission layer having a thickness of 250 Å.

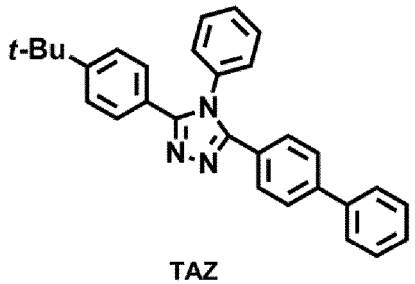
[0247] Then, 3-(4-biphenylyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole (TAZ) was deposited on the emission layer to form an electron transport layer having a thickness of 200 Å, an alkali metal halide LiF was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and Al was vacuum-deposited to a thickness of 100 Å to form a LiF/Al electrode, thereby completing the manufacture of an organic light-emitting device.



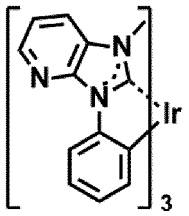
NPB



mCP



TAZ



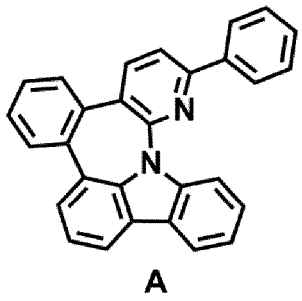
PD26

Examples 2 to 7

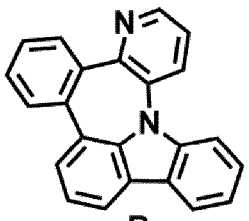
[0248] Organic light-emitting devices were manufactured in substantially the same manner as in Example 1, except that Compounds shown in Table 2 were each used instead of Compound 1 in forming an emission layer.

Comparative Examples 1 to 5

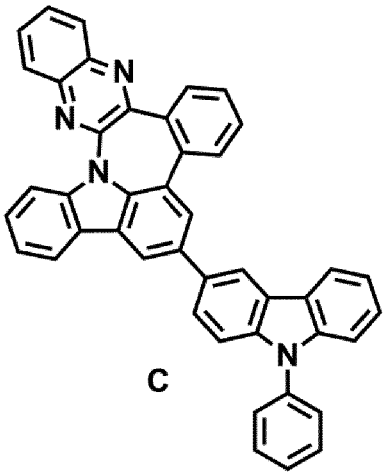
[0249] Organic light-emitting devices were manufactured in substantially the same manner as in Example 1, except that Compounds A to E were each used instead of Compound 1 in forming an emission layer.



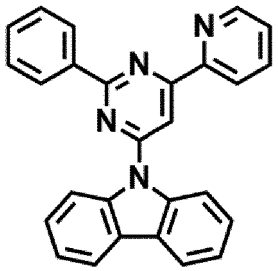
A



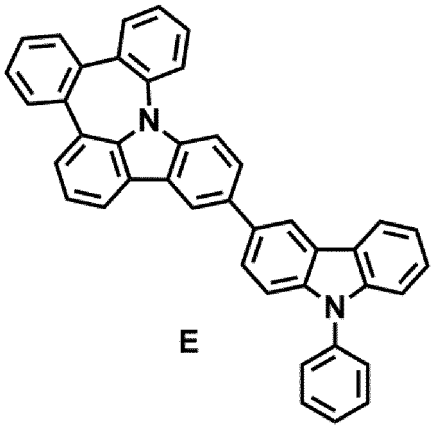
B



C



D



E

Evaluation Example 1

[0250] In order to evaluate characteristics of the organic light-emitting devices manufactured according to Examples 1 to 7 and Comparative Examples 1 to 5, the driving voltage, and maximum quantum efficiency of the organic light-emitting devices were measured at a current density of 10 mA/cm^2. The driving voltage of the organic light-emitting

devices were measured by using a source meter (2400 series, manufactured by Keithley Instrument), and the maximum quantum efficiency of the organic light-emitting devices was measured by using an external quantum efficiency measurement apparatus C9920-2-12 (manufactured by Hamamatsu Photonics Co., Ltd.). In evaluating the maximum quantum efficiency, the luminance and current density were measured by using a luminance meter in which wavelength sensitivity was calibrated, and the maximum quantum efficiency was converted based on the assumption that an angle luminance distribution (Lambertian) having a Lambertian surface. Results of the evaluation of the characteristics of the organic light-emitting devices are shown in Table 2.

Table 2

	Host in emission layer	Driving voltage (V)	Current Density (mA/cm^2)	Maximum quantum efficiency (%)	Emission color
Example 1	Compound 1	3.6	2.3	18.9	blue
Example 2	Compound 2	3.8	2.3	18.2	blue
Example 3	Compound 12	4.1	2.3	17.3	blue
Example 4	Compound 17	4.5	2.3	20.2	blue
Example 5	Compound 19	3.9	2.3	21.3	blue
Example 6	Compound 22	4.1	2.3	19.1	blue
Example 7	Compound 25	4.3	2.3	21.5	blue
Comparative Example 1	A	4.6	2.3	13.3	blue
Com parative Example 2	B	4.7	2.3	12.9	blue
Com parative Example 3	C	4.9	2.3	13.1	blue
Com parative Example 4	D	4.3	2.3	8.9	blue
Com parative Example 5	E	5.1	2.3	14.3	blue

[0251] From Table 2, it can be seen that when one of the compounds according to one or more embodiments is used as the host material of the emission layer, it is possible to obtain an effect that reduces a driving voltage and increases maximum quantum efficiency, as compared with the case in which the compounds of Comparative Examples are used as the host material of the emission layer.

[0252] The organic light-emitting device including the heterocyclic compound may have a low driving voltage, and high maximum quantum efficiency.

[0253] It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should be considered as available for other similar features or aspects in other embodiments.

[0254] It will be understood that, although the terms "first," "second," "third," etc., may be used herein to describe various elements, components, regions, layers and/or sections, these elements, components, regions, layers and/or sections should not be limited by these terms. These terms are used to distinguish one element, component, region, layer or section from another element, component, region, layer or section. Thus, a first element, component, region, layer or section described below could be termed a second element, component, region, layer or section, without departing from the scope of the present disclosure.

[0255] Spatially relative terms, such as "beneath," "below," "lower," "under," "above," "upper," and the like, may be used herein for ease of explanation to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or in operation, in addition to the orientation depicted in the figures. For example, if the device in the figures is turned over, elements described as "below" or "beneath" or "under" other elements or features would then be oriented "above" the other elements or features. Thus, the example terms "below" and "under" can encompass both an orientation of above and below. The device may be otherwise oriented (e.g., rotated 90 degrees or

at other orientations) and the spatially relative descriptors used herein should be interpreted accordingly.

[0256] The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the present disclosure. As used herein, the singular forms "a" and "an" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises," "comprising," "includes," and "including," when used in this specification, specify the presence of the stated features, integers, acts, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, acts, operations, elements, components, and/or groups thereof.

[0257] As used herein, the terms "substantially," "about," and similar terms are used as terms of approximation and not as terms of degree, and are intended to account for the inherent deviations in measured or calculated values that would be recognized by those of ordinary skill in the art. Further, the use of "may" when describing embodiments of the present disclosure refers to "one or more embodiments of the present disclosure." As used herein, the terms "use," "using," and "used" may be considered synonymous with the terms "utilize," "utilizing," and "utilized," respectively.

[0258] Also, any numerical range recited herein is intended to include all subranges of the same numerical precision subsumed within the recited range. For example, a range of "1.0 to 10.0" is intended to include all subranges between (and including) the recited minimum value of 1.0 and the recited maximum value of 10.0, that is, having a minimum value equal to or greater than 1.0 and a maximum value equal to or less than 10.0, such as, for example, 2.4 to 7.6. Any maximum numerical limitation recited herein is intended to include all lower numerical limitations subsumed therein, and any minimum numerical limitation recited in this specification is intended to include all higher numerical limitations subsumed therein.

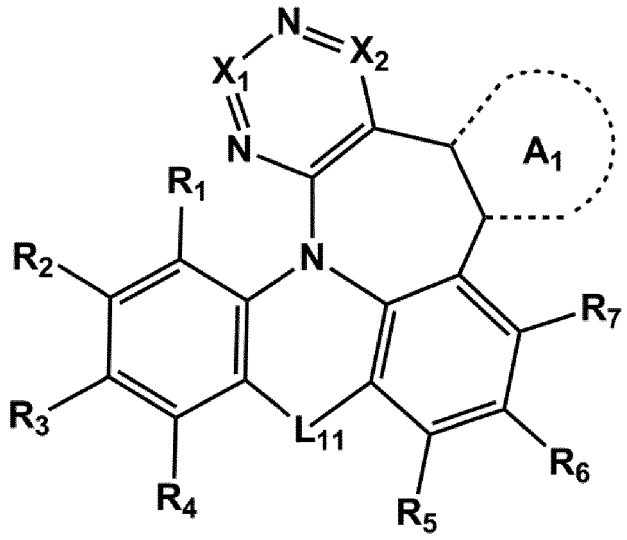
[0259] While one or more embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the scope of the present disclosure as defined by the following claims.

Claims

1. An organic light-emitting device comprising:

a first electrode (110);
a second electrode (190) facing the first electrode (110);
an organic layer (150) between the first electrode (110) and the second electrode (190) and comprising an emission layer; and
at least one of the heterocyclic compound represented by Formula 1:

Formula 1



Formula 2 $*-(L_1)_{a1}-(Ar_1)_{b1}$

wherein, in Formulae 1 and 2,

A_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
X_1 and X_2 are each independently C(Rs) or N,
L_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
a1 is an integer from 0 to 3,
L_{11} is a single bond, *-N(R_9)-*', *-C(R_{10})(R_{11})-*', *-O-*', or *-S-*',
Ar_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
b1 is an integer from 1 to 3,
R_1 to R_{11} are each independently selected from a group represented by Formula 2, hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, a 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 C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, -Si(Q_1)(Q_2)(Q_3), -N(Q_1)(Q_2), -B(Q_1)(Q_2), -S(=O)$_2$(Q_1), and - P(=O)(Q_1)(Q_2),
at least one substituent of the substituted C_5-C_{60} carbocyclic group, the substituted C_1-C_{60} heterocyclic group, the substituted C_1-C_{60} alkyl group, the substituted C_2-C_{60} alkenyl group, the substituted C_2-C_{60} alkynyl group, the substituted C_1-C_{60} alkoxy group, the substituted C_3-C_{10} cycloalkyl group, the substituted C_1-C_{10} heterocycloalkyl group, the substituted C_3-C_{10} cycloalkenyl group, the substituted C_1-C_{10} heterocycloalkenyl group, the substituted C_6-C_{60} aryl group, the substituted C_6-C_{60} aryloxy group, the substituted C_6-C_{60} arylthio group, the substituted C_1-C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from:

deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;
a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C1-C_{60} alkoxy group, each substituted with at least one selected from deuterium, -Cl, -Br, - I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, -Si(Q_{11})(Q_{12})(Q_{13}), -N(Q_{11})(Q_{12}), -B(Q_{11})(Q_{12}), -C(=O)(O_{11}), - S(=O)$_2$(Q_{11}), and -P(=O)(Q_{11})(Q_{12});
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, a biphenyl group, and a terphenyl 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, a biphenyl group, and a terphenyl group, each substituted with at least one selected from deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, a terphenyl group, -Si(Q_{21})(Q_{22})(Q_{23}), -N(Q_{21})(Q_{22}), -B(Q_{21})(Q_{22}), -C(=O)(Q_{21}), - S(=O)$_2$(Q_{21}), and -P(=O)(Q_{21})(Q_{22}); and
-Si(Q_{31})(Q_{32})(Q_{33}), -N(Q_{31})(Q_{32}), -B(Q_{31})(Q_{32}), -C(=O)(Q_{31}), -S(=O)$_2$(Q_{31}), and - P(=O)(Q_{31})(Q_{32}),
Q1 to Q_3, Q_{11} to Q_{13}, Q_{21} to Q_{23}, and Q_{31} to Q_{33} are each independently selected from hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono

group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with a C_1-C_{60} alkyl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, and
* and *' each indicate a binding site to a neighboring atom.

2. An organic light-emitting device according to claim 1, wherein,
the first electrode is an anode,
the second electrode is a cathode,
the organic layer comprises at least one of the heterocyclic compound represented by Formula 1,
the organic layer further comprises a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode,
the hole transport region comprises a hole injection layer, a hole transport layer, an emission auxiliary layer, an electron blocking layer, or any combination thereof, and
the electron transport region comprises a buffer layer, a hole blocking layer, an electron transport layer, an electron control layer, an electron injection layer, or any combination thereof.

3. An organic light-emitting device according to claim 1 or claim 2, wherein,
the emission layer comprises a dopant and a host, and
the host comprises at least one of the heterocyclic compound represented by Formula 1, optionally wherein,
the dopant comprises a phosphorescent dopant.

4. An organic light-emitting device according to claim 1 or claim 2, wherein,
the emission layer comprises a dopant and a host, and
the dopant comprises at least one of the heterocyclic compound.

5. An organic light-emitting device according to claim 4, wherein,
the host further comprises a compound represented by Formula 301:

Formula 301 $[Ar_{301}]_{xb11}$-$[(L_{301})_{xb1}$-$R_{301}]_{xb21}$,

wherein, in Formula 301,

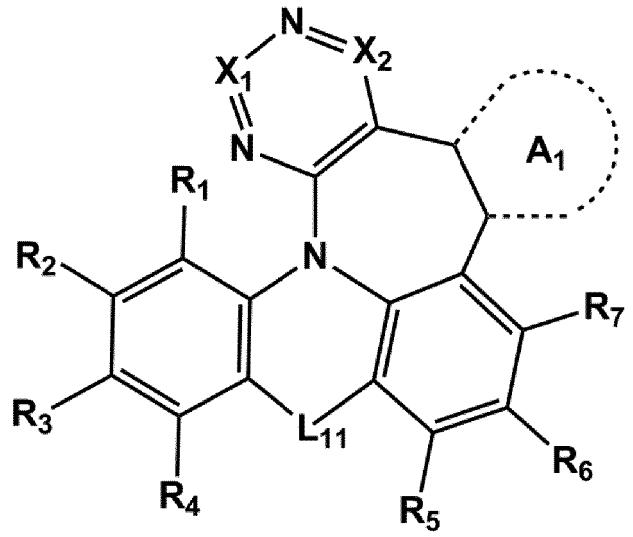
Ar_{301} is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
xb11 is 1, 2, or 3,
L_{301} is selected from a substituted or unsubstituted C_3-C_{10} cycloalkylene group, a substituted or unsubstituted C_1-C_{10} heterocycloalkylene 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,
xb1 is an integer from 0 to 5,
R_{301} is selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1-C_{60} alkyl group, a substituted or unsubstituted C_2-C_{60} alkenyl group, a substituted or unsubstituted C_2-C_{60} alkynyl group, a substituted or unsubstituted C_1-C_{60} alkoxy group, a substituted or unsubstituted C_3-C_{10} cycloalkyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3-C_{10} cycloalkenyl group, a substituted or unsubstituted C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, - $Si(Q_{301})(Q_{302})(Q_{303})$, -$N(Q_{301})(Q_{302})$, -$B(Q_{301})(Q_{302})$, -$C(=O)(Q_{301})$, -$S(=O)_2(Q_{301})$, and -$P(=O)(Q_{301})(Q_{302})$,
xb21 is an integer from 1 to 5, and
Q_{301} to Q_{303} 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, optionally wherein,

the electron transport region comprises an alkali metal, an alkaline earth metal, a rare earth metal, an alkali metal compound, an alkaline earth metal compound, a rare earth metal compound, an alkali metal complex, an alkaline earth metal complex, a rare earth metal complex, or any combination thereof.

6. An organic light-emitting device according to any one of claims 1 to 5, wherein,
the emission layer is a first emission layer configured to emit a first color light,
the organic light-emitting device further comprises, between the first electrode and the second electrode, i) at least one second emission layer configured to emit a second color light or ii) at least one second emission layer configured to emit a second color light and at least one third emission layer configured to emit a third color light,
a maximum emission wavelength of the first color light, a maximum emission wavelength of the second color light, and a maximum emission wavelength of the third color light are identical to or different from each other, and
the first color light and the second color light are emitted in the form of mixed light, or the first color light, the second color light, and the third color light are emitted in the form of mixed light.

7. A heterocyclic compound represented by Formula 1:

Formula 1



Formula 2 $*-(L_1)_{a1}-(Ar_1)_{b1}$,

wherein, in Formulae 1 and 2,

A_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
X_1 and X_2 are each independently $C(R_8)$ or N,
L_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
a1 is an integer from 0 to 3,
L_{11} is a single bond, *-$N(R_9)$-*', *-$C(R_{10})(R_{11})$-*', *-O-*', or *-S-*',
Ar_1 is a substituted or unsubstituted C_5-C_{60} carbocyclic group or a substituted or unsubstituted C_1-C_{60} heterocyclic group,
b1 is an integer from 1 to 3,
R_1 to R_{11} are each independently selected from a group represented by Formula 2, hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, a 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 C_1-C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6-C_{60} aryl group, a substituted or unsubstituted

C_6-C_{60} aryloxy group, a substituted or unsubstituted C_6-C_{60} arylthio group, a substituted or unsubstituted C_1-C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-Si(O_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$, and $-P(=O)(Q_1)(Q_2)$,

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

deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C_1-C_{60} alkoxy group;

a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, and a C1-C_{60} alkoxy group, each substituted with at least one selected from deuterium, -Cl, -Br, - I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_{11})(Q_{12})(Q_{13})$, $-N(Q_{11})(Q_{12})$, $-B(Q_{11})(Q_{12})$, $-C(=O)(O_{11})$, $-S(=O)_2(Q_{11})$, and $-P(=O)(Q_{11})(Q_{12})$;

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, a biphenyl group, and a terphenyl 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, a biphenyl group, and a terphenyl group, each substituted with at least one selected from deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryloxy group, a C_6-C_{60} arylthio group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, a terphenyl group, $-Si(Q_{21})(Q_{22})(Q_{23})$, $-N(Q_{21})(Q_{22})$, $-B(Q_{21})(Q_{22})$, $-C(=O)(Q_{21})$, $-S(=O)_2(Q_{21})$, and $-P(=O)(Q_{21})(Q_{22})$; and $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$, and $-P(=O)(Q_{31})(Q_{32})$,

Q_1 to Q_3, Q_{11} to Q_{13}, Q_{21} to Q_{23}, and Q_{31} to Q_{33} are each independently selected from hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with a C_1-C_{60} alkyl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group, and

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

8. A heterocyclic compound according to claim 7, wherein,

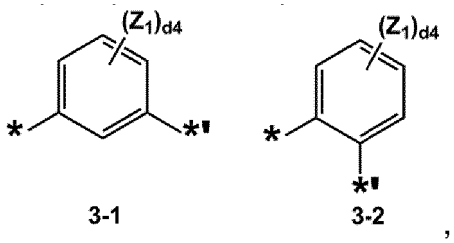
A_1 is selected from a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group;

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group, each substituted with at least one selected from deuterium, - CI, -Br, -I, a hydroxyl group, a cyano group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzofuranyl group, a benzothiophenyl group, -Si(Q_{31})(Q_{32})(Q_{33}), -N(Q_{31})(Q_{32}), and -B(Q_{31})(Q_{32}), and
Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group.

9. A heterocyclic compound according to claim 7 or claim 8, wherein:
X_1 and X_2 are each independently C(Rs); and/orLi is selected from:

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group; and
a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group, each substituted with at least one selected from deuterium, - CI, -Br, -I, a hydroxyl group, a cyano group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzofuranyl group, a benzothiophenyl group, -Si(Q_{31})(Q_{32})(Q_{33}), -N(Q_{31})(Q_{32}), and -B(Q_{31})(Q_{32}), and
Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group.

10. A heterocyclic compound according to any one of claims 7 to 9, wherein,
L_1 is selected from groups represented by Formula 3-1 or 3-2:



3-1 3-2 ,

wherein, in Formulae 3-1 and 3-2,

Z_1 is selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a benzofuranyl group, a benzothiophenyl group, a benzosilolyl group, a dibenzosilolyl group, and $-Si(Q_{31})(Q_{32})(Q_{33})$,
Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group,
d4 is an integer from 0 to 4, and
* and *' each indicate a binding site to a neighboring atom.

11. A heterocyclic compound according to any one of claims 7 to 10, wherein,
L_{11} is a single bond or *-$C(R_{10})(R_{11})$-*', and
R_{10} and R_{11} are each independently selected from:

hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, and a C_1-C_{20} alkyl group; and
a C_1-C_{20} alkyl group substituted with at least one selected from deuterium, -Cl, - Br, -I, a hydroxyl group, and a cyano group.

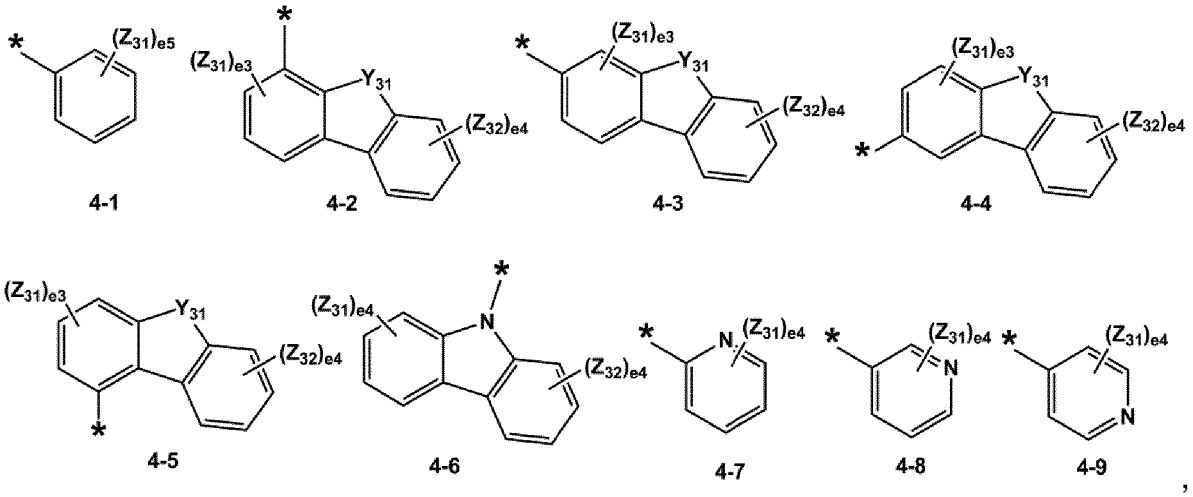
12. A heterocyclic compound according to any one of claims 7 to 11, wherein,
Ar_1 is selected from:

a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group, a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group; and
a benzene group, a pentalene group, an indene group, a naphthalene group, an azulene group, a heptalene group, an indacene group, an acenaphthalene group, a fluorene group, a spiro-bifluorene group, a spiro-benzofluorene-fluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pyrrole group, a thiophene group, a furan group, a silole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a triazine group, a benzofuran group, a benzothiophene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, a benzosilole group,

a dibenzosilole group, a quinoline group, an isoquinoline group, a benzimidazole group, an imidazopyridine group, and an imidazopyrimidine group, each substituted with at least one selected from deuterium, - CI, -Br, -I, a hydroxyl group, a cyano group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a benzofuranyl group, a benzothiophenyl group, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, and $-B(Q_{31})(Q_{32})$, and

Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group.

13. A heterocyclic compound according to any one of claims 7 to 12, wherein,
Ar_1 is represented by one of Formulae 4-1 to 4-9:



,

wherein, in Formulae 4-1 to 4-9,

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, -CI, - Br, -I, a hydroxyl group, a cyano group, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a pyrenyl group, a chrysenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a silolyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a carbazolyl group, a benzosilolyl group, a dibenzosilolyl group, and $-Si(Q_{31})(Q_{32})(Q_{33})$,

Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group,

e3 is an integer from 0 to 3,

e4 is an integer from 0 to 4,

e5 is an integer from 0 to 5, and

* indicates a binding site to a neighboring atom, optionally wherein,

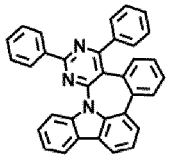
Z_{31} to Z_{37} are each independently selected from hydrogen, a cyano group, a C_1-C_{20} alkyl group, a phenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a carbazolyl group, and $-Si(Q_{31})(Q_{32})(Q_{33})$, and

Q_{31} to Q_{33} are each independently selected from a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and a pyridinyl group.

14. A heterocyclic compound according to any one of claims 7 to 13, wherein:

(A) R_1 to R_{11} are each independently selected from a group represented by Formula 2, hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{20} alkyl group, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$, and $-P(=O)(Q_1)(Q_2)$; and
a C_1-C_{20} alkyl group substituted with at least one selected from deuterium, -Cl, - Br, -I, a hydroxyl group, and a cyano group, and
Q_1 to Q_3 are each independently selected from hydrogen, deuterium, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl group, a C_1-C_{60} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_1-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_1-C_{10} heterocycloalkenyl group, a C_6-C_{60} aryl group, a C_6-C_{60} aryl group substituted with a C_1-C_{60} alkyl group, a C_1-C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group; and/or
(B) R_1 to R_7 are hydrogen.

15. A heterocyclic compound according to claim 7, wherein,
the heterocyclic compound is selected from Compounds 1 to 30:



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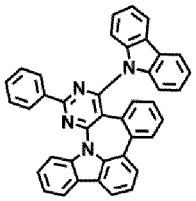

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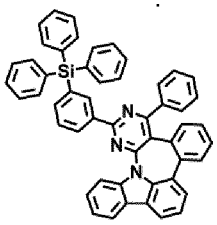

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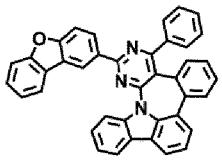

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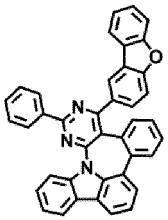

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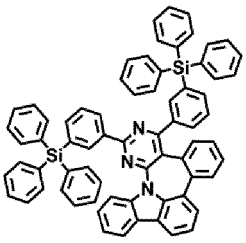

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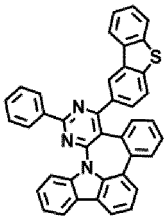

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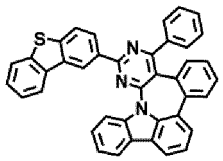

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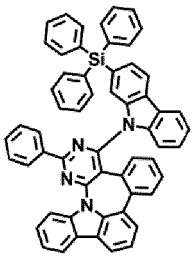

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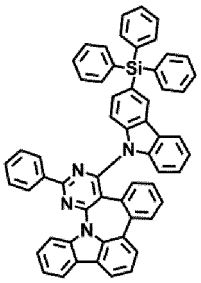

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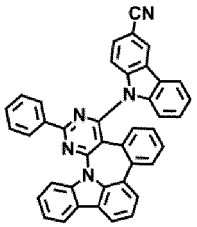

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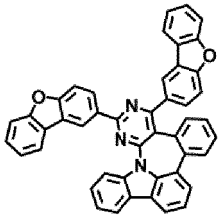

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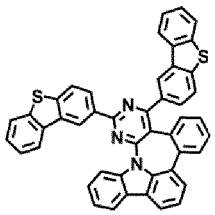

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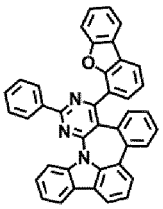

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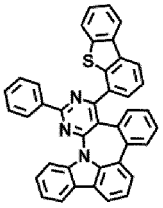

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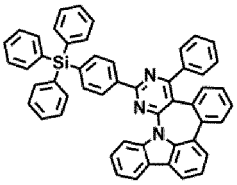

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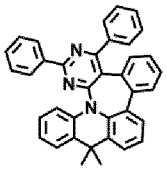

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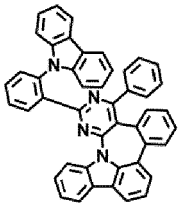

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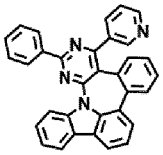

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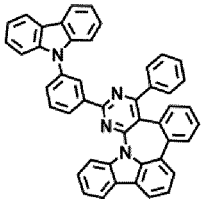

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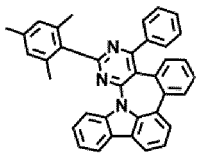

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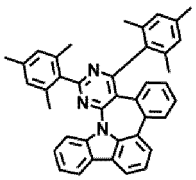

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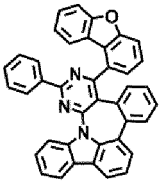

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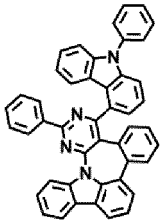

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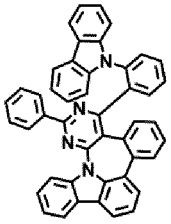

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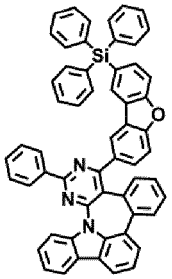
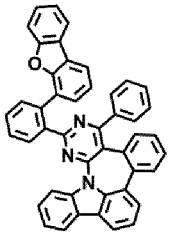


26



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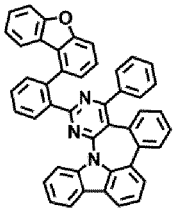

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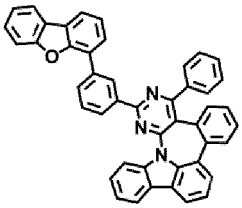

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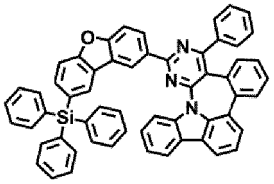


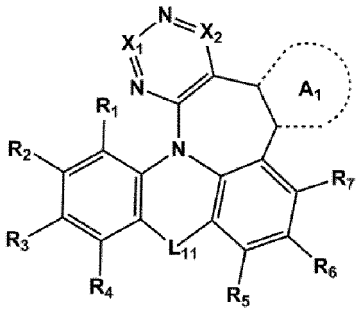
30

Patentansprüche

1. Organische lichtemittierende Vorrichtung, umfassend:

eine erste Elektrode (110);
eine zweite Elektrode (190), die der ersten Elektrode (110) gegenüberliegt;
eine organische Schicht (150) zwischen der ersten Elektrode (110) und der zweiten Elektrode (190) und eine Emissionsschicht umfassend; und
mindestens eine der heterocyclischen Verbindungen, die durch Formel 1 repräsentiert werden:

Formel 1



Formel 2 $*-(L_1)_{a1}-(Ar_1)_{b1}$,

wobei in den Formeln 1 und 2

A_1 eine substituierte oder nicht substituierte carbocyclische C_5-C_{60}-Gruppe oder eine substituierte oder nicht substituierte heterocyclische C_1-C_{60}-Gruppe ist,
X_1 und X_2 jeweils unabhängig $C(R_8)$ oder N sind,
L_1 eine substituierte oder nicht substituierte carbocyclische C_5-C_{60}-Gruppe oder eine substituierte oder nicht substituierte heterocyclische C_1-C_{60}-Gruppe ist,
a1 eine ganze Zahl von 0 bis 3 ist,
L_{11} eine Einzelbindung, *-$N(R_9)$-*', *-$C(R_{10})(R_{11})$-* ', *-O-*' oder *-S-*' ist,
Ar_1 eine substituierte oder nicht substituierte carbocyclische C_5-C_{60}-Gruppe oder eine substituierte oder nicht substituierte heterocyclische C_1-C_{60}-Gruppe ist,
b1 eine ganze Zahl von 1 bis 3 ist,
R_1 bis R_{11} jeweils unabhängig aus einer Gruppe, die durch Formel 2 repräsentiert wird, Wasserstoff, Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Aminogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer Carbonsäuregruppe oder einem Salz davon, einer Sulfonsäuregruppe oder einem Salz davon, einer Phosphorsäuregruppe oder einem Salz davon, einer substituierten oder nicht substituierten C_1-C_{60}-Alkylgruppe, einer substituierten oder nicht substituierten C_2-C_{60}-Alkenylgruppe, einer substituierten oder nicht substituierten C_2-C_{60}-Alkynylgruppe, einer substituierten oder nicht substituierten C_1-C_{60}-Alkoxygruppe, einer substituierten oder nicht substituierten C_3-C_{10}-Cycloalkylgruppe, einer substituierten oder nicht substituierten C_1-C_{10}-Heterocycloalkylgruppe, einer substituierten oder nicht substituierten C_3-C_{10}-Cycloalkenylgruppe, einer substituierten oder nicht substituierten C_1-C_{10}-Heterocycloalkenylgruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Arylgruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Aryloxygruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Arylthiogruppe, einer substituierten oder nicht substituierten C_1-C_{60}-Heteroarylgruppe, einer substituierten oder nicht substituierten monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer substituierten oder nicht substituierten monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$ und $-P(=O)(Q_1)(Q_2)$ ausgewählt sind,
mindestens ein Substituent der substituierten carbocyclischen C_5-C_{60}-Gruppe, der substituierten heterocyclischen C_1-C_{60}-Gruppe, der substituierten C_1-C_{60}-Alkylgruppe, der substituierten C_2-C_{60}-Alkenylgruppe, der substituierten C_2-C_{60}-Alkynylgruppe, der substituierten C_1-C_{60}-Alkoxygruppe, der substituierten C_3-C_{10}-Cycloalkylgruppe, der substituierten C_1-C_{10}-Heterocycloalkylgruppe, der substituierten C_3-C_{10}-Cycloalkenylgruppe, der substituierten C_1-C_{10}-Heterocycloalkenylgruppe, der substituierten C_6-C_{60}-Arylgruppe, der substituierten C_6-C_{60}-Aryloxygruppe, der substituierten C_6-C_{60}-Arylthiogruppe, der substituierten C_1-C_{60}-Heteroarylgruppe,

der substituierten monovalenten nichtaromatischen kondensierten polycyclischen Gruppe und der substituierten monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe ausgewählt ist aus:

Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_1-C_{60}-Alkylgruppe, einer C_2-C_{60}-Alkenylgruppe, einer C_2-C_{60}-Alkynylgruppe und einer C_1-C_{60}-Alkoxygruppe;
einer C_1-C_{60}-Alkylgruppe, einer C_2-C_{60}-Alkenylgruppe, einer C_2-C_{60}-Alkynylgruppe und einer C_1-C_{60}-Alkoxygruppe, jede substituiert mit mindestens einem, ausgewählt aus Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Aryloxygruppe, einer C_6-C_{60}-Arylthiogruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, - $Si(Q_{11})(Q_{12})(Q_{13})$, $-N(Q_{11})(Q_{12})$, $-B(Q_{11})(Q_{12})$, $-C(=O)(Q_{11})$, $-S(=O)_2(Q_{11})$ und $-P(=O)(Q_{11})(Q_{12})$;
einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Aryloxygruppe, einer C_6-C_{60}-Arylthiogruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, einer Biphenylgruppe und einer Terphenylgruppe;
einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Aryloxygruppe, einer C_6-C_{60}-Arylthiogruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, einer Biphenylgruppe und einer Terphenylgruppe, jede substituiert mit mindestens einem, ausgewählt aus Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_1-C_{60}-Alkylgruppe, einer C_2-C_{60}-Alkenylgruppe, einer C_2-C_{60}-Alkynylgruppe, einer C_1-C_{60}-Alkoxygruppe, einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Aryloxygruppe, einer C_6-C_{60}-Arylthiogruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, einer Biphenylgruppe, einer Terphenylgruppe, $-Si(Q_{21})(Q_{22})(Q_{23})$, $-N(Q_{21})(Q_{22})$, $-B(Q_{21})(Q_{22})$, $-C(=O)(Q_{21})$, $-S(=O)_2(Q_{21})$ und $-P(=O)(Q_{21})(Q_{22})$; und
$-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$ und $-P(=O)(Q_{31})(Q_{32})$,
Q_1 bis Q_3, Q_{11} bis Q_{13}, Q_{21} bis Q_{23} und Q_{31} bis Q_{33} jeweils unabhängig aus Wasserstoff, Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_1-C_{60}-Alkylgruppe, einer C_2-C_{60}-Alkenylgruppe, einer C_2-C_{60}-Alkynylgruppe, einer C_1-C_{60}-Alkoxygruppe, einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Arylgruppe, substituiert mit einer C_1-C_{60}-Alkylgruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, einer Biphenylgruppe und einer Terphenylgruppe, ausgewählt sind und
* und *' jeweils eine Bindungsstelle zu einem benachbarten Atom angeben.

2. Organische lichtemittierende Vorrichtung nach Anspruch 1, wobei
die erste Elektrode eine Anode ist,
die zweite Elektrode eine Kathode ist,
die organische Schicht mindestens eine der heterocyclischen Verbindung umfasst, die durch Formel 1 repräsentiert wird,
die organische Schicht ferner eine Lochtransportregion zwischen der ersten Elektrode und der Emissionsschicht und eine Elektronentransportregion zwischen der Emissionsschicht und der zweiten Elektrode umfasst,
die Lochtransportregion eine Lochinjektionsschicht, eine Lochtransportschicht, eine Emissionshilfsschicht, eine Elektronensperrschicht oder eine beliebige Kombination davon umfasst und
die Elektronentransportregion eine Pufferschicht, eine Lochsperrschicht, eine Elektronentransportschicht, eine Elektronensteuerschicht, eine Elektroneninj ektionsschicht oder eine beliebige Kombination davon umfasst.

3. Organische lichtemittierende Vorrichtung nach Anspruch 1 oder Anspruch 2, wobei
die Emissionsschicht einen Dotierstoff und einen Wirt umfasst und
der Wirt mindestens eine der heterocyclischen Verbindung, die durch Formel 1 repräsentiert wird, umfasst, wobei wahlweise
der Dotierstoff einen phosphoreszierenden Dotierstoff umfasst.

4. Organische lichtemittierende Vorrichtung nach Anspruch 1 oder Anspruch 2, wobei die Emissionsschicht einen Dotierstoff und einen Wirt umfasst und
der Dotierstoff mindestens eine der heterocyclischen Verbindung umfasst.

5. Organische lichtemittierende Vorrichtung nach Anspruch 4, wobei der Wirt ferner eine Verbindung umfasst, die durch Formel 301 repräsentiert wird:

Formel 301 $[Ar_{301}]_{xb11}$-$[(L_{301})_{xb1}$-$R_{301}]_{xb21}$,

wobei in Formel 301

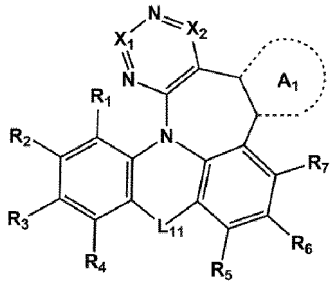
Ar_{301} eine substituierte oder nicht substituierte carbocyclische C_5-C_{60}-Gruppe oder eine substituierte oder nicht substituierte heterocyclische C_1-C_{60}-Gruppe ist,
xb11 1, 2 oder 3 ist,
L_{301} aus einer substituierten oder nicht substituierten C_3-C_{10}-Cycloalkylengruppe, einer substituierten oder nicht substituierten C_1-C_{10}-Heterocycloalkylengruppe, einer substituierten oder nicht substituierten C_3-C_{10}-Cycloalkenylengruppe, einer substituierten oder nicht substituierten C_1-C_{10}-Heterocycloalkenylengruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Arylengruppe, einer substituierten oder nicht substituierten C_1-C_{60}-Heteroarylengruppe, einer substituierten oder nicht substituierten divalenten nichtaromatischen kondensierten polycyclischen Gruppe und einer substituierten oder nicht substituierten divalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe ausgewählt ist,
xb1 eine ganze Zahl von 0 bis 5 ist,
R_{301} aus Deuterium, -F, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer substituierten oder nicht substituierten C_1-C_{60}-Alkylgruppe, einer substituierten oder nicht substituierten C_2-C_{60}-Alkenylgruppe, einer substituierten oder nicht substituierten C_2-C_{60}-Alkynylgruppe, einer substituierten oder nicht substituierten C_1-C_{60}-Alkoxygruppe, einer substituierten oder nicht substituierten C_3-C_{10}-Cycloalkylgruppe, einer substituierten oder nicht substituierten C_1-C_{10}-Heterocycloalkylgruppe, einer substituierten oder nicht substituierten C_3-C_{10}-Cycloalkenylgruppe, einer substituierten oder nicht substituierten C_1-C_{10}-Heterocycloalkenylgruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Arylgruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Aryloxygruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Arylthiogruppe, einer substituierten oder nicht substituierten C_1-C_{60}-Heteroarylgruppe, einer substituierten oder nicht substituierten monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer substituierten oder nicht substituierten monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, $-Si(Q_{301})(Q_{302})(Q_{303})$, $-N(Q_{301})(Q_{302})$, $-B(Q_{301})(Q_{302})$, $-C(=O)(Q_{301})$, $-S(=O)_2(Q_{301})$ und $-P(=O)(Q_{301})(Q_{302})$ ausgewählt ist,
xb21 eine ganze Zahl von 1 bis 5 ist und
Q_{301} bis Q_{303} jeweils unabhängig aus einer C_1-C_{10}-Alkylgruppe, einer C_1-C_{10}-Alkoxygruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe und einer Naphthylgruppe ausgewählt sind, wobei wahlweise
die Elektronentransportregion ein Alkalimetall, ein Erdalkalimetall, ein Seltenerdmetall, eine Alkalimetallverbindung, eine Erdalkalimetallverbindung, eine Seltenerdmetallverbindung, einen Alkalimetallkomplex, einen Erdalkalimetallkomplex, einen Seltenerdmetallkomplex oder eine beliebige Kombination davon umfasst.

6. Organische lichtemittierende Vorrichtung nach einem der Ansprüche 1 bis 5, wobei
die Emissionsschicht eine erste Emissionsschicht ist, die konfiguriert ist, um ein erstes farbiges Licht zu emittieren,
die organische lichtemittierende Vorrichtung ferner zwischen der ersten Elektrode und der zweiten Elektrode i) mindestens eine zweite Emissionsschicht, die konfiguriert ist, um ein zweites farbiges Licht zu emittieren, oder ii) mindestens eine zweite Emissionsschicht, die konfiguriert ist, um ein zweites farbiges Licht zu emittieren, und mindestens eine dritte Emissionsschicht, die konfiguriert ist, um ein drittes farbiges Licht zu emittieren, umfasst,
wobei eine maximale Emissionswellenlänge des ersten farbigen Lichts , eine maximale Emissionswellenlänge des zweiten farbigen Lichts und eine maximale Emissionswellenlänge des dritten farbigen Lichts identisch oder verschieden voneinander sind und
das Licht der ersten Farbe und das Licht der zweiten Farbe in der Form von gemischtem Licht emittiert werden oder

das Licht der ersten Farbe, das Licht der zweiten Farbe und das Licht der dritten Farbe in der Form von gemischtem Licht emittiert werden.

7. Heterocyclische Verbindung, die durch Formel 1 repräsentiert wird:

Formel 1



Formel 2 $*-(L_1)_{a1}-(Ar_1)_{b1}$,

wobei in den Formeln 1 und 2

A_1 eine substituierte oder nicht substituierte carbocyclische C_5-C_{60}-Gruppe oder eine substituierte oder nicht substituierte heterocyclische C_1-C_{60}-Gruppe ist,
X_1 und X_2 jeweils unabhängig $C(R_8)$ oder N sind,
L_1 eine substituierte oder nicht substituierte carbocyclische C_5-C_{60}-Gruppe oder eine substituierte oder nicht substituierte heterocyclische C_1-C_{60}-Gruppe ist,
a1 eine ganze Zahl von 0 bis 3 ist,
L_{11} eine Einzelbindung, *-$N(R_9)$-*', *-$C(R_{10})(R_{11})$-*', *-O-*' oder *-S-*' ist,
Ar_1 eine substituierte oder nicht substituierte carbocyclische C_5-C_{60}-Gruppe oder eine substituierte oder nicht substituierte heterocyclische C_1-C_{60}-Gruppe ist,
b1 eine ganze Zahl von 1 bis 3 ist,
R_1 bis R_{11} jeweils unabhängig aus einer Gruppe, die durch Formel 2 repräsentiert wird, Wasserstoff, Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Aminogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer Carbonsäuregruppe oder einem Salz davon, einer Sulfonsäuregruppe oder einem Salz davon, einer Phosphorsäuregruppe oder einem Salz davon, einer substituierten oder nicht substituierten C_1-C_{60}-Alkylgruppe, einer substituierten oder nicht substituierten C_2-C_{60}-Alkenylgruppe, einer substituierten oder nicht substituierten C_2-C_{60}-Alkynylgruppe, einer substituierten oder nicht substituierten C_1-C_{60}-Alkoxygruppe, einer substituierten oder nicht substituierten C_3-C_{10}-Cycloalkylgruppe, einer substituierten oder nicht substituierten C_1-C_{10}-Heterocycloalkylgruppe, einer substituierten oder nicht substituierten C_3-C_{10}-Cycloalkenylgruppe, einer substituierten oder nicht substituierten C_1-C_{10}-Heterocycloalkenylgruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Arylgruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Aryloxygruppe, einer substituierten oder nicht substituierten C_6-C_{60}-Arylthiogruppe, einer substituierten oder nicht substituierten C_1-C_{60}-Heteroarylgruppe, einer substituierten oder nicht substituierten monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer substituierten oder nicht substituierten monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$ und $-P(=O)(Q_1)(Q_2)$ ausgewählt sind,
mindestens ein Substituent der substituierten carbocyclischen C_5-C_{60}-Gruppe, der substituierten heterocyclischen C_1-C_{60}-Gruppe, der substituierten C_1-C_{60}-Alkylgruppe, der substituierten C_2-C_{60}-Alkenylgruppe, der substituierten C_2-C_{60}-Alkynylgruppe, der substituierten C_1-C_{60}-Alkoxygruppe, der substituierten C_3-C_{10}-Cycloalkylgruppe, der substituierten C_1-C_{10}-Heterocycloalkylgruppe, der substituierten C_3-C_{10}-Cycloalkenylgruppe, der substituierten C_1-C_{10}-Heterocycloalkenylgruppe, der substituierten C_6-C_{60}-Arylgruppe, der substituierten C_6-C_{60}-Aryloxygruppe, der substituierten C_6-C_{60}-Arylthiogruppe, der substituierten C_1-C_{60}-Heteroarylgruppe, der substituierten monovalenten nichtaromatischen kondensierten polycyclischen Gruppe und der substituierten monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe ausgewählt ist aus:

Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Amidinogruppe,

einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_1-C_{60}-Alkylgruppe, einer C_2-C_{60}-Alkenylgruppe, einer C_2-C_{60}-Alkynylgruppe und einer C_1-C_{60}- Alkoxygruppe;
einer C_1-C_{60}-Alkylgruppe, einer C_2-C_{60}-Alkenylgruppe, einer C_2-C_{60}-Alkynylgruppe und einer C_1-C_{60}-Alkoxygruppe, jede substituiert mit mindestens einem, ausgewählt aus Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Aryloxygruppe, einer C_6-C_{60}-Arylthiogruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, - $Si(Q_{11})(Q_{12})(Q_{13})$, $-N(Q_{11})(Q_{12})$, $-B(Q_{11})(Q_{12})$, $-C(=O)(Q_{11})$, $-S(=O)_2(Q_{11})$ und $-P(=O)(Q_{11})(Q_{12})$;
einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Aryloxygruppe, einer C_6-C_{60}-Arylthiogruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, einer Biphenylgruppe und einer Terphenylgruppe;
einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Aryloxygruppe, einer C_6-C_{60}-Arylthiogruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, einer Biphenylgruppe und einer Terphenylgruppe, jede substituiert mit mindestens einem, ausgewählt aus Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_1-C_{60}-Alkylgruppe, einer C_2-C_{60}-Alkenylgruppe, einer C_2-C_{60}-Alkynylgruppe, einer C_1-C_{60}-Alkoxygruppe, einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Aryloxygruppe, einer C_6-C_{60}-Arylthiogruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, einer Biphenylgruppe, einer Terphenylgruppe, $-Si(Q_{21})(Q_{22})(Q_{23})$, $-N(Q_{21})(Q_{22})$, $-B(Q_{21})(Q_{22})$, $-C(=O)(Q_{21})$, $-S(=O)_2(Q_{21})$ und $-P(=O)(Q_{21})(Q_{22})$; und
$-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$ und $-P(=O)(Q_{31})(Q_{32})$,
Q_1 bis Q_3, Q_{11} bis Q_{13}, Q_{21} bis Q_{23} und Q_{31} bis Q_{33} jeweils unabhängig aus Wasserstoff, Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, an Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_1-C_{60}-Alkylgruppe, einer C_2-C_{60}-Alkenylgruppe, einer C_2-C_{60}-Alkynylgruppe, einer C_1-C_{60}-Alkoxygruppe, einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Arylgruppe, substituiert mit einer C_1-C_{60}-Alkylgruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, einer Biphenylgruppe und einer Terphenylgruppe, ausgewählt sind und
* und *' jeweils eine Bindungsstelle zu einem benachbarten Atom angeben.

8. Heterocyclische Verbindung nach Anspruch 7, wobei
A_1 aus einer Benzengruppe, einer Pentalengruppe, einer Indengruppe, einer Naphthalengruppe, einer Azulengruppe, einer Heptalengruppe, einer Indacengruppe, einer Acenaphthalengruppe, einer Fluorengruppe, einer Spirobifluorengruppe, einer Spirobenzofluoren-fluorengruppe, einer Benzofluorengruppe, einer Dibenzofluorengruppe, einer Phenalengruppe, einer Phenanthrengruppe, einer Anthracengruppe, einer Fluoranthengruppe, einer Pyrengruppe, einer Chrysengruppe, einer Naphthacengruppe, einer Picengruppe, einer Perylengruppe, einer Pyrrolgruppe, einer Thiophengruppe, einer Furangruppe, einer Silolgruppe, einer Imidazolgruppe, einer Pyrazolgruppe, einer Thiazolgruppe, einer Isothiazolgruppe, einer Oxazolgruppe, einer Isoxazolgruppe, einer Pyridingruppe, einer Pyrazingruppe, einer Pyrimidingruppe, einer Pyridazingruppe, einer Triazingruppe, einer Benzofurangruppe, einer Benzothiophengruppe, einer Dibenzofurangruppe, einer Dibenzothiophengruppe, einer Carbazolgruppe, einer Benzosilolgruppe, einer Dibenzosilolgruppe, einer Chinolingruppe, einer Isochinolingruppe, einer Benzimidazolgruppe, einer Imidazopyridingruppe und einer Imidazopyrimidingruppe ausgewählt ist;
einer Benzengruppe, einer Pentalengruppe, einer Indengruppe, einer Naphthalengruppe, einer Azulengruppe, einer Heptalengruppe, einer Indacengruppe, einer Acenaphthalengruppe, einer Fluorengruppe, einer Spiro-bifluorengruppe, einer Spirobenzofluoren-fluorengruppe, einer Benzofluorengruppe, einer Dibenzofluorengruppe, einer Phenalengruppe, einer Phenanthrengruppe, einer Anthracengruppe, einer Fluoranthengruppe, einer Pyrengruppe, einer

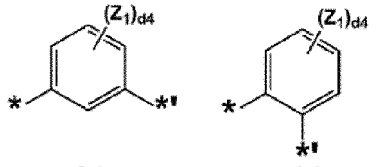
Chrysengruppe, einer Naphthacengruppe, einer Picengruppe, einer Perylengruppe, einer Pyrrolgruppe, einer Thiophengruppe, einer Furangruppe, einer Silolgruppe, einer Imidazolgruppe, einer Pyrazolgruppe, einer Thiazolgruppe, einer Isothiazolgruppe, einer Oxazolgruppe, einer Isoxazolgruppe, einer Pyridingruppe, einer Pyrazingruppe, einer Pyrimidingruppe, einer Pyridazingruppe, einer Triazingruppe, einer Benzofurangruppe, einer Benzothiophengruppe, einer Dibenzofurangruppe, einer Dibenzothiophengruppe, einer Carbazolgruppe, einer Benzosilolgruppe, einer Dibenzosilolgruppe, einer Chinolingruppe, einer Isochinolingruppe, einer Benzimidazolgruppe, einer Imidazopyridingruppe und einer Imidazopyrimidingruppe, jede substituiert mit mindestens einem, ausgewählt aus Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Cyclopentylgruppe, einer Cyclohexylgruppe, einer Cycloheptylgruppe, einer Cyclopentenylgruppe, einer Cyclohexenylgruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Pentalenylgruppe, einer Indenylgruppe, einer Naphthylgruppe, einer Azulenylgruppe, einer Heptalenylgruppe, einer Indacenylgruppe, einer Acenaphthylgruppe, einer Fluorenylgruppe, einer Spiro-bifluorenylgruppe, einer Benzofluorenylgruppe, einer Dibenzofluorenylgruppe, einer Phenalenylgruppe, einer Phenanthrenylgruppe, einer Anthracenylgruppe, einer Fluoranthenylgruppe, einer Pyrenylgruppe, einer Chrysenylgruppe, einer Naphthacenylgruppe, einer Picenylgruppe, einer Perylenylgruppe, einer Pentaphenylgruppe, einer Hexacenylgruppe, einer Pentacenylgruppe, einer Rubicenylgruppe, einer Coronenylgruppe, einer Ovalenylgruppe, einer Pyrrolylgruppe, einer Thiophenylgruppe, einer Furanylgruppe, einer Pyridinylgruppe, einer Pyrazinylgruppe, einer Pyrimidinylgruppe, einer Pyridazinylgruppe, einer Chinolinylgruppe, einer Isochinolinylgruppe, einer Benzofuranylgruppe, einer Benzothiophenylgruppe, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$ und $-B(Q_{31})(Q_{32})$, und
Q_{31} bis Q_{33} jeweils unabhängig aus einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Naphthylgruppe und einer Pyridinylgruppe ausgewählt sind.

9. Heterocyclische Verbindung nach Anspruch 7 oder Anspruch 8, wobei:
X_1 und X_2 jeweils unabhängig $C(R_8)$ sind; und/oder L_1 ausgewählt ist aus:

einer Benzengruppe, einer Pentalengruppe, einer Indengruppe, einer Naphthalengruppe, einer Azulengruppe, einer Heptalengruppe, einer Indacengruppe, einer Acenaphthalengruppe, einer Fluorengruppe, einer Spirobifluorengruppe, einer Spirobenzofluoren-fluorengruppe, einer Benzofluorengruppe, einer Dibenzofluorengruppe, einer Phenalengruppe, einer Phenanthrengruppe, einer Anthracengruppe, einer Fluoranthengruppe, einer Pyrengruppe, einer Chrysengruppe, einer Naphthacengruppe, einer Picengruppe, einer Perylengruppe, einer Pyrrolgruppe, einer Thiophengruppe, einer Furangruppe, einer Silolgruppe, einer Imidazolgruppe, einer Pyrazolgruppe, einer Thiazolgruppe, einer Isothiazolgruppe, einer Oxazolgruppe, einer Isoxazolgruppe, einer Pyridingruppe, einer Pyrazingruppe, einer Pyrimidingruppe, einer Pyridazingruppe, einer Triazingruppe, einer Benzofurangruppe, einer Benzothiophengruppe, einer Dibenzofurangruppe, einer Dibenzothiophengruppe, einer Carbazolgruppe, einer Benzosilolgruppe, einer Dibenzosilolgruppe, einer Chinolingruppe, einer Isochinolingruppe, einer Benzimidazolgruppe, einer Imidazopyridingruppe und einer Imidazopyrimidingruppe; und
einer Benzengruppe, einer Pentalengruppe, einer Indengruppe, einer Naphthalengruppe, einer Azulengruppe, einer Heptalengruppe, einer Indacengruppe, einer Acenaphthalengruppe, einer Fluorengruppe, einer Spirobifluorengruppe, einer Spirobenzofluoren-fluorengruppe, einer Benzofluorengruppe, einer Dibenzofluorengruppe, einer Phenalengruppe, einer Phenanthrengruppe, einer Anthracengruppe, einer Fluoranthengruppe, einer Pyrengruppe, einer Chrysengruppe, einer Naphthacengruppe, einer Picengruppe, einer Perylengruppe, einer Pyrrolgruppe, einer Thiophengruppe, einer Furangruppe, einer Silolgruppe, einer Imidazolgruppe, einer Pyrazolgruppe, einer Thiazolgruppe, einer Isothiazolgruppe, einer Oxazolgruppe, einer Isoxazolgruppe, einer Pyridingruppe, einer Pyrazingruppe, einer Pyrimidingruppe, einer Pyridazingruppe, einer Triazingruppe, einer Benzofurangruppe, einer Benzothiophengruppe, einer Dibenzofurangruppe, einer Dibenzothiophengruppe, einer Carbazolgruppe, einer Benzosilolgruppe, einer Dibenzosilolgruppe, einer Chinolingruppe, einer Isochinolingruppe, einer Benzimidazolgruppe, einer Imidazopyridingruppe und einer Imidazopyrimidingruppe, jede substituiert mit mindestens einem, ausgewählt aus Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Cyclopentylgruppe, einer Cyclohexylgruppe, einer Cycloheptylgruppe, einer Cyclopentenylgruppe, einer Cyclohexenylgruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Pentalenylgruppe, einer Indenylgruppe, einer Naphthylgruppe, einer Azulenylgruppe, einer Heptalenylgruppe, einer Indacenylgruppe, einer Acenaphthylgruppe, einer Fluorenylgruppe, einer Spiro-bifluorenylgruppe, einer Benzofluorenylgruppe, einer Dibenzofluorenylgruppe, einer Phenalenylgruppe, einer Phenanthrenylgruppe, einer Anthracenylgruppe, einer Fluoranthenylgruppe, einer Pyrenylgruppe, einer Chrysenylgruppe, einer Naphthacenylgruppe, einer Picenylgruppe, einer Perylenylgruppe, einer Pentaphenylgruppe, einer Hexacenylgruppe, einer Pentacenylgruppe, einer Rubicenylgruppe, einer Coronenylgruppe, einer Ovalenylgruppe, einer Pyrrolylgruppe, einer Thiophenylgruppe, einer Furanylgruppe, einer Pyridinylgruppe, einer Pyrazinylgruppe, einer Pyrimidinylgruppe, einer Pyridazinylgruppe, einer Chinolinylgrup-

pe, einer Isochinolinylgruppe, einer Benzofuranylgruppe, einer Benzothiophenylgruppe, -Si(Q_{31})(Q_{32})(Q_{33}), -N(Q_{31})(Q_{32}) und -B(Q_{31})(Q_{32}), und
Q_{31} bis Q_{33} jeweils unabhängig aus einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Naphthylgruppe und einer Pyridinylgruppe ausgewählt sind.

10. Heterocyclische Verbindung nach einem der Ansprüche 7 bis 9, wobei
L_1 aus Gruppen ausgewählt ist, die durch die Formel 3-1 oder 3-2 repräsentiert werden:



3-1 3-2 ,

wobei in den Formeln 3-1 und 3-2

Z_1 aus Wasserstoff, Deuterium, -F, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Cyclopentylgruppe, einer Cyclohexylgruppe, einer Cycloheptylgruppe, einer Cyclopentenylgruppe, einer Cyclohexenylgruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Naphthylgruppe, einer Fluorenylgruppe, einer Spiro-bifluorenylgruppe, einer Benzofluorenylgruppe, einer Dibenzofluorenylgruppe, einer Phenanthrenylgruppe, einer Anthracenylgruppe, einer Fluoranthenylgruppe, einer Pyrenylgruppe, einer Chrysenylgruppe, einer Pyrrolylgruppe, einer Thiophenylgruppe, einer Furanylgruppe, einer Silolylgruppe, einer Imidazolylgruppe, einer Pyrazolylgruppe, einer Thiazolylgruppe, einer Isothiazolylgruppe, einer Oxazolylgruppe, einer Isoxazolylgruppe, einer Pyridinylgruppe, einer Pyrazinylgruppe, einer Pyrimidinylgruppe, einer Pyridazinylgruppe, einer Benzofuranylgruppe, einer Benzothiophenylgruppe, einer Benzosilolylgruppe, einer Dibenzosilolylgruppe und - Si(Q_{31})(Q_{32})(Q_{33}) ausgewählt ist,
Q_{31} bis Q_{33} jeweils unabhängig aus einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Naphthylgruppe und einer Pyridinylgruppe ausgewählt sind,
d4 eine ganze Zahl von 0 bis 4 ist und
* und *' jeweils eine Bindungsstelle zu einem benachbarten Atom angeben.

11. Heterocyclische Verbindung nach einem der Ansprüche 7 bis 10, wobei
L_{11} eine Einzelbindung oder *-C(R_{10})(R_{11})-*' ist und
R_{10} und R_{11} jeweils unabhängig ausgewählt sind aus:

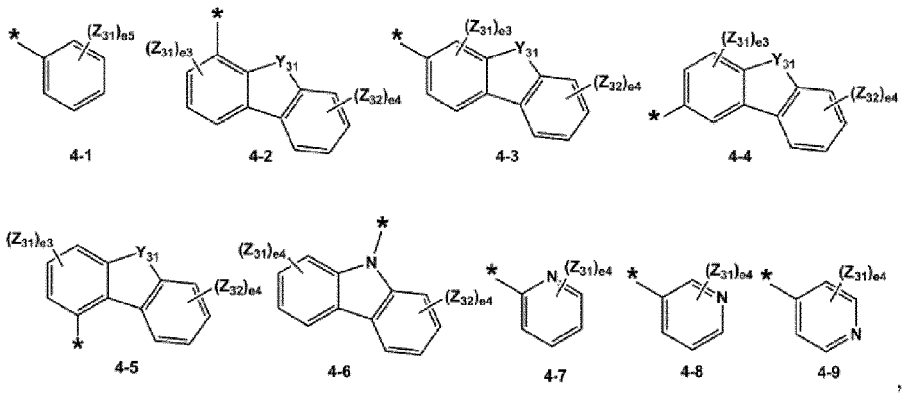
Wasserstoff, Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Aminogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe und einer C_1-C_{20}-Alkylgruppe; und
einer C_1-C_{20}-Alkylgruppe, substituiert mit mindestens einem, ausgewählt aus Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe und einer Cyanogruppe.

12. Heterocyclische Verbindung nach einem der Ansprüche 7 bis 11, wobei
Ar_1 ausgewählt ist aus:

einer Benzengruppe, einer Pentalengruppe, einer Indengruppe, einer Naphthalengruppe, einer Azulengruppe, einer Heptalengruppe, einer Indacengruppe, einer Acenaphthalengruppe, einer Fluorengruppe, einer Spirobifluorengruppe, einer Spirobenzofluoren-fluorengruppe, einer Benzofluorengruppe, einer Dibenzofluorengruppe, einer Phenalengruppe, einer Phenanthrengruppe, einer Anthracengruppe, einer Fluoranthengruppe, einer Pyrengruppe, einer Chrysengruppe, einer Naphthacengruppe, einer Picengruppe, einer Perylengruppe, einer Pyrrolgruppe, einer Thiophengruppe, einer Furangruppe, einer Silolgruppe, einer Imidazolgruppe, einer Pyrazolgruppe, einer Thiazolgruppe, einer Isothiazolgruppe, einer Oxazolgruppe, einer Isoxazolgruppe, einer Pyridingruppe, einer Pyrazingruppe, einer Pyrimidingruppe, einer Pyridazingruppe, einer Triazingruppe, einer Benzofurangruppe, einer Benzothiophengruppe, einer Dibenzofurangruppe, einer Dibenzothiophengruppe, einer Carbazolgruppe, einer Benzosilolgruppe, einer Dibenzosilolgruppe, einer Chinolingruppe, einer Isochinolingruppe, einer Benzimidazolgruppe, einer Imidazopyridingruppe und einer Imidazopyrimidingruppe; und
einer Benzengruppe, einer Pentalengruppe, einer Indengruppe, einer Naphthalengruppe, einer Azulengruppe,

einer Heptalengruppe, einer Indacengruppe, einer Acenaphthalengruppe, einer Fluorengruppe, einer Spirobifluorengruppe, einer Spirobenzofluoren-fluorengruppe, einer Benzofluorengruppe, einer Dibenzofluorengruppe, einer Phenalengruppe, einer Phenanthrengruppe, einer Anthracengruppe, einer Fluoranthengruppe, einer Pyrengruppe, einer Chrysengruppe, einer Naphthacengruppe, einer Picengruppe, einer Perylengruppe, einer Pyrrolgruppe, einer Thiophengruppe, einer Furangruppe, einer Silolgruppe, einer Imidazolgruppe, einer Pyrazolgruppe, einer Thiazolgruppe, einer Isothiazolgruppe, einer Oxazolgruppe, einer Isoxazolgruppe, einer Pyridingruppe, einer Pyrazingruppe, einer Pyrimidingruppe, einer Pyridazingruppe, einer Triazingruppe, einer Benzofurangruppe, einer Benzothiophengruppe, einer Dibenzofurangruppe, einer Dibenzothiophengruppe, einer Carbazolgruppe, einer Benzosilolgruppe, einer Dibenzosilolgruppe, einer Chinolingruppe, einer Isochinolingruppe, einer Benzimidazolgruppe, einer Imidazopyridingruppe und einer Imidazopyrimidingruppe, jede substituiert mit mindestens einem, ausgewählt aus Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Cyclopentylgruppe, einer Cyclohexylgruppe, einer Cycloheptylgruppe, einer Cyclopentenylgruppe, einer Cyclohexenylgruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Pentalenylgruppe, einer Indenylgruppe, einer Naphthylgruppe, einer Azulenylgruppe, einer Heptalenylgruppe, einer Indacenylgruppe, einer Acenaphthylgruppe, einer Fluorenylgruppe, einer Spiro-bifluorenylgruppe, einer Benzofluorenylgruppe, einer Dibenzofluorenylgruppe, einer Phenalenylgruppe, einer Phenanthrenylgruppe, einer Anthracenylgruppe, einer Fluoranthenylgruppe, einer Pyrenylgruppe, einer Chrysenylgruppe, einer Naphthacenylgruppe, einer Picenylgruppe, einer Perylenylgruppe, einer Pentaphenylgruppe, einer Hexacenylgruppe, einer Pentacenylgruppe, einer Rubicenylgruppe, einer Coronenylgruppe, Ovalenylgruppe, einer Pyrrolylgruppe, einer Thiophenylgruppe, einer Furanylgruppe, einer Pyridinylgruppe, einer Pyrazinylgruppe, einer Pyrimidinylgruppe, einer Pyridazinylgruppe, einer Chinolinylgruppe, einer Isochinolinylgruppe, einer Benzofuranylgruppe, einer Benzothiophenylgruppe, - $Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$ und $-B(Q_{31})(Q_{32})$, und
Q_{31} bis Q_{33} jeweils unabhängig aus einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Naphthylgruppe und einer Pyridinylgruppe ausgewählt sind.

13. Heterocyclische Verbindung nach einem der Ansprüche 7 bis 12, wobei
Ar_1 durch eine der Formeln 4-1 bis 4-9 repräsentiert wird:



wobei in den Formeln 4-1 bis 4-9

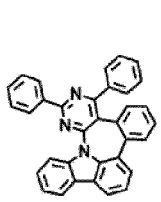
Y_{31} O, S, $C(Z_{33})(Z_{34})$, $N(Z_{35})$ oder $Si(Z_{36})(Z_{37})$ ist,
Z_{31} bis Z_{37} jeweils unabhängig aus Wasserstoff, Deuterium, -F, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Cyclopentylgruppe, einer Cyclohexylgruppe, einer Cycloheptylgruppe, einer Cyclopentenylgruppe, einer Cyclohexenylgruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Naphthylgruppe, einer Fluorenylgruppe, einer Spiro-bifluorenylgruppe, einer Benzofluorenylgruppe, einer Dibenzofluorenylgruppe, einer Phenanthrenylgruppe, einer Anthracenylgruppe, einer Fluoranthenylgruppe, einer Pyrenylgruppe, einer Chrysenylgruppe, einer Pyrrolylgruppe, einer Thiophenylgruppe, einer Furanylgruppe, einer Silolylgruppe, einer Imidazolylgruppe, einer Pyrazolylgruppe, einer Thiazolylgruppe, einer Isothiazolylgruppe, einer Oxazolylgruppe, einer Isoxazolylgruppe, einer Pyridinylgruppe, einer Pyrazinylgruppe, einer Pyrimidinylgruppe, einer Pyridazinylgruppe, einer Benzofuranylgruppe, einer Benzothiophenylgruppe, einer Dibenzofuranylgruppe, einer Dibenzothiophenylgruppe, einer Carbazolylgruppe, einer Benzosilolylgruppe, einer Dibenzosilolylgruppe und - $Si(Q_{31})(Q_{32})(Q_{33})$ ausgewählt sind,

Q_{31} bis Q_{33} jeweils unabhängig aus einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Naphthylgruppe, und einer Pyridinylgruppe ausgewählt sind,
e3 eine ganze Zahl von 0 bis 3 ist,
e4 eine ganze Zahl von 0 bis 4 ist,
e5 eine ganze Zahl von 0 bis 5 ist und
* eine Bindungsstelle zu einem benachbarten Atom angibt, wobei wahlweise
Z_{31} bis Z_{37} jeweils unabhängig aus Wasserstoff, einer Cyanogruppe, einer C_1-C_{20}-Alkylgruppe, einer Phenylgruppe, einer Dibenzofuranylgruppe, einer Dibenzothiophenylgruppe, einer Carbazolylgruppe und $-Si(Q_{31})(Q_{32})(Q_{33})$ ausgewählt sind und
Q_{31} bis Q_{33} jeweils unabhängig aus einer C_1-C_{20}-Alkylgruppe, einer C_1-C_{20}-Alkoxygruppe, einer Phenylgruppe, einer Biphenylgruppe, einer Terphenylgruppe, einer Naphthylgruppe und einer Pyridinylgruppe ausgewählt sind.

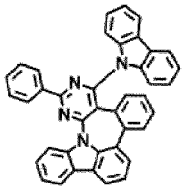
14. Heterocyclische Verbindung nach einem der Ansprüche 7 bis 13, wobei:

(A) R_1 bis R_{11} jeweils unabhängig aus einer Gruppe, die durch Formel 2 repräsentiert wird, Wasserstoff, Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Aminogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_1-C_{20}-Alkylgruppe, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$ und $-P(=O)(Q_1)(Q_2)$ ausgewählt sind; und
einer C_1-C_{20}-Alkylgruppe, substituiert mit mindestens einem, ausgewählt aus Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe und einer Cyanogruppe, und
Q_1 bis Q_{33} jeweils unabhängig aus Wasserstoff, Deuterium, -Cl, -Br, -I, einer Hydroxylgruppe, einer Cyanogruppe, einer Nitrogruppe, einer Amidinogruppe, einer Hydrazinogruppe, einer Hydrazonogruppe, einer C_1-C_{60}-Alkylgruppe, einer C_2-C_{60}-Alkenylgruppe, einer C_2-C_{60}-Alkynylgruppe, einer C_1-C_{60}-Alkoxygruppe, einer C_3-C_{10}-Cycloalkylgruppe, einer C_1-C_{10}-Heterocycloalkylgruppe, einer C_3-C_{10}-Cycloalkenylgruppe, einer C_1-C_{10}-Heterocycloalkenylgruppe, einer C_6-C_{60}-Arylgruppe, einer C_6-C_{60}-Arylgruppe, substituiert mit einer C_1-C_{60}-Alkylgruppe, einer C_1-C_{60}-Heteroarylgruppe, einer monovalenten nichtaromatischen kondensierten polycyclischen Gruppe, einer monovalenten nichtaromatischen kondensierten heteropolycyclischen Gruppe, einer Biphenylgruppe und einer Terphenylgruppe, ausgewählt sind; und/oder
(B) R_1 bis R_7 Wasserstoff sind.

15. Heterocyclische Verbindung nach Anspruch 7, wobei
die heterocyclische Verbindung aus den Verbindungen 1 bis 30 ausgewählt ist:



1



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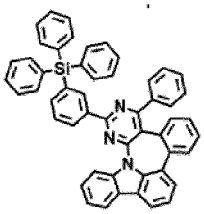

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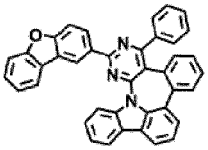

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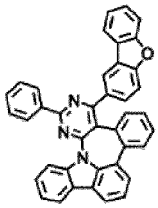

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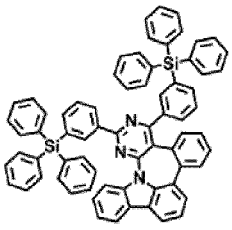

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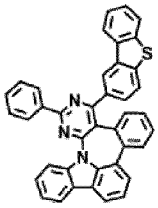

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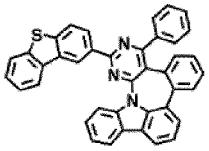

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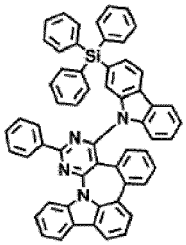

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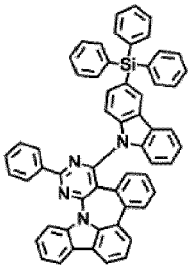

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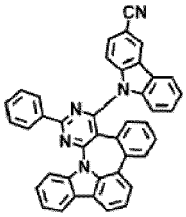

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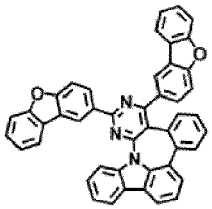

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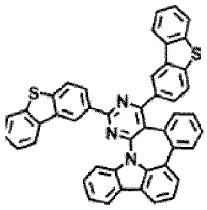

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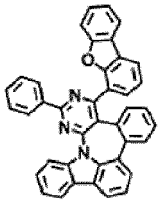

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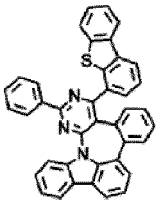

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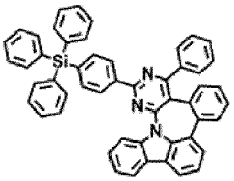

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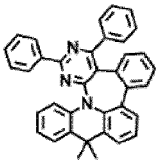

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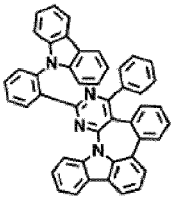

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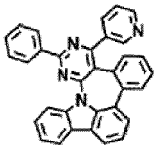

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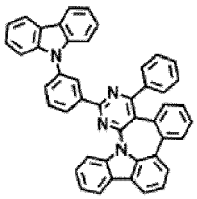

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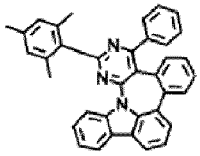

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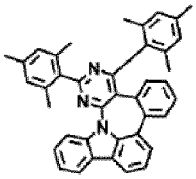

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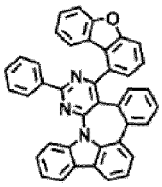

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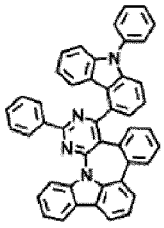

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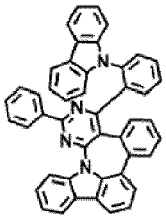

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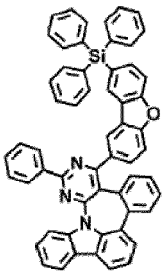

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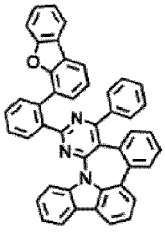

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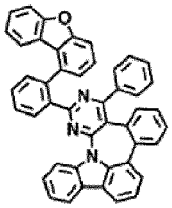

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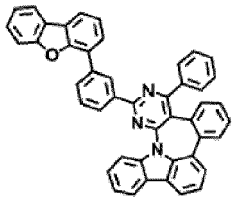

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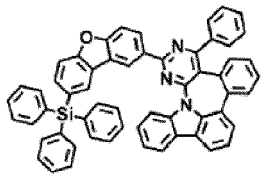


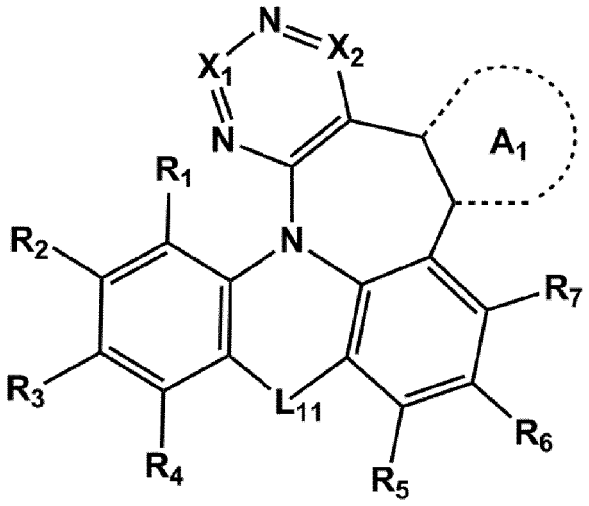
30

Revendications

1. Dispositif électroluminescent comprenant :

une première électrode (110) ;
une seconde électrode (190) faisant face à la première électrode (110) ;
une couche organique (150) entre la première électrode (110) et la seconde électrode (190) et comprenant une couche d'émission ; et
au moins un du composé hétérocyclique représenté par la Formule 1 :

Formule 1



Formule 2 *-$(L_1)_{a1}$-$(Ar_1)_{b1}$

dans lequel, dans les Formules 1 et 2,

A_1 est un groupe carbocyclique en C_5-C_{60} substitué ou non substitué ou un groupe hétérocyclique en C_1-C_{60} substitué ou non substitué,
X_1 et X_2 sont chacun indépendamment un $C(R_8)$ ou un N,
L_1 est un groupe carbocyclique en C_5-C_{60} substitué ou non substitué ou un groupe hétérocyclique en C_1-C_{60} substitué ou non substitué,
a1 est un nombre entier de 0 à 3,
L_{11} est une liaison simple, *-$N(R_9)$-*', *-$C(R_{10})(R_{11})$-*', *-O-*' ou *-S-*',
Ar_1 est un groupe carbocyclique en C_5-C_{60} substitué ou non substitué ou un groupe hétérocyclique en C_1-C_{60} substitué ou non substitué,
b_1 est un nombre entier de 1 à 3,
R_1 à R_{11} sont chacun indépendamment sélectionnés dans un groupe représenté par la Formule 2, un hydrogène, un deutérium, un -Cl, un -Br, un -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amino, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe acide carboxylique ou un sel de celui-ci, un groupe acide sulfonique ou un sel de celui-ci, un groupe acide phosphorique ou un sel de celui-ci,

un groupe alkyle en C_1-C_{60} substitué ou non substitué, un groupe alcényle en C_2-C_{60} substitué ou non substitué, un groupe alcynyle en C_2-C_{60} substitué ou non substitué, un groupe alcoxy en C_1-C_{60} substitué ou non substitué, un groupe cycloalkyle en C_3-C_{10} substitué ou non substitué, un groupe hétérocycloalkyle en C_1-C_{10} substitué ou non substitué, un groupe cycloalcényle en C_3-C_{10} substitué ou non substitué, un groupe hétérocycloalcényle en C_1-C_{10} substitué ou non substitué, un groupe aryle en C_6-C_{60} substitué ou non substitué, un groupe aryloxy en C_6-C_{60} substitué ou non substitué, un groupe arylthio en C_6-C_{60} substitué ou non substitué, un groupe hétéroaryle en C_1-C_{60} substitué ou non substitué, un groupe polycyclique condensé non-aromatique monovalent substitué ou non substitué, un groupe hétéropolycyclique condensé non-aromatique monovalent substitué ou non substitué, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$, et $-P(=O)(Q_1)(Q_2)$,
au moins un substituant du groupe carbocyclique en C_5-C_{60} substitué, du groupe hétérocyclique en C_1-C_{60} substitué, du groupe alkyle en C_1-C_{60} substitué, du groupe alcényle en C_2-C_{60} substitué, du groupe alcynyle en C_2-C_{60} substitué, du groupe alcoxy en C_1-C_{60} substitué, du groupe cycloalkyle en C_3-C_{10} substitué, du groupe hétérocycloalkyle C_1-C_{10} substitué, du groupe cycloalcényle en C_3-C_{10} substitué, du groupe hétérocycloalcényle en C_1-C_{10} substitué, du groupe aryle en C_6-C_{60} substitué, du groupe aryloxy en C_6-C_{60} substitué, du groupe arylthio en C_6-C_{60} substitué, du groupe hétéroaryle en C_1-C_{60} substitué, du groupe polycyclique condensé non-aromatique monovalent substitué, et du groupe hétéropolycyclique condensé non-aromatique monovalent substitué est sélectionné parmi :

le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe alkyle en C_1-C_{60}, un groupe alcényle en C_2-C_{60}, un groupe alcynyle en C_2-C_{60}, et un groupe alcoxy en C_1-C_{60} ;
un groupe alkyle en C_1-C_{60}, un groupe alcényle en C_2-C_{60}, un groupe alcynyle en C_2-C_{60}, et un groupe alcoxy en C_1-C_{60}, chacun substitué par au moins l'un sélectionné parmi le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryloxy en C_6-C_{60}, un groupe arylthio en C_6-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, $-Si(Q_{11})(Q_{12})(Q_{13})$, $-N(Q_{11})(Q_{12})$, $-B(Q_{11})(Q_{12})$, $-C(=O)(Q_{11})$, $-S(=O)_2(Q_{11})$, et $-P(=O)(Q_{11})(Q_{12})$;
un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryloxy en C_6-C_{60}, un groupe arylthio en C_6-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, un groupe biphényle et un groupe terphényle ;
un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryloxy en C_6-C_{60}, un groupe arylthio en C_6-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, un groupe biphényle et un groupe terphényle, chacun substitué par au moins l'un sélectionné parmi le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe alkyle en C_1-C_{60}, un groupe alcényle en C_2-C_{60}, un groupe alcynyle en C_2-C_{60}, un groupe alcoxy en C_1-C_{60}, un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryloxy en C_6-C_{60}, un groupe arylthio en C_6-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, un groupe biphényle, un groupe terphényle, $-Si(Q_{21})(Q_{22})(Q_{23})$, $-N(Q_{21})(Q_{22})$, $-B(Q_{21})(Q_{22})$, $-C(=O)(Q_{21})$, $-S(=O)_2(Q_{21})$, et $-P(=O)(Q_{21})(Q_{22})$; et
$-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$, et $-P(=O)(Q_{31})(Q_{32})$;
Q_1 à Q_3, Q_{11} à Q_{13}, Q_{21} à Q_{23}, et Q_{31} à Q_{33} sont chacun indépendamment sélectionnés parmi l'hydrogène, le deutérium, -Cl, -Br, -I, un groupe hydroxy, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe alkyle en C_1-C_{60}, un groupe alcényle en C_2-C_{60}, un groupe alcynyle en C_2-C_{60}, un groupe alcoxy en C_1-C_{60}, un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryle en C_6-C_{60}, substitué avec un groupe alkyle en C_1-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, un groupe biphényle, et un groupe terphényle, et
* et *' indiquent un site de liaison à un atome voisin.

2. Dispositif électroluminescent organique selon la revendication 1, dans lequel :

la première électrode est une anode,
la seconde électrode est une cathode,
la couche organique comprend au moins un du composé hétérocyclique représenté par la Formule 1,
la couche organique comprend en outre une région de transport de trou entre la première électrode et la couche d'émission et une région de transport d'électron entre la couche d'émission et la seconde électrode,
la région de transport de trou comprend une couche d'injection de trou, une couche de transport de trou, une couche auxiliaire d'émission, une couche de blocage d'électron, ou toute combinaison de celles-ci, et
la région de transport d'électron comprend une couche tampon, une couche de blocage de trou, une couche de transport d'électrons, une couche de contrôle d'électrons, une couche d'injection d'électrons ou toute combinaison de celles-ci.

3. Dispositif électroluminescent organique selon la revendication 1 ou la revendication 2, dans lequel :

la couche d'émission comprend un dopant et un hôte, et
l'hôte comprend au moins un du composé hétérocyclique représenté par la Formule 1, optionnellement dans lequel
le dopant comprend un dopant phosphorescent.

4. Dispositif électroluminescent organique selon la revendication 1 ou la revendication 2, dans lequel
la couche d'émission comprend un dopant et un hôte, et
le dopant comprend au moins un du composé hétérocyclique.

5. Dispositif électroluminescent organique selon la revendication 4, dans lequel
l'hôte comprend en outre un composé représenté par la Formule 301 :

Formule 301 $[Ar_{301}]_{xb11}-[(L_{301})_{xb1}-R_{301}]_{xb21}$,

dans laquelle, dans la Formule 301,

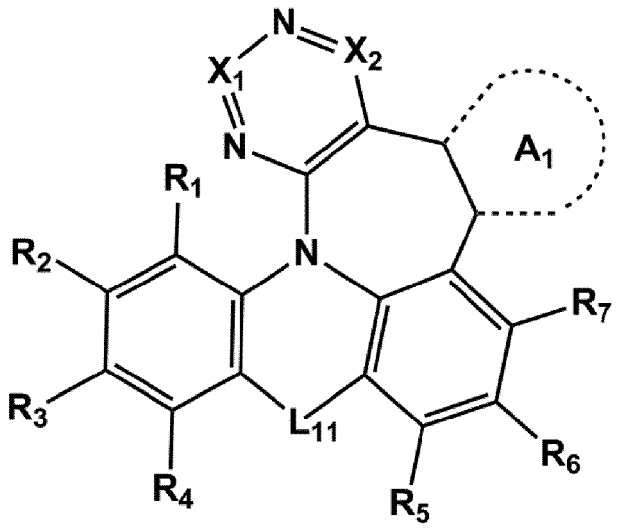
Ar_{301} est un groupe carbocyclique en C_5-C_{60} substitué ou non substitué ou un groupe hétérocyclique en C_1-C_{60} substitué ou non substitué,
xb11 est égal à 1, 2, ou 3,
L_{301} est sélectionné à partir d'un groupe cycloalcylène en C_3-C_{10} substitué ou non substitué, un groupe hétérocycloalcylène en C_1-C_{10} substitué ou non substitué, un groupe cycloalcénylène en C_3-C_{10} substitué ou non substitué, un groupe hétérocycloalcénylène en C_1-C_{10} substitué ou non substitué, un groupe arylène en C_6-C_{60} substitué ou non substitué, un groupe hétéroarylène en C_1-C_{60} substitué ou non substitué, un groupe polycyclique condensé non-aromatique divalent substitué ou non substitué, et un groupe hétéropolycyclique condensé non-aromatique divalent substitué ou non substitué,
xb1 est un nombre entier de 0 à 5,
R_{301} est sélectionné parmi le deutérium, -F, -Cl, -B, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe alkyle en C_1-C_{60} substitué ou non substitué, un groupe alcényle en C_2-C_{60} substitué ou non substitué, un groupe alcynyle en C_2-C_{60} substitué ou non substitué, un groupe alcoxy en C_1-C_{60} substitué ou non substitué, un groupe cycloalkyle en C_3-C_{10} substitué ou non substitué, un groupe hétérocycloalkyle en C_1-C_{10} substitué ou non substitué, un groupe cycloalcényle en C_3-C_{10} substitué ou non substitué, un groupe hétérocycloalcényle en C_1-C_{10} substitué ou non substitué, un groupe aryle en C_6-C_{60} substitué ou non substitué, un groupe aryloxy en C_6-C_{60} substitué ou non substitué, un groupe arylthio en C_6-C_{60} substitué ou non substitué, un groupe hétéroaryle en C_1-C_{60} substitué ou non substitué, un groupe polycyclique condensé non-aromatique monovalent substitué ou non substitué, un groupe hétéropolycyclique condensé non-aromatique monovalent substitué ou non substitué, $-Si(Q_{301})(Q_{302})(Q_{303})$, $-N(Q_{301})(Q_{302})$, $-B(Q_{301})(Q_{302})$, $-C(=O)(Q_{301})$, $-S(=O)_2(Q_{301})$ et $-P(=O)(Q_{301})(Q_{302})$,
xb21 est un nombre entier de 1 à 5, et
Q_{301} à Q_{303} sont chacun indépendamment sélectionnés parmi un groupe alkyle en C_1-C_{10}, un groupe alcoxy en C_1-C_{10}, un groupe phényle, un groupe biphényle, un groupe terphényle, et un groupe naphthyle, optionnellement dans lequel :
la région de transport d'électron comprend un métal alcalin, un métal alcalino-terreux, un métal terreux rare, un composé de métal alcalin, un composé de métal alcalino-terreux, un composé de métal terreux rare, un

complexe de métal alcalin, un complexe de métal alcalino-terreux, un complexe de métal terreux rare ou toute combinaison de ceux-ci.

6. Dispositif électroluminescent organique selon l'une quelconque des revendications 1 à 5, dans lequel la couche d'émission est une première couche d'émission configurée pour émettre une première lumière de couleur, le dispositif électroluminescent organique comprend en outre, entre la première électrode et la seconde électrode, i) au moins une seconde couche d'émission configurée pour émettre une seconde lumière de couleur ou ii) au moins une deuxième couche d'émission configurée pour émettre une deuxième lumière de couleur et au moins une troisième couche d'émission configurée pour émettre une troisième lumière de couleur,
une longueur d'onde d'émission maximale de la première lumière de couleur, une longueur d'onde d'émission maximale de la deuxième lumière de couleur, et une longueur d'onde d'émission maximale de la troisième lumière de couleur sont identiques ou différentes les unes des autres, et
la première lumière de couleur et la deuxième lumière de couleur sont émises sous la forme d'une lumière mélangée, ou la première lumière de couleur, la deuxième lumière de couleur et la troisième lumière de couleur sont émises sous la forme de lumière mélangée.

7. Composé hétérocyclique représenté par la Formule 1 :

Formule 1 :



Formule 2 $-(L_1)_{a1}-(Ar_1)_{b1}$,

dans lequel, dans les Formules 1 et 2,

A_1 est un groupe carbocyclique en C_5-C_{60} substitué ou non substitué ou un groupe hétérocyclique en C_1-C_{60} substitué ou non substitué,
X_1 et X_2 sont chacun indépendamment un $C(R_8)$ ou un N,
L_1 est un groupe carbocyclique en C_5-C_{60} substitué ou non substitué ou un groupe hétérocyclique en C_1-C_{60} substitué ou non substitué,
al est un nombre entier de 0 à 3,
L_{11} est une liaison simple, *-$N(R_9)$-*', *-$C(R_{10})(R_{11})$-*', *-O-*' ou *-S-*',
Ar_1 est un groupe carbocyclique en C_5-C_{60} substitué ou non substitué ou un groupe hétérocyclique en C_1-C_{60} substitué ou non substitué,
b_1 est un nombre entier de 1 à 3,
R_1 à R_{11} sont chacun indépendamment sélectionnés dans un groupe représenté par la Formule 2, un hydrogène, un deutérium, un -Cl, un -Br, un -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amino, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe acide carboxylique ou un sel de celui-ci, un groupe acide sulfonique ou un sel de celui-ci, un groupe acide phosphorique ou un sel de celui-ci, un groupe alkyle en C_1-C_{60} substitué ou non substitué, un groupe alcényle en C_2-C_{60} substitué ou non substitué, un groupe alcynyle en C_2-C_{60} substitué ou non substitué, un groupe alcoxy en C_1-C_{60} substitué ou non substitué,

un groupe cycloalkyle en C_3-C_{10} substitué ou non substitué, un groupe hétérocycloalkyle en C_1-C_{10} substitué ou non substitué, un groupe cycloalcényle en C_3-C_{10} substitué ou non substitué, un groupe hétérocycloalcényle en C_1-C_{10} substitué ou non substitué, un groupe aryle en C_6-C_{60} substitué ou non substitué, un groupe aryloxy en C_6-C_{60} substitué ou non substitué, un groupe arylthio en C_6-C_{60} substitué ou non substitué, un groupe hétéroaryle en C_1-C_{60} substitué ou non substitué, un groupe polycyclique condensé non-aromatique monovalent substitué ou non substitué, un groupe hétéropolycyclique condensé non-aromatique monovalent substitué ou non substitué, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$, et $-P(=O)(Q_1)(Q_2)$,
au moins un substituant du groupe carbocyclique en C_5-C_{60} substitué, du groupe hétérocyclique en C_1-C_{60} substitué, du groupe alkyle en C_1-C_{60} substitué, du groupe alcényle en C_2-C_{60} substitué, du groupe alcynyle en C_2-C_{60} substitué, du groupe alcoxy en C_1-C_{60} substitué, du groupe cycloalkyle en C_3-C_{10} substitué, du groupe hétérocycloalkyle C_1-C_{10} substitué, du groupe cycloalcényle en C_3-C_{10} substitué, du groupe hétérocycloalcényle en C_1-C_{10} substitué, du groupe aryle en C_6-C_{60} substitué, du groupe aryloxy en C_6-C_{60} substitué, du groupe arylthio en C_6-C_{60} substitué, du groupe hétéroaryle en C_1-C_{60} substitué, du groupe polycyclique condensé non-aromatique monovalent substitué, et du groupe hétéropolycyclique condensé non-aromatique monovalent substitué est sélectionné parmi :

le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe alkyle en C_1-C_{60}, un groupe alcényle en C_2-C_{60}, un groupe alcynyle en C_2-C_{60}, et un groupe alcoxy en C_1-C_{60} ;
un groupe alkyle en C_1-C_{60}, un groupe alcényle en C_2-C_{60}, un groupe alcynyle en C_2-C_{60}, et un groupe alcoxy en C_1-C_{60}, chacun substitué par au moins l'un sélectionné parmi le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryloxy en C_6-C_{60}, un groupe arylthio en C_6-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, $-Si(Q_{11})(Q_{12})(Q_{13})$, $-N(Q_{11})(Q_{12})$, $-B(Q_{11})(Q_{12})$, $-C(=O)(Q_{11})$, $-S(=O)_2(Q_{11})$, et $-P(=O)(Q_{11})(Q_{12})$;
un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryloxy en C_6-C_{60}, un groupe arylthio en C_6-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, un groupe biphényle et un groupe terphényle ;
un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryloxy en C_6-C_{60}, un groupe arylthio en C_6-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, un groupe biphényle et un groupe terphényle, chacun substitué par au moins l'un sélectionné parmi le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe alkyle en C_1-C_{60}, un groupe alcényle en C_2-C_{60}, un groupe alcynyle en C_2-C_{60}, un groupe alcoxy en C_1-C_{60}, un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryloxy en C_6-C_{60}, un groupe arylthio en C_6-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, un groupe biphényle, un groupe terphényle, $-Si(Q_{21})(Q_{22})(Q_{23})$, $-N(Q_{21})(Q_{22})$, $-B(Q_{21})(Q_{22})$, $-C(=O)(Q_{21})$, $-S(=O)_2(Q_{21})$, et $-P(=O)(Q_{21})(Q_{22})$; et
$-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, $-B(Q_{31})(Q_{32})$, $-C(=O)(Q_{31})$, $-S(=O)_2(Q_{31})$, et $-P(=O)(Q_{31})(Q_{32})$;
Q_1 à Q_3, Q_{11} à Q_{13}, Q_{21} à Q_{23}, et Q_{31} à Q_{33} sont chacun indépendamment sélectionnés parmi l'hydrogène, le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe alkyle en C_1-C_{60}, un groupe alcényle en C_2-C_{60}, un groupe alcynyle en C_2-C_{60}, un groupe alcoxy en C_1-C_{60}, un groupe cycloalkyle en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcényle en C_3-C_{10}, un groupe hétérocycloalcényle en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryle en C_6-C_{60}, substitué avec un groupe alkyle en C_1-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, un groupe biphényle, et un groupe terphényle, et
* et *' indiquent chacun un site de liaison à un atome voisin.

8. Composé hétérocyclique selon la revendication 7, dans lequel
A_1 est sélectionné parmi un groupe benzène, un groupe pentalène, un groupe indène, un groupe naphtalène, un

groupe azulène, un groupe heptalène, un groupe indacène, un groupe acénaphtalène, un groupe fluorène, un groupe spiro-bifluorène, un groupe spiro-benzofluorène-fluorène, un groupe benzofluorène, un groupe dibenzofluorène, un groupe phénalène, un groupe phénanthrène, un groupe anthracène, un groupe fluoranthène, un groupe pyrène, un groupe chrysène, un groupe naphtacène, un groupe picène, un groupe périylène, un groupe pyrrole, un groupe thiophène, un groupe furane, un groupe silole, un groupe imidazole, un groupe pyrazole, un groupe thiazole, un groupe isothiazole, un groupe oxazole, un groupe isoxazole, un groupe pyridine, un groupe pyrazine, un groupe pyrimidine, un groupe pyridazine, un groupe triazine, un groupe benzofurane, un groupe benzothiophène, un groupe dibenzofurane, un groupe dibenzothiophène, un groupe carbazole, un groupe benzosilole, un groupe dibenzosilole, un groupe quinoline, un groupe isoquinoline, un groupe benzimidazole, un groupe imidazopyridine, et un groupe imidazopyrimidine ;

un groupe benzène, un groupe pentalène, un groupe indène, un groupe naphtalène, un groupe azulène, un groupe heptalène, un groupe indacène, un groupe acénaphtalène, un groupe fluorène, un groupe spiro-bifluorène, un groupe spiro-benzofluorène-fluorène, un groupe benzofluorène, un groupe dibenzofluorène, un groupe phénalène, un groupe phénanthrène, un groupe anthracène, un groupe fluoranthène, un groupe pyrène, un groupe chrysène, un groupe naphtacène, un groupe picène, un groupe périylène, un groupe pyrrole, un groupe thiophène, un groupe furane, un groupe silole, un groupe imidazole, un groupe pyrazole, un groupe thiazole, un groupe isothiazole, un groupe oxazole, un groupe isoxazole, un groupe pyridine, un groupe pyrazine, un groupe pyrimidine, un groupe pyridazine, un groupe triazine, un groupe benzofurane, un groupe benzothiophène, un groupe dibenzofurane, un groupe dibenzothiophène, un groupe carbazole, un groupe benzosilole, un groupe dibenzosilole, un groupe quinoline, un groupe isoquinoline, un groupe benzimidazole, un groupe imidazopyridine, et un groupe imidazopyrimidine, chacun substitué avec au moins l'un sélectionné parmi le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe cyclopentyle, un groupe cyclohexyle, un groupe cycloheptyle, un groupe cyclopentényle, un groupe cyclohexényle, un groupe phényle, un groupe biphényle, un groupe terphényle, un groupe pentalényle, un groupe indényle, un groupe naphtyle, un groupe azulényle, un groupe heptalényle, un groupe indacényle, un groupe acénaphtyle, un groupe fluorényle, un groupe spirobifluorényle, un groupe benzofluorényle, un groupe dibenzofluorényle, un groupe phénalényle, un groupe phénanthrényle, un groupe anthracényle, un groupe fluoranthényle, un groupe pyrényle, un groupe chrysényle, un groupe naphtacényle, un groupe picényle, un groupe périylényle, un groupe pentaphényle, un groupe hexacényle, un groupe pentacényle, un groupe rubicényle, un groupe coronényle, un groupe ovalényle, un groupe pyrrolyle, un groupe thiophényle, un groupe furanyle, un groupe pyridynile, un groupe pyrazinyle, un groupe pyrimidinyle, un groupe pyridazinyle, un groupe quinolinyle, un groupe isoquinolinyle, un groupe benzofuranyle, un groupe benzothiophényle, un $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, et $-B(Q_{31})(Q_{32})$, et

Q_{31} à Q_{33} sont chacun indépendamment sélectionnés parmi un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe phényle, un groupe biphényle, un groupe terphényle, un groupe naphtyle, et un groupe pyridinyle.

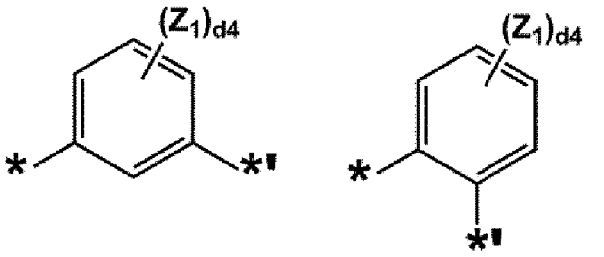
9. Composé hétérocyclique selon la revendication 7 ou la revendication 8, dans lequel :
X_1 et X_2 sont chacun indépendamment $C(R_8)$; et/ou L_1 est sélectionné à partir de :

un groupe benzène, un groupe pentalène, un groupe indène, un groupe naphtalène, un groupe azulène, un groupe heptalène, un groupe indacène, un groupe acénaphtalène, un groupe fluorène, un groupe spiro-bifluorène, un groupe spiro-benzofluorène-fluorène, un groupe benzofluorène, un groupe dibenzofluorène, un groupe phénalène, un groupe phénanthrène, un groupe anthracène, un groupe fluoranthrène, un groupe pyrène, un groupe chrysène, un groupe naphtacène, un groupe picène, un groupe périylène, un groupe pyrrole, un groupe thiophène, un groupe furane, un groupe silole, un groupe imidazole, un groupe pyrazole, un groupe thiazole, un groupe isothiazole, un groupe oxazole, un groupe isoxazole, un groupe pyridine, un groupe pyrazine, un groupe pyrimidine, un groupe pyridazine, un groupe triazine, un groupe benzofurane, un groupe benzothiophène, un groupe dibenzofurane, un groupe dibenzothiophène, un groupe carbazole, un groupe benzosilole, un groupe dibenzosilole, un groupe quinoline, un groupe isoquinoline, un groupe benzimidazole, un groupe imidazopyridine, et un groupe imidazopyrimidine ; et

un groupe benzène, un groupe pentalène, un groupe indène, un groupe naphtalène, un groupe azulène, un groupe heptalène, un groupe indacène, un groupe acénaphtalène, un groupe fluorène, un groupe spiro-bifluorène, un groupe spiro-benzofluorène-fluorène, un groupe benzofluorène, un groupe dibenzofluorène, un groupe phénalène, un groupe phénanthrène, un groupe anthracène, un groupe fluoranthrène, un groupe pyrène, un groupe chrysène, un groupe naphtacène, un groupe picène, un groupe périylène, un groupe pyrrole, un groupe thiophène, un groupe furane, un groupe silole, un groupe imidazole, un groupe pyrazole, un groupe thiazole, un groupe isothiazole, un groupe oxazole, un groupe isoxazole, un groupe pyridine, un groupe pyrazine, un groupe pyrimidine, un groupe pyridazine, un groupe triazine, un groupe benzofurane, un groupe benzothiophène, un groupe dibenzofurane, un groupe dibenzothiophène, un groupe carbazole, un groupe benzosilole, un groupe

dibenzosilole, un groupe quinoline, un groupe isoquinoline, un groupe benzimidazole, un groupe imidazopyridine, et un groupe imidazopyrimidine, chacun substitué avec au moins l'un sélectionné parmi le deutérium, le -Cl, -B, -I, un groupe hydroxyle, un groupe cyano, un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe cyclopentyle, un groupe cyclohexyle, un groupe cycloheptyle, un groupe cyclopenténylе, un groupe cyclohexénylе, un groupe phénylе, un groupe biphénylе, un groupe terphénylе, un groupe pentalénylе, un groupe indénylе, un groupe naphtylе, un groupe azulénylе, un groupe heptalénylе, un groupe indacénylе, un groupe acénaphtylе, un groupe fluorénylе, un groupe spiro-bifluorénylе, un groupe benzofluorénylе, un groupe dibenzofluorénylе, un groupe phénalénylе, un groupe phénanthrénylе, un groupe anthracénylе, un groupe fluoranthénylе, un groupe pyrénylе, un groupe chrysénylе, un groupe naphtacénylе, un groupe picénylе, un groupe pérylénylе, un groupe pentaphénylе, un groupe hexacénylе, un groupe pentacénylе, un groupe rubicénylе, un groupe coronénylе, un groupe ovalénylе, un groupe pyrrolylе, un groupe thiophénylе, un groupe furanylе, un groupe pyridinylе, un groupe pyrazinylе, un groupe pyrimidinylе, un groupe pyridazinylе, un groupe quinolinylе, un groupe isoquinolinylе, un groupe benzofuranylе, un groupe benzothiophénylе, un $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, et $-B(Q_{31})(Q_{32})$, et
Q_{31} à Q_{33} sont chacun indépendamment sélectionnés parmi un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe phénylе, un groupe biphénylе, un groupe terphénylе, un groupe naphtylе, et un groupe pyridinylе.

10. Composé hétérocyclique selon l'une quelconque des revendications 7 à 9, dans lequel :
L_1 est sélectionné parmi des groupes représentés par les Formules 3-1 ou 3-2 :



3-1 3-2 ,

dans lequel, dans les Formules 3-1 et 3-2,

Z_1 est sélectionné parmi l'hydrogène, le deutérium, -F, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe cyclopentyle, un groupe cyclohexyle, un groupe cycloheptyle, un groupe cyclopenténylе, un groupe cyclohexénylе, un groupe phénylе, un groupe biphénylе, un groupe terphénylе, un groupe naphtylе, un groupe fluorénylе, un groupe spiro-bifluorénylе, un groupe benzofluorénylе, un groupe dibenzofluorénylе, un groupe phénanthrénylе, un groupe anthracénylе, un groupe fluoranthénylе, un groupe pyrénylе, un groupe chrysénylе, un groupe pyrrolylе, un groupe thiophénylе, un groupe furanylе, un groupe silolylе, un groupe imidazolylе, un groupe pyrazolylе, un groupe thiazolylе, un groupe isothiazolylе, un groupe oxazolylе, un groupe isoxazolylе, un groupe pyridinylе, un groupe pyrazinylе, un groupe pyrimidinylе, un groupe pyridazinylе, un groupe benzofuranylе, un groupe benzothiophénylе, un groupe benzosilolylе, un groupe dibenzosilolylе, et $-Si(Q_{31})(Q_{32})(Q_{33})$,
Q_{31} à Q_{33} sont chacun indépendamment sélectionnés parmi un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe phénylе, un groupe biphénylе, un groupe terphénylе, un groupe naphtylе, et un groupe pyridinylе,
d4 est un nombre entier de 0 à 4, et
* et *' indiquent chacun un site de liaison à un atome voisin.

11. Composé hétérocyclique selon l'une quelconque des revendications 7 à 10, dans lequel
L_{11} est une liaison simple, ou $*-C(R_{10})(R_{11})-*'$, et
R_{10} et R_{11} sont chacun indépendamment sélectionnés parmi :

l'hydrogène, le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amino, un groupe amidino, un groupe hydrazino, un groupe hydrazono, et un groupe alkyle en C_1-C_{20} ; et
un groupe alkyle en C_1-C_{20} substitué avec au moins l'un sélectionné parmi le deutérium, -Cl, -Br, -I, un groupe hydroxyle et un groupe cyano.

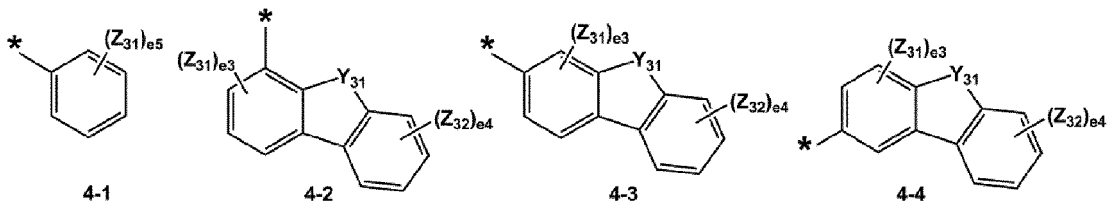
12. Composé hétérocyclique selon l'une quelconque des revendications 7 à 11, dans lequel Ar_1 est sélectionné parmi :

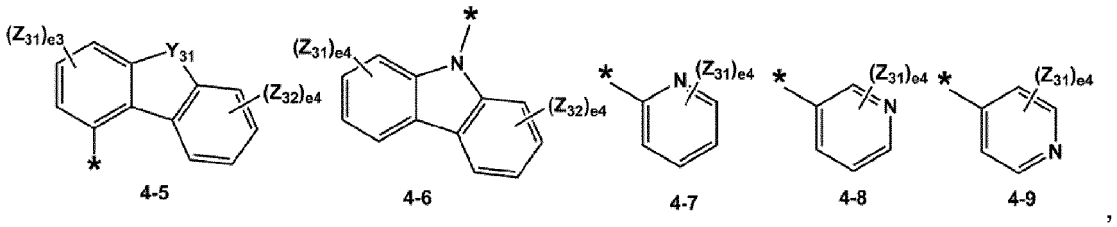
un groupe benzène, un groupe pentalène, un groupe indène, un groupe naphtalène, un groupe azulène, un groupe heptalène, un groupe indacène, un groupe acénaphtalène, un groupe fluorène, un groupe spiro-bifluorène, un groupe spiro-benzofluorène-fluorène, un groupe benzofluorène, un groupe dibenzofluorène, un groupe phénalène, un groupe phénanthrène, un groupe anthracène, un groupe fluoranthène, un groupe pyrène, un groupe chrysène, un groupe naphtacène, un groupe picène, un groupe pérylène, un groupe pyrrole, un groupe thiophène, un groupe furane, un groupe silole, un groupe imidazole, un groupe pyrazole, un groupe thiazole, un groupe isothiazole, un groupe oxazole, un groupe isoxazole, un groupe pyridine, un groupe pyrazine, un groupe pyrimidine, un groupe pyridazine, un groupe triazine, un groupe benzofurane, un groupe benzothiophène, un groupe dibenzofurane, un groupe dibenzothiophène, un groupe carbazole, un groupe benzosilole, un groupe dibenzosilole, un groupe quinoline, un groupe isoquinoline, un groupe benzimidazole, un groupe imidazopyridine, et un groupe imidazopyrimidine ; et

un groupe benzène, un groupe pentalène, un groupe indène, un groupe naphtalène, un groupe azulène, un groupe heptalène, un groupe indacène, un groupe acénaphtalène, un groupe fluorène, un groupe spiro-bifluorène, un groupe spiro-benzofluorène-fluorène, un groupe benzofluorène, un groupe dibenzofluorène, un groupe phénalène, un groupe phénanthrène, un groupe anthracène, un groupe fluoranthrène, un groupe pyrène, un groupe chrysène, un groupe naphtacène, un groupe picène, un groupe pérylène, un groupe pyrrole, un groupe thiophène, un groupe furane, un groupe silole, un groupe imidazole, un groupe pyrazole, un groupe thiazole, un groupe isothiazole, un groupe oxazole, un groupe isoxazole, un groupe pyridine, un groupe pyrazine, un groupe pyrimidine, un groupe pyridazine, un groupe triazine, un groupe benzofurane, un groupe benzothiophène, un groupe dibenzofurane, un groupe dibenzothiophène, un groupe carbazole, un groupe benzosilole, un groupe dibenzosilole, un groupe quinoline, un groupe isoquinoline, un groupe benzimidazole, un groupe imidazopyridine, et un groupe imidazopyrimidine, chacun substitué avec au moins l'un sélectionné parmi le deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe cyclopentyle, un groupe cyclohexyle, un groupe cycloheptyle, un groupe cyclopentényle, un groupe cyclohexényle, un groupe phényle, un groupe biphényle, un groupe terphényle, un groupe pentalényle, un groupe indényle, un groupe naphtyle, un groupe azulényle, un groupe heptalényle, un groupe indacényle, un groupe acénaphtyle, un groupe fluorényle, un groupe spiro-fluorényle, un groupe benzofluorényle, un groupe dibenzofluorényle, un groupe phénalényle, un groupe phénanthrényle, un groupe anthracényle, un groupe fluoranthényle, un groupe pyrényle, un groupe chrysényle, un groupe naphtacényle, un groupe picényle, un groupe pérylényle, un groupe pentaphényle, un groupe hexacényle, un groupe pentacényle, un groupe rubicényle, un groupe coronényle, un groupe ovalényle, un groupe pyrrolyle, un groupe thiophényle, un groupe furanyle, un groupe pyridinyle, un groupe pyrazinyle, un groupe pyrimidinyle, un groupe pyridazinyle, un groupe quinolinyle, un groupe isoquinolinyle, un groupe benzofuranyle, un groupe benzothiophényle, $-Si(Q_{31})(Q_{32})(Q_{33})$, $-N(Q_{31})(Q_{32})$, et $-B(Q_{31})(Q_{32})$, et

Q_{31} à Q_{33} sont chacun indépendamment sélectionnés parmi un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe phényle, un groupe biphényle, un groupe terphényle, un groupe naphtyle, et un groupe pyridinyle.

13. Composé hétérocyclique selon l'une quelconque des revendications 7 à 12, dans lequel Ar_1 est représenté par une des Formules 4-1 à 4-9 :





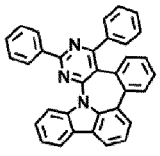
dans lequel, dans les Formules 4-1 à 4-9,

Y_{31} est un O, S, $C(Z_{33})(Z_{34})$, $N(Z_{35})$ ou $Si(Z_{36})(Z_{37})$,
Z_{31} à Z_{37} sont chacun indépendamment sélectionnés parmi un hydrogène, un deutérium, -F, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe cyclopentyle, un groupe cyclohexyle, un groupe cycloheptyle, un groupe cyclopenténylе, un groupe cyclohexénylе, un groupe phényle, un groupe biphényle, un groupe terphényle, un groupe naphtyle, un groupe fluorényle, un groupe spiro-bifluorényle, un groupe benzofluorényle, un groupe dibenzofluorényle, un groupe phénanthrényle, un groupe anthracényle, un groupe fluoranthényle, un groupe pyrényle, un groupe chrysényle, un groupe pyrrolyle, un groupe thiophényle, un groupe furanyle, un groupe silolyle, un groupe imidazolyle, un groupe pyrazolyle, un groupe thiazolyle, un groupe isothiazolyle, un groupe oxazolyle, un groupe isoxazolyle, un groupe pyridinyle, un groupe pyrazinyle, un groupe pyrimidinyle, un groupe pyridazinyle, un groupe benzofuranyle, un groupe benzothiophényle, un groupe dibenzofuranyle, un groupe dibenzothiophényle, un groupe carbazolyle, un groupe benzosilolyle, un groupe dibenzosilolyle, et $-Si(Q_{31})(Q_{32})(Q_{33})$,
Q_{31} à Q_{33} sont chacun indépendamment sélectionnés parmi un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe phényle, un groupe biphényle, un groupe terphényle, un groupe naphtyle, et un groupe pyridinyle.
e3 est un nombre entier de 0 à 3,
e4 est un nombre entier de 0 à 4,
e5 est un nombre entier de 0 à 5, et
* indique un site de liaison à un atome voisin, optionnellement dans lequel
Z_{31} à Z_{37} sont chacun indépendamment sélectionnés parmi l'hydrogène, un groupe cyano, un groupe alkyle en C_1-C_{20}, un groupe phényle, un groupe dibenzofuranyle, un groupe dibenzothiophényle, un groupe carbazolyle, et $-Si(Q_{31})(Q_{32})(Q_{33})$, et
Q_{31} à Q_{33} sont chacun indépendamment sélectionnés parmi un groupe alkyle en C_1-C_{20}, un groupe alcoxy en C_1-C_{20}, un groupe phényle, un groupe biphényle, un groupe terphényle, un groupe naphtyle, et un groupe pyridinyle.

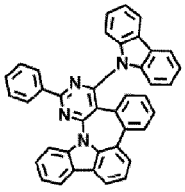
14. Composé hétérocyclique selon l'une quelconque des revendications 7 à 13, dans lequel

(A) R_1 à R_{11} sont chacun indépendamment sélectionnés dans un groupe représenté par la Formule 2, de l'hydrogène, un deutérium, -Cl, -Br, -I, un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amino, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe alkyle en C_1-C_{20}, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-S(=O)_2(Q_1)$, et $-P(=O)(Q_1)(Q_2)$; et
un groupe alkyle en C_1-C_{20} substitué par au moins l'un sélectionné parmi le deutérium, -Cl, -Br, -I, un groupe hydroxyle et un groupe cyano, et
Q_{31} à Q_{33} sont chacun indépendamment sélectionnés parmi l'hydrogène, le deutérium, -Cl, -Br, -I, d'un groupe hydroxyle, un groupe cyano, un groupe nitro, un groupe amidino, un groupe hydrazino, un groupe hydrazono, un groupe alkyle en C_1-C_{60}, un groupe alcényle en C_2-C_{60}, un groupe alcynyle en C_2-C_{60}, un groupe alcoxy en C_1-C_{60}, un groupe cycloalcoxy en C_3-C_{10}, un groupe hétérocycloalkyle en C_1-C_{10}, un groupe cycloalcénylе en C_3-C_{10}, un groupe hétérocycloalcénylе en C_1-C_{10}, un groupe aryle en C_6-C_{60}, un groupe aryle en C_6-C_{60} substitué par un groupe alkyle en C_1-C_{60}, un groupe hétéroaryle en C_1-C_{60}, un groupe polycyclique condensé non-aromatique monovalent, un groupe hétéropolycyclique condensé non-aromatique monovalent, un groupe biphényle, et un groupe terphényle ; et/ou
(B) R_1 à R_7 sont de l'hydrogène.

15. Composé hétérocyclique selon la revendication 7, dans lequel :
le composé hétérocyclique est sélectionné parmi les Composés 1 à 30 :



1



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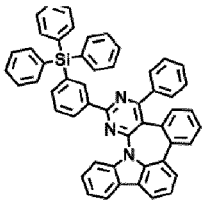

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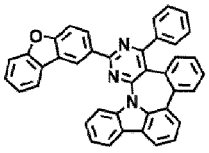

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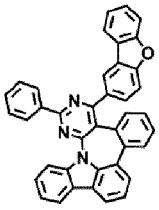

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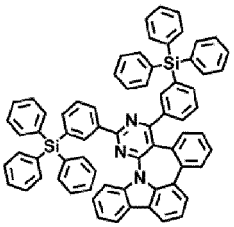

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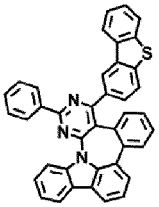

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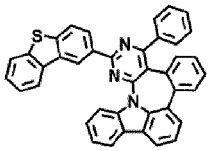

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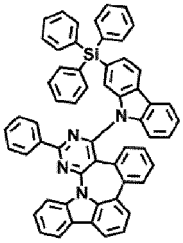

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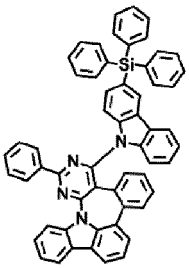

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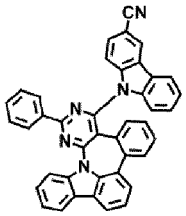

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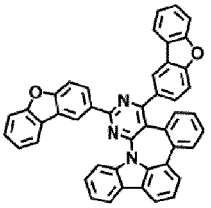

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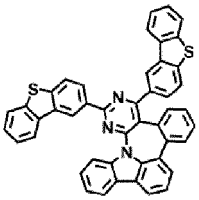

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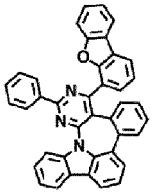

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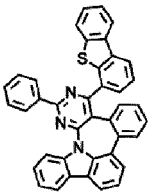

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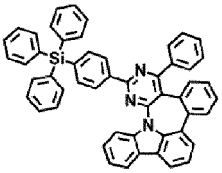

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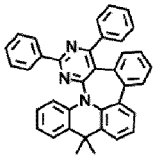

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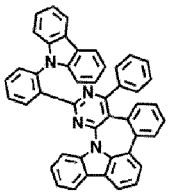

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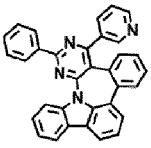

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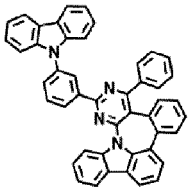

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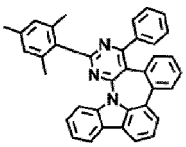

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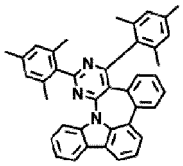

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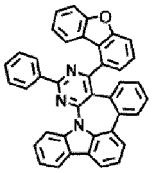

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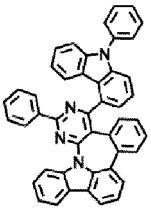

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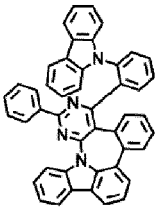

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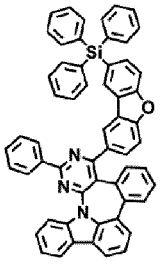

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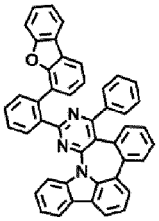

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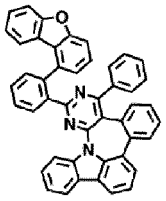

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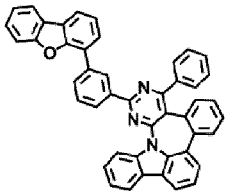

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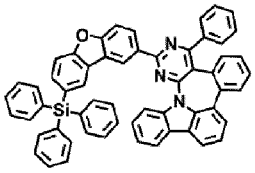

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FIG. 1

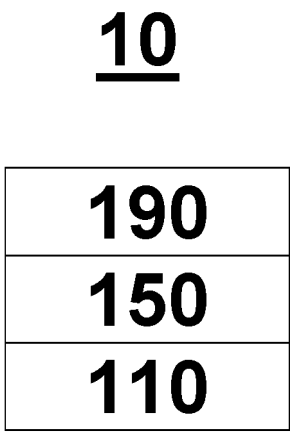


FIG. 2

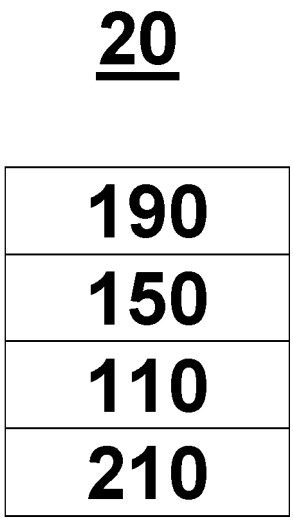


FIG. 3

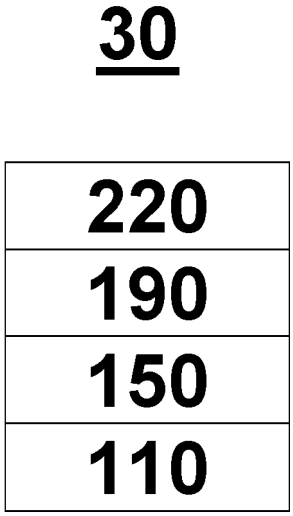
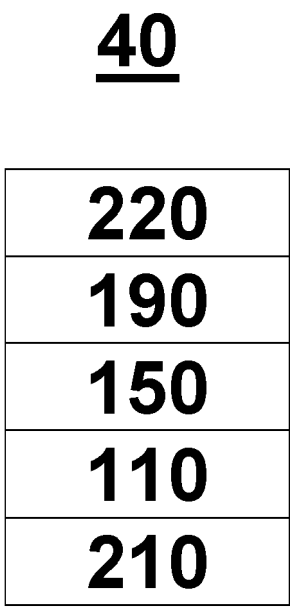


FIG. 4



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- US 2016163998 A1 **[0004]**