



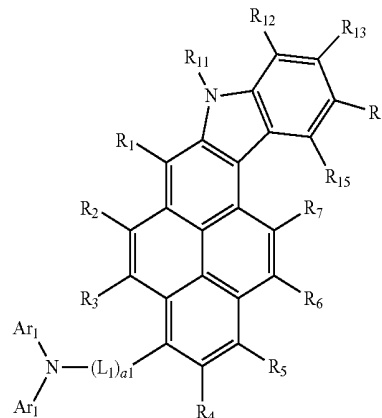
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Hwang et al.(10) **Pub. No.: US 2015/0263293 A1**(43) **Pub. Date: Sep. 17, 2015**(54) **CONDENSED CYCLIC COMPOUND AND
ORGANIC LIGHT-EMITTING DEVICE
COMPRISING THE SAME****C07F 7/0812** (2013.01); **C07D 405/12**
(2013.01); **H01L 51/5088** (2013.01)(71) Applicant: **SAMSUNG DISPLAY CO., LTD.**,
Yongin-City (KR)(57) **ABSTRACT**

A condensed cyclic compound represented by Formula 1:

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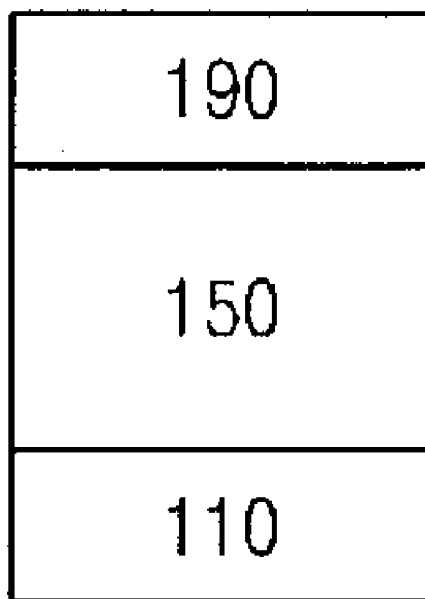
Formula 1

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(2013.01); **H01L 51/0094** (2013.01); **H01L**
51/0073 (2013.01); **C07D 209/56** (2013.01);

Also disclosed is an organic light-emitting device including a first electrode; a second electrode; and an organic layer between the first electrode and the second electrode, the organic layer including an emission layer and the condensed cyclic compound of Formula 1. An organic light-emitting device including the condensed cyclic compound of Formula 1 may have low driving voltage, high efficiency, a high luminance, and long lifetime.

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

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2014-0029762, filed on Mar. 13, 2014, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] One or more aspects of embodiments of the present disclosure relate to a condensed cyclic compound and an organic light-emitting device including the same.

[0004] 2. Description of the Related Art

[0005] Organic light-emitting devices (OLEDs) are self-emitting devices that can provide multicolored images. Advantages of OLEDs include wide viewing angles, excellent contrast, quick response, high brightness, and excellent driving voltage characteristics.

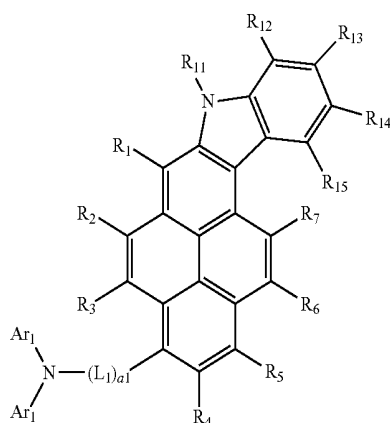
[0006] An organic light-emitting device may have a structure in which a first electrode, a hole transport region, an emission layer, an electron transport region, and a second electrode are sequentially stacked on a substrate. Holes injected from the first electrode move to the emission layer via the hole transport region, while electrons injected from the second electrode move to the emission layer via the electron transport region. Holes and electrons recombine in the emission layer to generate excitons. When the excitons drop from an excited state to a ground state, light is emitted.

SUMMARY

[0007] Aspects of one or more embodiments of the present disclosure are directed toward a novel condensed cyclic compound and an organic light-emitting device including the same.

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

[0009] According to one or more embodiments of the present disclosure, there is provided a condensed cyclic compound represented by Formula 1:



Formula 1

[0010] In Formula 1,

[0011] R_1 to R_7 , and R_{12} to R_{15} are each independently selected from a hydrogen, a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, and/or a C_1 - C_{60} alkoxy group,

[0012] a C_1 - C_{60} alkyl group and/or a C_1 - C_{60} alkoxy group, each substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof,

[0013] a phenyl group and/or a naphthyl group,

[0014] a phenyl and/or a naphthyl group, each substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_1 - C_{60} alkoxy group, a phenyl group, and a naphthyl group, and

[0015] $-Si(Q_1)(Q_2)(Q_3)$, wherein Q_1 to Q_3 are each independently selected from a C_1 - C_{60} alkyl group and/or a C_1 - C_{60} alkoxy group substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

[0016] at least one of R_1 to R_7 is selected from a C_1 - C_{60} alkyl group,

[0017] a C_1 - C_{60} alkyl group substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

[0018] $-Si(Q_1)(Q_2)(Q_3)$;

[0019] L_1 is selected from a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenylene group, a substituted or unsubstituted C_6 - C_{60} arylene group, a substituted or unsubstituted C_2 - C_{60} heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group;

[0020] a_1 is an integer selected from 0, 1, 2, and 3;

[0021] R_{11} is selected from a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_2 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_2 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group; and

[0022] Ar_1 and Ar_2 are each independently selected from a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a sub-

stituted or unsubstituted C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₂-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

[0023] wherein at least one substituent of the substituted C₃-C₁₀ cycloalkylene group, the substituted C₂-C₁₀ heterocycloalkylene group, the substituted C₃-C₁₀ cycloalkenylene group, the substituted C₂-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₂-C₆₀ heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C₁-C₆₀ alkyl group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₂-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from

[0024] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group,

[0025] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇), a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group,

[0026] a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a

phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇), and

[0027] —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇),

[0028] wherein Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and/or a monovalent non-aromatic condensed heteropolycyclic group.

[0029] According to one or more embodiments of the present disclosure, an organic light-emitting device includes: a first electrode; a second electrode; and an organic layer between the first electrode and the second electrode, the organic layer including an emission layer and the above-described condensed cyclic compound of Formula 1.

BRIEF DESCRIPTION OF THE DRAWINGS

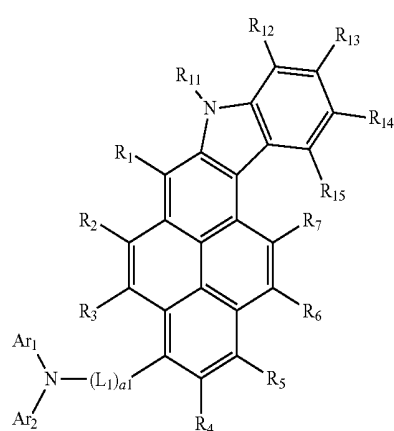
[0030] These and/or other aspects will become apparent and more readily appreciated from the following description of embodiments, taken in conjunction with the accompanying drawings in which:

[0031] The drawing is a schematic view of a structure of an organic light-emitting device according to an embodiment of the present disclosure.

DETAILED DESCRIPTION

[0032] Reference will now be made in detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to the like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of 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 selected from” when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list. Further, the use of “may” when describing embodiments of the present invention refers to “one or more embodiments of the present invention.”

[0033] According to an embodiment of the present disclosure, there is provided a condensed cyclic compound represented by Formula 1:



Formula 1

[0034] In Formula 1,

[0035] R_1 to R_7 , and R_{12} to R_{15} may be each independently selected from

[0036] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, and/or a C_1 - C_{60} alkoxy group,

[0037] a C_1 - C_{60} alkyl group and/or a C_1 - C_{60} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof,

[0038] a phenyl group and/or a naphthyl group,

[0039] a phenyl and/or a naphthyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_1 - C_{60} alkoxy group, a phenyl group, and a naphthyl group, and/or

[0040] —Si(Q_1)(Q_2)(Q_3), wherein Q_1 to Q_3 are each independently selected from a C_1 - C_{60} alkyl group and/or a C_1 - C_{60} alkoxy group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof; and

[0041] at least one of R_1 to R_7 may be selected from

[0042] a C_1 - C_{60} alkyl group,

[0043] a C_1 - C_{60} alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

—Si(Q_1)(Q_2)(Q_3).

[0044] In some embodiments, R_1 to R_7 , and R_{12} to R_{15} may be each independently selected from

[0045] a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, and/or a C_1 - C_{20} alkoxy group,

[0046] a C_1 - C_{20} alkyl group and/or a C_1 - C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

[0047] —Si(Q_1)(Q_2)(Q_3), wherein Q_1 to Q_3 are each independently selected from a C_1 - C_{20} alkyl group and/or a C_1 - C_{20} alkoxy group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof; and

[0048] at least one of R_1 to R_7 may be selected from

[0049] a C_1 - C_{20} alkyl group,

[0050] a C_1 - C_{20} alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

[0051] —Si(Q_1)(Q_2)(Q_3).

[0052] In some other embodiments, any two of R_1 to R_7 may be each independently selected from

[0053] a C_1 - C_{60} alkyl group,

[0054] a C_1 - C_{60} alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

[0055] —Si(Q_1)(Q_2)(Q_3), wherein Q_1 to Q_3 are as defined above.

[0056] In some embodiments, at least one of R_1 to R_5 may be selected from

[0057] a C_1 - C_{20} alkyl group,

[0058] a C_1 - C_{20} alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

[0059] —Si(Q_1)(Q_2)(Q_3), wherein Q_1 to Q_3 are each independently selected from a C_1 - C_{20} alkyl group and/or a C_1 - C_{20} alkoxy group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof. However, embodiments of the present disclosure are not limited thereto.

[0060] In Formula 1, L_1 may be selected from a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkylene group, a substi-

tuted or unsubstituted C₃-C₁₀ cycloalkenylene group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkenylene group, a substituted or unsubstituted C₆-C₆₀ arylene group, a substituted or unsubstituted C₁-C₆₀ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group.

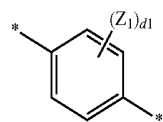
[0061] In some embodiments, L₁ may be selected from

[0062] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoimidazolylene group, a benzofuranylene group, a benzothienophenylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothienophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group, and/or an imidazopyrimidinylene group; and/or

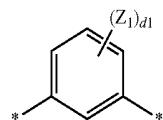
[0063] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an isoxazolylene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolylene group, a purinylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylene group, a phenanthridinylene group, an acridinylene

group, a phenanthrolinylene group, a phenazinylene group, a benzoimidazolylene group, a benzofuranylene group, a benzothienophenylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothienophenylene group, a benzocarbazolylene group, a dibenzocarbazolylene group, a thiadiazolylene group, an imidazopyridinylene group, and/or an imidazopyrimidinylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothienophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothienophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

[0064] In some other embodiments, L₁ may be represented by one of Formulae 3-1 to 3-32, but is not limited thereto:

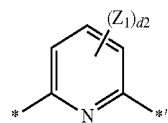


Formula 3-1

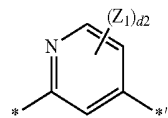


Formula 3-2

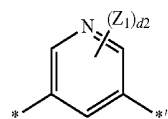
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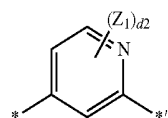
Formula 3-12



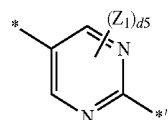
Formula 3-13



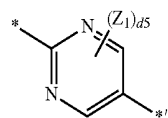
Formula 3-14



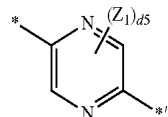
Formula 3-15



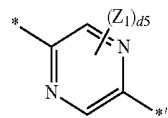
Formula 3-16



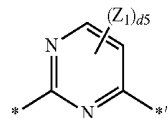
Formula 3-17



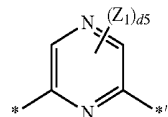
Formula 3-18



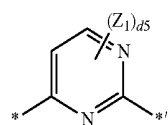
Formula 3-19



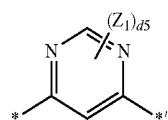
Formula 3-20



Formula 3-21

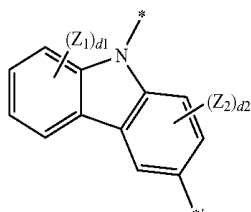
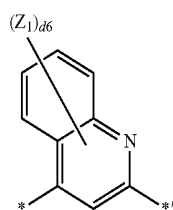
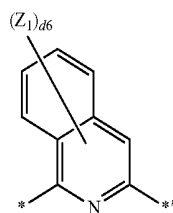
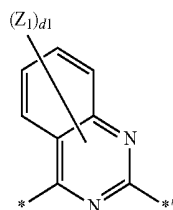
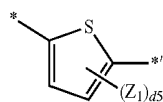
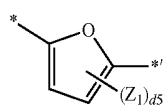
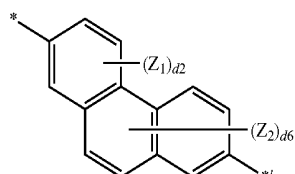
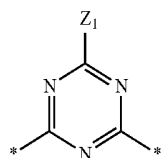


Formula 3-22



Formula 3-23

-continued



Formula 3-24

Formula 3-25

Formula 3-26

Formula 3-27

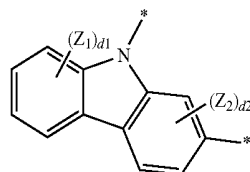
Formula 3-28

Formula 3-29

Formula 3-30

Formula 3-31

-continued



Formula 3-32

[0065] In Formulae 3-1 to 3-32,

[0066] Y_1 may be O, S, C(Z_3)(Z_4), N(Z_5), or Si(Z_6)(Z_7);

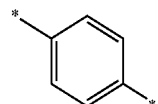
[0067] Z_1 to Z_7 may be each independently be selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group;

[0068] d_1 may be an integer selected from 1 to 4; d_2 may be an integer selected from 1 to 3; d_3 may be an integer selected from 1 to 6; d_4 may be an integer selected from 1 to 8; d_5 may be 1 or 2; d_6 may be an integer selected from 1 to 5; and

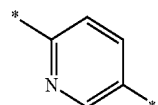
[0069] * and *' may be binding sites with adjacent atoms.

[0070] In some other embodiments, L_1 may be represented by one of Formulae 4-1 to 4-23, but is not limited thereto:

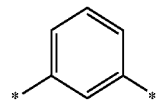
Formula 4-1



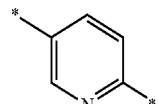
Formula 4-2



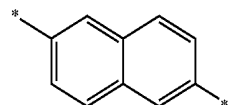
Formula 4-3



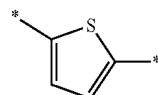
Formula 4-4



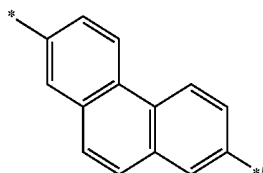
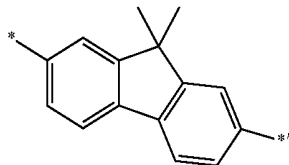
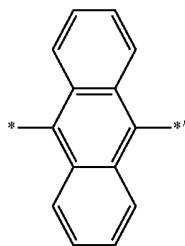
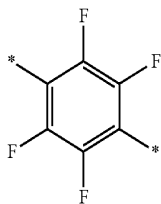
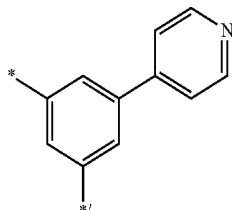
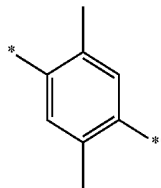
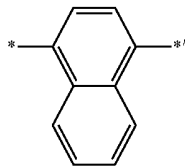
Formula 4-5



Formula 4-6



-continued



Formula 4-7

Formula 4-8

Formula 4-9

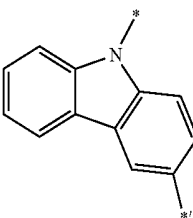
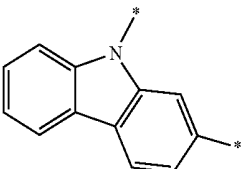
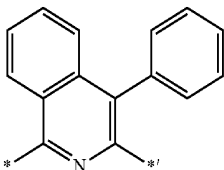
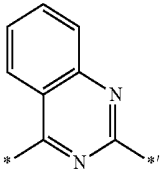
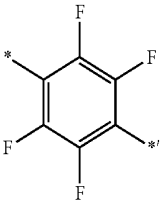
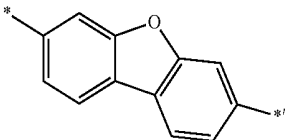
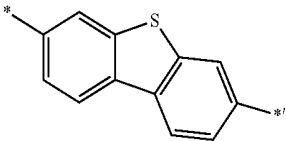
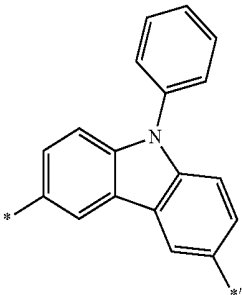
Formula 4-10

Formula 4-11

Formula 4-12

Formula 4-13

-continued



Formula 4-14

Formula 4-15

Formula 4-16

Formula 4-17

Formula 4-18

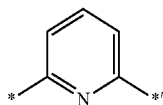
Formula 4-19

Formula 4-20

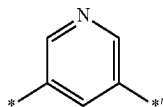
Formula 4-21

-continued

Formula 4-22



Formula 4-23



[0071] In Formulae 4-1 and 4-23, * and *' may be binding sites with adjacent atoms.

[0072] In Formula 1, a_1 , which indicates the number of L_1 s, may be an integer selected from 0 to 3. For example, a_1 may be 0 or 1. When a_1 is 0, $-(L_1)_{a_1}-$ may represent a single bond. When a_1 is 2 or greater, a_1 number of L_1 s may be identical to or different from each other.

[0073] In Formula 1, R_{11} may be selected from a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_2 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group; and

[0074] Ar_1 and Ar_2 may be each independently selected from a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0075] For example, in Formula 1, R_{11} may be selected from a substituted or unsubstituted C_1 - C_{20} alkyl group, a substituted or unsubstituted C_6 - C_{20} aryl group, a substituted or unsubstituted C_2 - C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group; and Ar_1 and Ar_2 may be each independently selected from a substituted or unsubstituted C_5 - C_{20} aryl group, a substituted or unsubstituted C_2 - C_{20} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group. However, embodiments of the present disclosure are not limited thereto.

[0076] In some embodiments, R_{11} , Ar_1 and Ar_2 in Formula 1 may be each independently selected from

[0077] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naph-

thacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and/or an imidazopyrimidinyl group, and/or

[0078] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and/or an imidazopyrimidinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl, a cyclopentenyl, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a

perylene group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and $\text{Si}(\text{Q}_{33})(\text{Q}_{34})(\text{Q}_{35})$,

[0079] wherein Q_{33} to Q_{35} may be each independently selected from a hydrogen, a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino groups, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group.

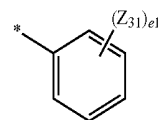
[0080] In some other embodiments, R_{11} , Ar_1 , and Ar_2 in Formula 1 may be each independently selected from a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and/or a dibenzocarbazolyl group, and/or

[0081] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and/or a dibenzocarbazolyl group, each substituted with at least one selected from a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyre-

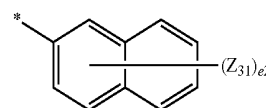
nyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and $-\text{Si}(\text{Q}_{33})(\text{Q}_{34})(\text{Q}_{35})$,

[0082] wherein Q_{33} to Q_{35} may be each independently selected from a hydrogen, a deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino groups, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group.

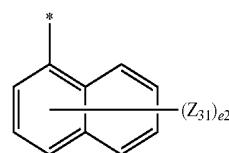
[0083] In some embodiments, R_{11} , Ar_1 , and Ar_2 in Formula 1 may be each independently selected from groups represented by Formulae 5-1 to 5-14:



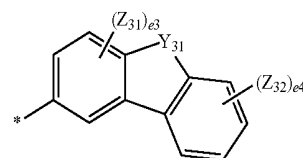
Formula 5-1



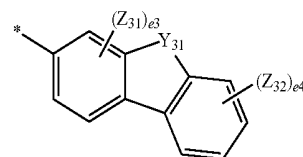
Formula 5-2



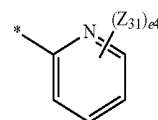
Formula 5-3



Formula 5-4

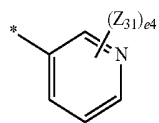


Formula 5-5

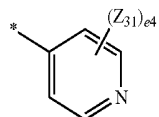


Formula 5-6

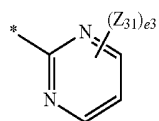
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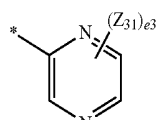
Formula 5-7



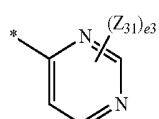
Formula 5-8



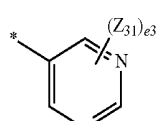
Formula 5-9



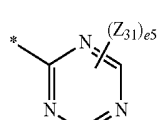
Formula 5-10



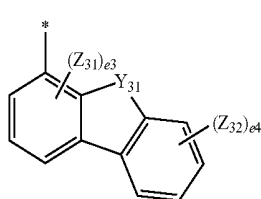
Formula 5-11



Formula 5-12



Formula 5-13



Formula 5-14

[0084] In Formulae 5-1 to 5-14,

[0085] Y_{31} may be O, S, $C(Z_{33})(Z_{34})$, or $N(Z_{35})$;

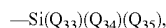
[0086] Z_{31} to Z_{35} are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a C_1 - C_{20} alkyl group, and/or a C_1 - C_{20} alkoxy group,

[0087] a C_1 - C_{20} alkyl group and/or a C_1 - C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof,

[0088] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group,

a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and/or a dibenzocarbazolyl group,

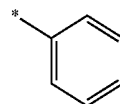
[0089] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and/or a dibenzocarbazolyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, and a naphthyl group, and/or



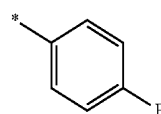
[0090] wherein Q_{33} to Q_{35} may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof,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

[0091] e_1 may be an integer of 1 to 5; e_2 may be an integer of 1 to 7; e_3 may be an integer of 1 to 3; e_4 may be an integer of 1 to 4; e_5 may be 1 or 2; and * may be a binding site with an adjacent atom.

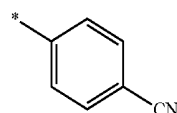
[0092] In some other embodiments, R_{11} , Ar_1 , and Ar_2 in Formula 1 may be each independently selected from groups represented by Formulae 6-1 to 6-22. However, embodiments of the present disclosure are not limited thereto:



Formula 6-1

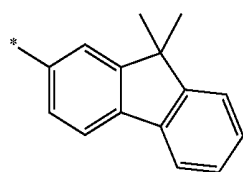
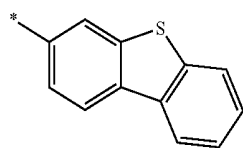
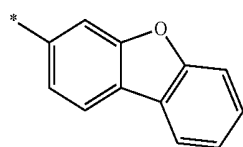
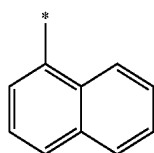
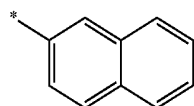
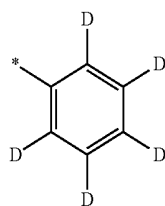
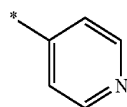
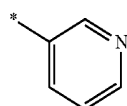
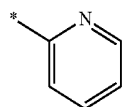
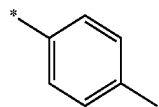


Formula 6-2



Formula 6-3

-continued



Formula 6-4

Formula 6-5

Formula 6-6

Formula 6-7

Formula 6-8

Formula 6-9

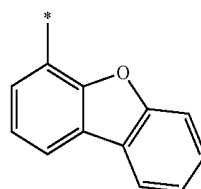
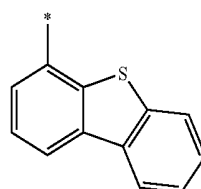
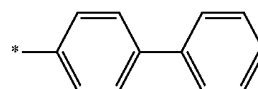
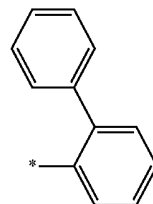
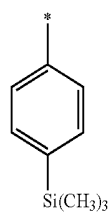
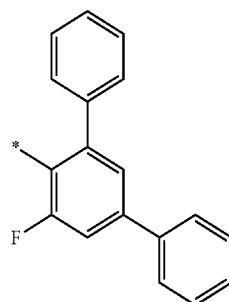
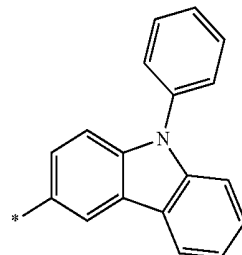
Formula 6-10

Formula 6-11

Formula 6-12

Formula 6-13

-continued



Formula 6-14

Formula 6-15

Formula 6-16

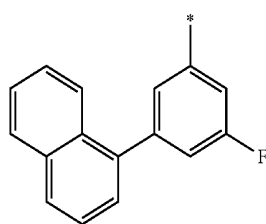
Formula 6-17

Formula 6-18

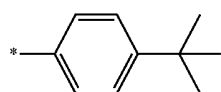
Formula 6-19

Formula 6-20

-continued



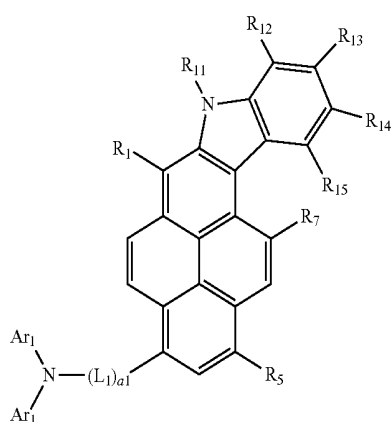
Formula 6-21



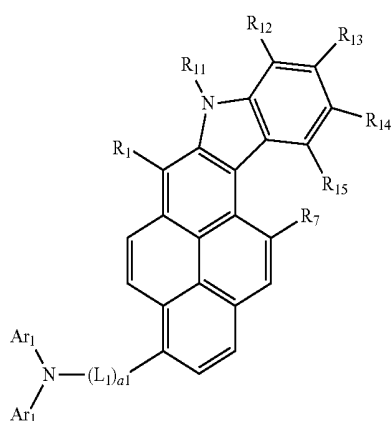
Formula 6-22

[0093] In Formulae 6-1 to 6-22, * may be a binding site with an adjacent atom.

[0094] In some embodiments, the condensed cyclic compound represented by Formula 1 may be represented by one of Formulae 1(1), 1(2), and 1(3):

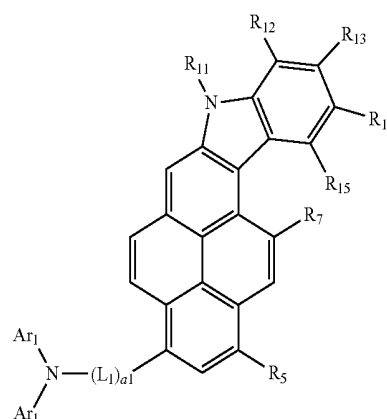


Formula 1(1)



Formula 1(2)

-continued



Formula 1(3)

[0095] In Formulae 1(1), 1(2), and 1(3), R_{11} to R_{15} , L_1 , a_1 , Ar_1 and Ar_2 may be as defined therein.

[0096] For example, in Formulae 1(1), 1(2), and 1(3),

[0097] R_{12} to R_{15} may be each independently selected from a hydrogen, a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, and/or a C_1 - C_{20} alkoxy group;

[0098] L_1 may be selected from groups represented by Formulae 3-1 to 3-32, and in some embodiments from groups represented by Formulae 4-1 to 4-23;

[0099] a_1 may be 0 or 1;

[0100] R_{11} , Ar_1 , and Ar_2 may be each independently selected from groups represented by Formulae 5-1 to 5-14, and in some embodiments from groups represented by Formulae 6-1 to 6-22. However, embodiments of the present disclosure are not limited thereto.

[0101] In Formulae 1(1), 1(2), and 1(3), R_1 and R_5 may be each independently selected from

[0102] a C_1 - C_{60} alkyl group such as, for example, a C_1 - C_{20} alkyl group,

[0103] a C_1 - C_{60} alkyl group substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and/or a phosphoric acid group or a salt thereof such as, for example, a C_1 - C_{20} alkyl group substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof; and/or

[0104] $-Si(Q_1)(Q_2)(Q_3)$, wherein Q_1 to Q_3 may be each independently selected from a C_1 - C_{60} alkyl group such as, for example, a C_1 - C_{20} alkyl group, and/or a C_1 - C_{60} alkyl group substituted with at least one selected from a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof such as, for example, a C_1 - C_{20} alkyl group substituted with at least one selected from a deuterium,

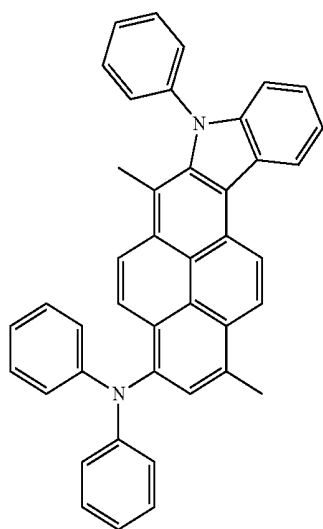
—F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof.

[0105] In some embodiments, R_1 and R_5 may be each independently selected from

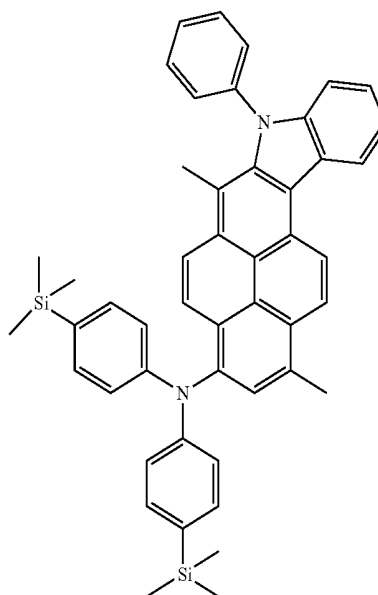
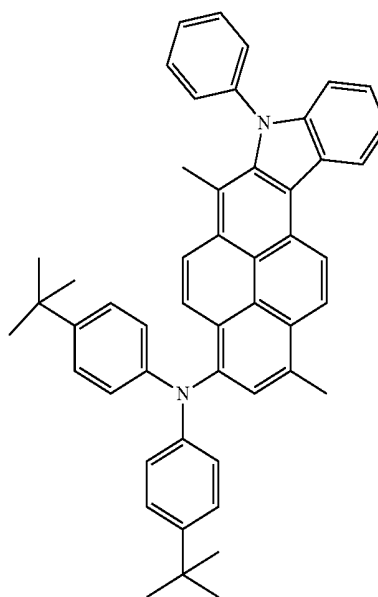
[0106] a methyl group, an ethyl group, a propyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-decanyl group, an isodecanyl group, a sec-decanyl group, and/or a tert-decanyl group, and/or

[0107] $-\text{Si}(\text{Q}_1)(\text{Q}_2)(\text{Q}_3)$, wherein Q_1 to Q_3 may be each independently selected from a methyl group, an ethyl group, a propyl group, an n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an n-pentyl group, an isopentyl group, a sec-pentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, an n-octyl group, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-decanyl group, an isodecanyl group, a sec-decanyl group, and/or a tert-decanyl group.

[0108] In some embodiments, the condensed cyclic compound represented by Formula 1 may be one of Compounds 1 to 21.

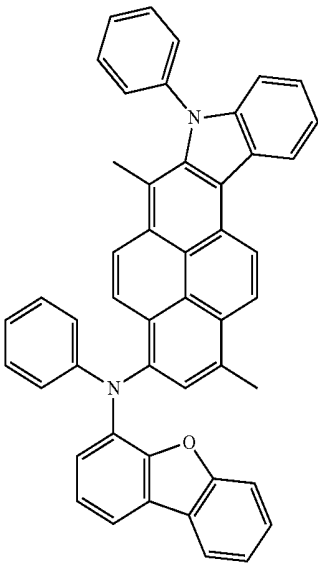


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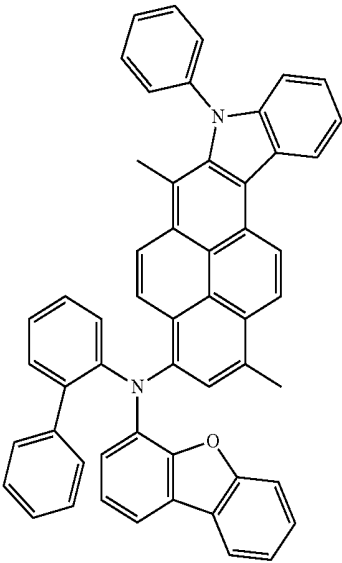
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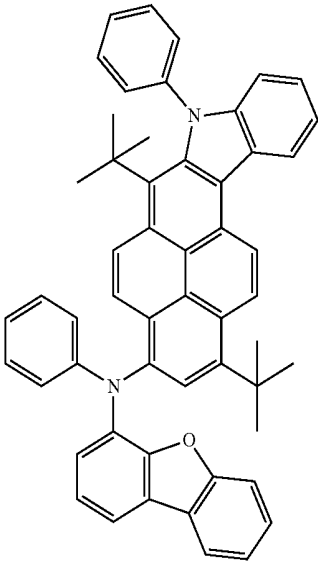
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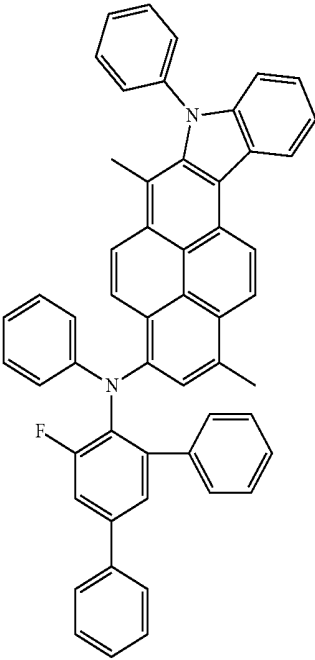
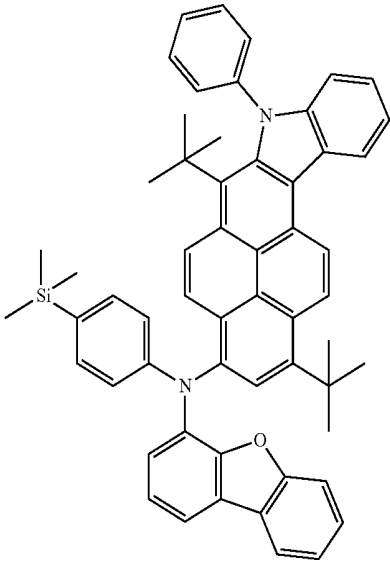
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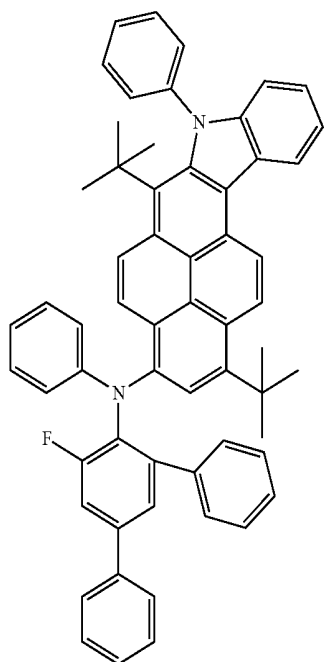
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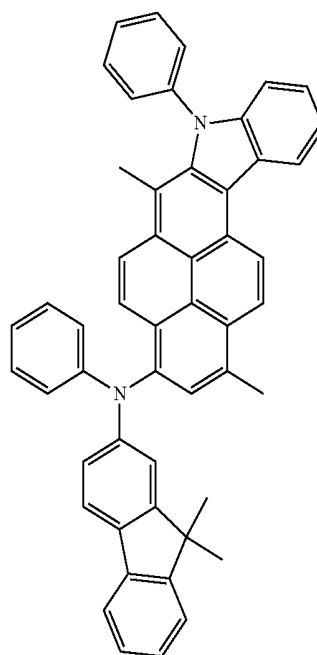
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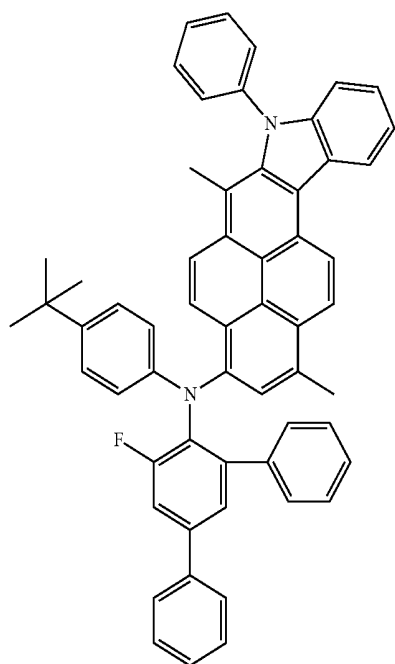
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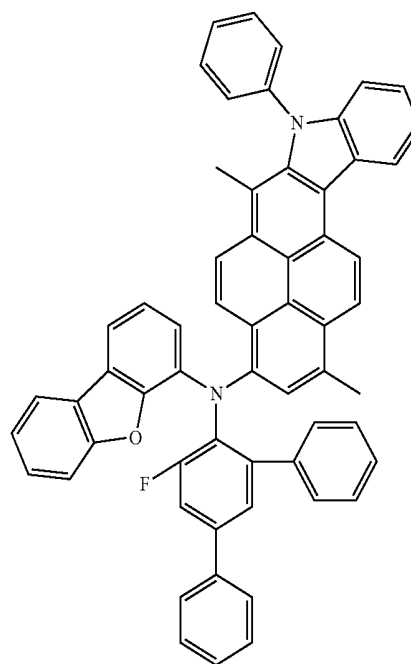


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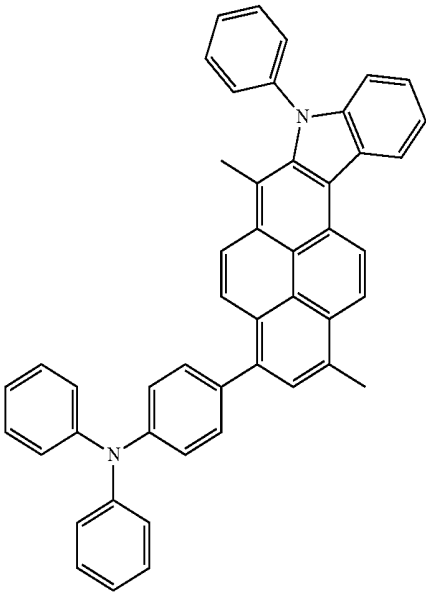
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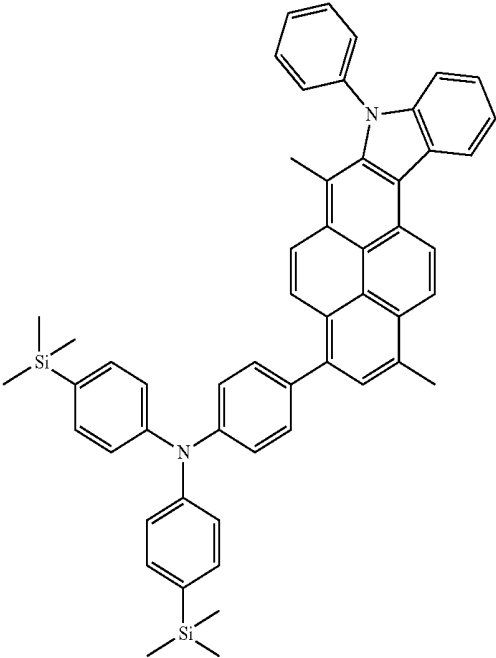


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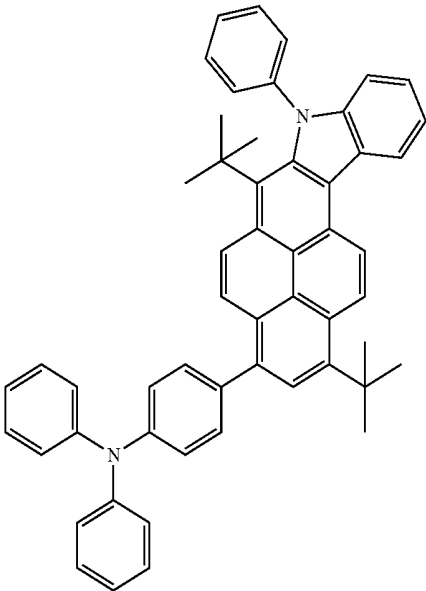
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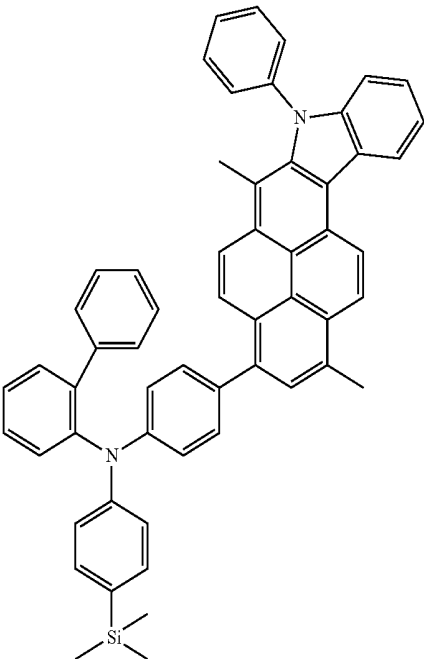


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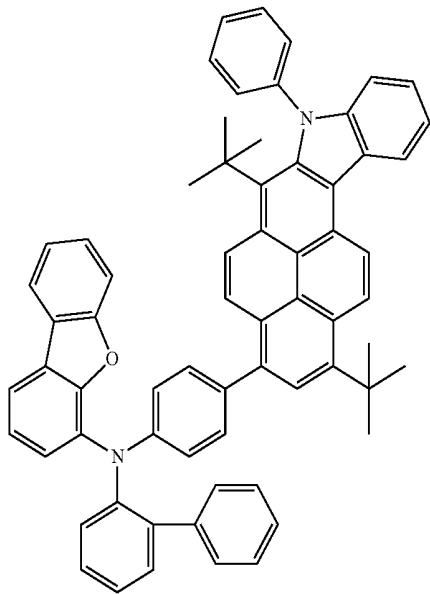


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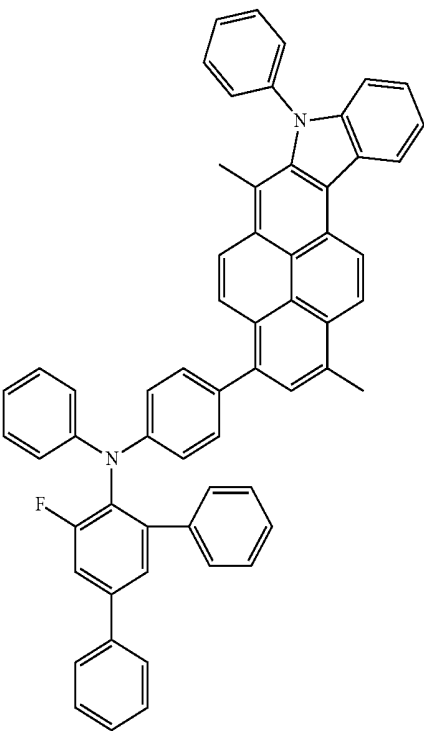
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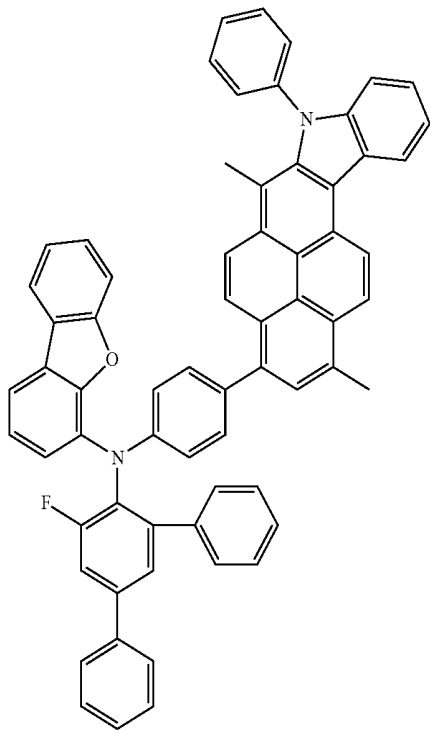
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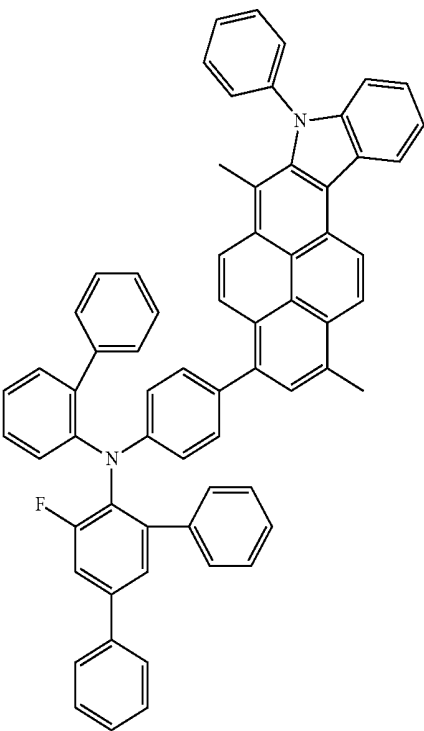


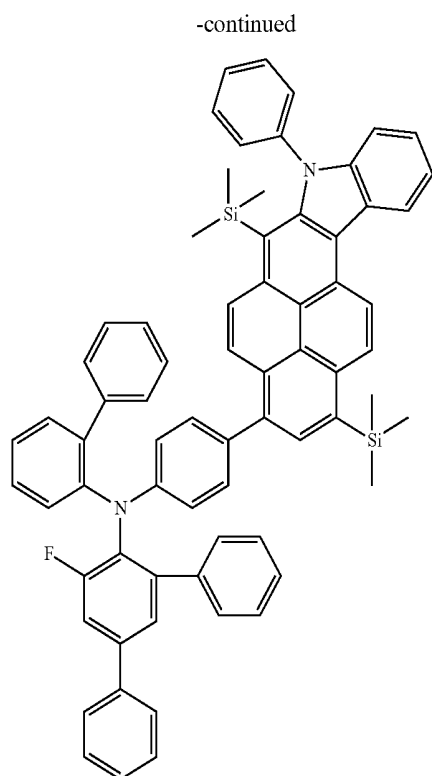
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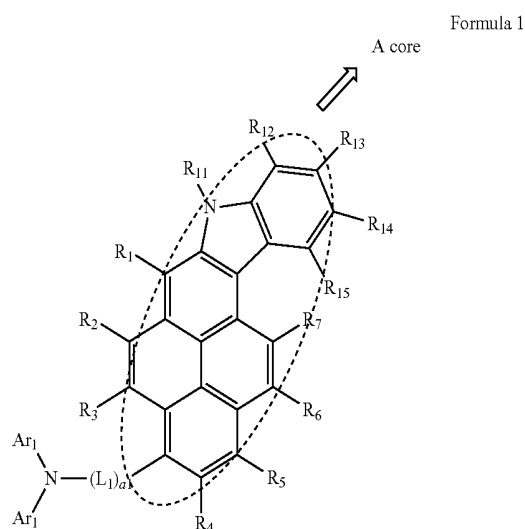


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[0109] The condensed cyclic compound of Formula 1 includes a core as illustrated in the marked-up Formula 1 below, which may facilitate a high glass transition temperature. Accordingly, an organic light-emitting device including the condensed cyclic compound of Formula 1 may have enhanced heat resistance against a Joule heating generated between the organic layers or between the organic layer and the electrode of the organic light-emitting device under high-temperature environments, during storage and/or operation. Accordingly, the organic light-emitting device including the condensed cyclic compound of Formula 1 may have improved lifetime (lifespan) characteristics.



[0110] In Formula 1, at least one of R_1 to R_7 may be selected from a C_1 - C_{60} alkyl group, a C_1 - C_{60} alkyl group substituted with at least one of a deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and/or a phosphoric acid group or a salt thereof, and/or $-Si(Q_1)(Q_2)(Q_3)$, wherein Q_1 to Q_3 may be as defined above.

[0111] When at least one of R_1 to R_7 in Formula 1 is a substituted or unsubstituted C_1 - C_{60} alkyl group as described above, the presence of the substituted or unsubstituted C_1 - C_{60} alkyl group may lead to intramolecular $C-H$ or $C-C$ $\sigma-\pi$ conjugation to generate a new antibonding molecular orbital in a highest occupied molecular orbital (HOMO) region of the molecule. This may extend a π conjugated system, enhance oscillator strength at a transition from the HOMO region to a lowest unoccupied molecular orbital (LUMO) region, and consequently stabilize a singlet state (S_1) energy of the condensed cyclic compound of Formula 1. As a result, fluorescence characteristics of the condensed cyclic compound represented by Formula 1 may be enhanced, which may contribute to improved emission characteristics of the condensed cyclic compound of Formula 1.

[0112] When at least one of R_1 to R_7 in Formula 1 is $-Si(Q_1)(Q_2)(Q_3)$ group as described above, the presence of $-Si(Q_1)(Q_2)(Q_3)$ group may lead to intramolecular $Si-C$ $\sigma^*-\pi^*$ conjugation to stabilize molecular π^* orbital of LUMO. This may extend a π conjugated system, enhance oscillator strength at a transition from the HOMO region to the LUMO region, and consequently stabilize a singlet state (S_1) energy of the condensed cyclic compound of Formula 1. As a result, fluorescence characteristics of the condensed cyclic compound represented by Formula 1 may be enhanced, which may contribute to improved emission characteristics of the condensed cyclic compound of Formula 1.

[0113] Accordingly, an organic light-emitting device including any of the condensed cyclic compounds represented by Formula 1 above may have low driving voltage, high luminance, high efficiency, and long lifetime.

[0114] The condensed cyclic compound of Formula 1 may be synthesized using (utilizing) any suitable organic synthesis method. Methods of synthesizing the condensed cyclic compounds of Formula 1 may be understood by those of ordinary skill in the art based on the examples described below, but methods of synthesizing the condensed cyclic compounds of Formula 1 are not limited to these examples.

[0115] The condensed cyclic compound of Formula 1 may be in a layer between a pair of electrodes of an organic light-emitting device. For example, the condensed cyclic compound of Formula 1 may be in the emission layer.

[0116] According to one embodiment of the present disclosure, an organic light-emitting device includes a first electrode, a second electrode opposite to the first electrode, and an organic layer between the first electrode and the second electrode.

[0117] The organic layer includes an emission layer and at least one of the condensed cyclic compounds of Formula 1 described above.

[0118] As used herein, "the organic layer including at least one condensed cyclic compound means "the organic layer including one of the condensed cyclic compounds of Formula 1 above, or at least two different condensed cyclic compounds of Formula 1 above".

[0119] In some embodiments, the organic layer may include only Compound 1 above as the condensed cyclic compound, and Compound 1 may be present in the emission layer of the organic light-emitting device. In some embodiments, the organic layer may include Compounds 1 and 2 as the condensed cyclic compounds, and Compounds 1 and 2 may be both present in the same layer (for example, in the emission layer) or may be present in different layers (for example, in the emission layer and the electron transport layer, respectively).

[0120] The organic layer may include i) a hole transport region between the first electrode (e.g. an anode) and the emission layer, the hole transport region including at least one selected from a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer; and ii) an electron transport region between the emission layer and the second electrode (e.g. a cathode), the electron transport region including at least one selected from a hole blocking layer, an electron transport layer, and an electron injection layer. The emission layer may include the condensed cyclic compound represented by Formula 1 above.

[0121] As used herein, the term "organic layer" refers to a single layer and/or a plurality of layers between the first and second electrodes of the organic light-emitting device. A material in the "organic layer" is not limited to an organic material.

[0122] Hereinafter, a structure of an organic light-emitting device according to an embodiment of the present disclosure and a method of manufacturing the same will now be described with reference to the drawing.

[0123] The drawing is a schematic sectional view of an organic light-emitting device 10 according to an embodiment of the present disclosure. Referring to the drawing, the organic light-emitting device 10 includes a first electrode 110, an organic layer 150, and a second electrode 190.

[0124] A substrate may be positioned under the first electrode 110 or on the second electrode 190. The substrate may be a glass substrate or a transparent plastic substrate with good mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water resistance.

[0125] In one embodiment, the first electrode 110 may be formed by depositing or sputtering a first electrode-forming material on the substrate, but the method for forming the first electrode 110 is not limited thereto. When the first electrode 110 is an anode, a material having a high work function may be used as the first electrode-forming material to facilitate hole injection. The first electrode 110 may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. Transparent and conductive materials such as ITO, IZO, SnO₂, and ZnO may be used to form the first electrode. When the first electrode 110 is a semi-transmissive electrode or a reflective electrode, the first electrode 110 may be formed of at least one material selected from magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag).

[0126] The first electrode 110 may have a single-layer structure or a multi-layer structure that includes a plurality of layers. For example, the first electrode 110 may have a three-layered structure of ITO/Ag/ITO, but is not limited thereto.

[0127] The organic layer 150 may be disposed on the first electrode 110. The organic layer 150 may include an emission layer (EML).

[0128] The organic layer 150 may further include a hole transport region between the first electrode and the EML, and an electron transport region between the EML and the second electrode.

[0129] In one embodiment, the hole transport region may include at least one selected from a hole injection layer (HIL), a hole transport layer (HTL), a buffer layer, and an electron blocking layer (EBL). In one embodiment, the electron transport layer may include at least one selected from a hole blocking layer (HBL), an electron transport layer (ETL), and an electron injection layer (EIL). However, embodiments of the present disclosure are not limited thereto.

[0130] The hole transport region may have a single-layered structure including a single material, a single-layered structure including a plurality of materials, or a multi-layered structure including a plurality of layers including different materials.

[0131] In some embodiments, the electron transport region may have a single-layered structure including a plurality of materials, or a multi-layered structure of HIL/HTL, HIL/HTL/buffer layer, HIL/buffer layer, HTL/buffer layer, or HIL/HTL/EBL, where the layers forming a multi-layered structure of the electron transport region are sequentially stacked on the first electrode 110 in the order stated above. However, embodiments of the present disclosure are not limited thereto.

[0132] When the hole transport region includes a HIL, the HIL may be formed on the first electrode 110 by using (utilizing) any of a variety of methods such as, for example, vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like.

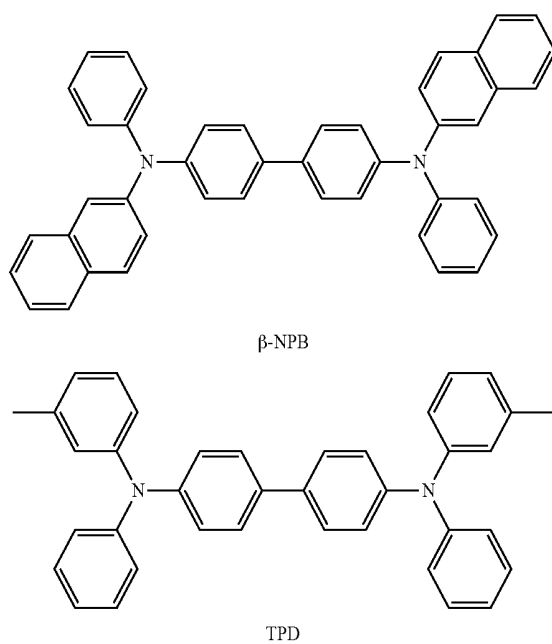
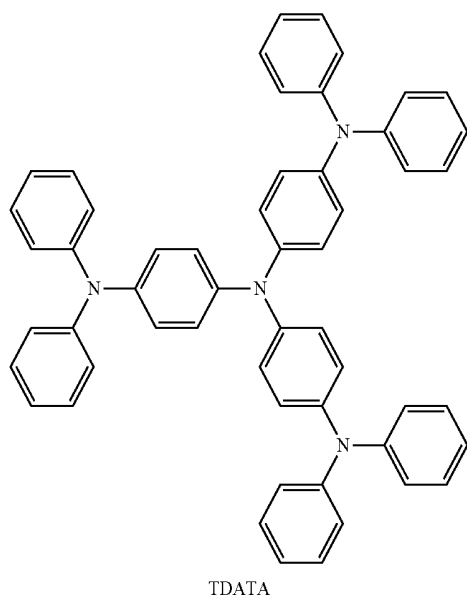
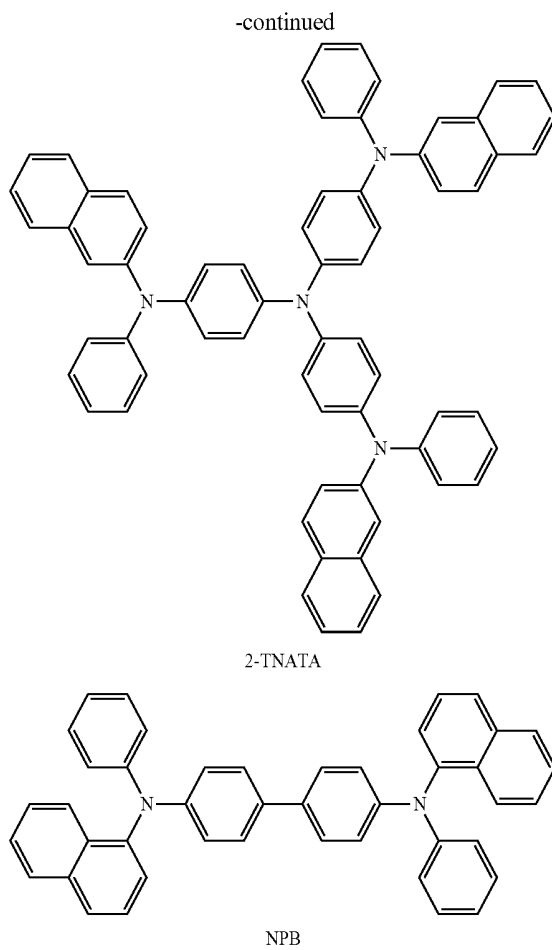
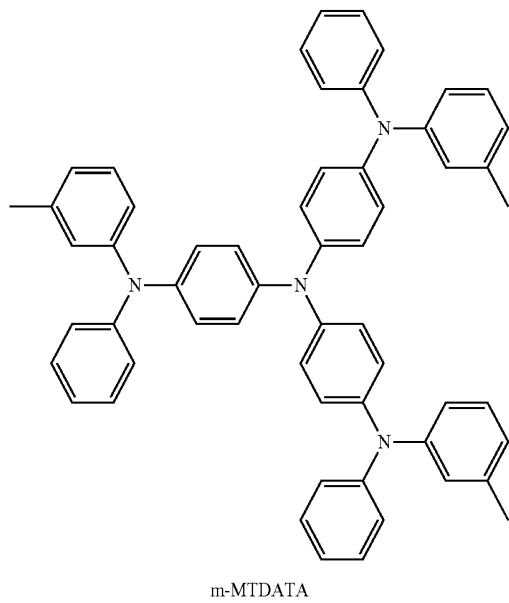
[0133] When the HIL is formed using vacuum deposition, the deposition conditions may vary depending on the material that is used to form the HIL and the structure of the HIL. In one embodiment, the deposition conditions may be as follows: a deposition temperature of about 100° C. to about 500° C., a degree of vacuum of about 10⁻⁸ to about 10⁻³ torr, and a deposition rate of about 0.01 to 100 Å/sec, but the deposition conditions are not limited thereto.

[0134] When the HIL is formed using spin coating, the coating conditions may vary depending on the material that is used to form the HIL and the structure of the HIL. In one embodiment, the coating conditions may be as follows: a coating rate of about 2,000 rpm to about 5,000 rpm and a heat treatment temperature of about 800° C. to about 200° C., but the coating conditions are not limited thereto.

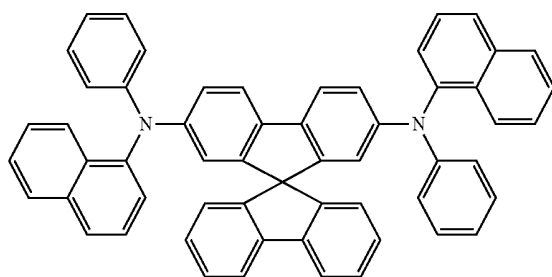
[0135] When the hole transport region includes a HTL, the HTL may be formed on the first electrode 110 or on the HIL by using any of a variety of methods such as, for example, vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the HTL is formed using vacuum deposition or spin coating, the conditions for deposition and coating may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

[0136] In some embodiments, the hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB, TPD, Spiro-TPD, Spiro-NPB, methylated NPB, TAPC, HMTPD, 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzene sulfonic acid (Pani/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate)(PEDOT/PSS), polyaniline/camphor sul-

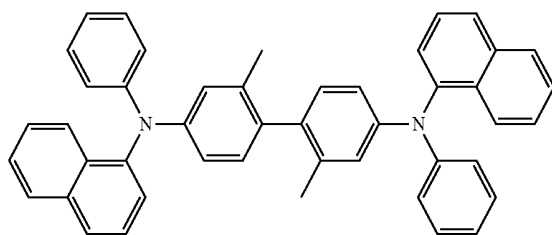
fonic acid (Pani/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201 below, and/or a compound represented by Formula 202 below.



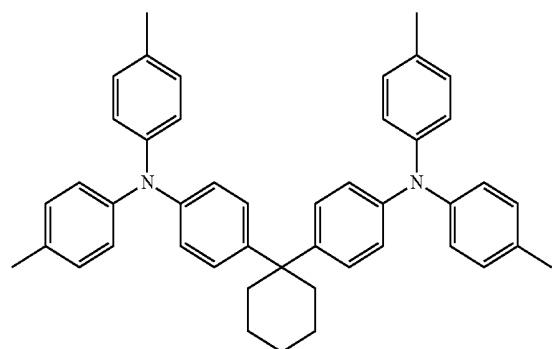
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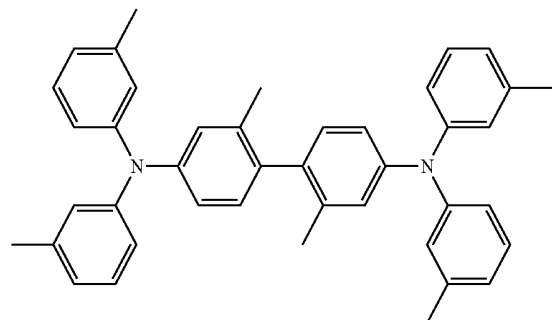
Spiro-NPB



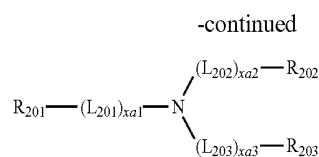
methyiated NPB



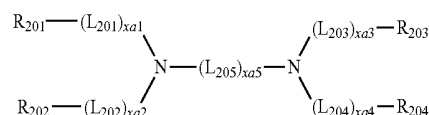
TAPC



HMTDP



Formula 201



Formula 202

[0138] L₂₀₁ to L₂₀₅ may be each independently defined as L₁ in Formula 1 described above;

[0139] xa1 to xa4 are each independently selected from 0, 1, 2, and 3;

[0140] xa5 may be selected from 1, 2, 3, 4, and 5;

[0141] R₂₀₁ to R₂₀₄ may be each independently selected from a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₂-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0142] For example, in Formulae 201 and 202,

[0143] L₂₀₁ to L₂₀₅ may be each independently

[0144] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, a chrysénylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a carbazolylenylene group, and/or a triazinylenylene; and/or

[0145] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, a chrysénylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a quinolinylene group, an isoquinolinylene group, a quinoxalinylenylene group, a quinazolinylene group, a carbazolylenylene group, and/or a triazinylene group, each substituted with at least one selected from a deuterium, —F, Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phe-

nyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group,

[0146] x_{a1} to x_{a4} may be each independently 0, 1, or 2;

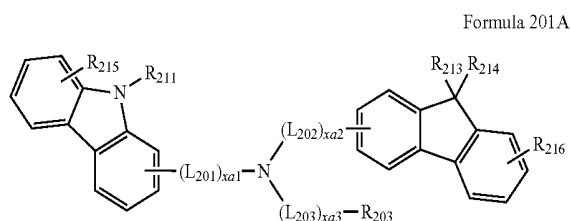
[0147] x_{a5} may be 1, 2, or 3;

[0148] R_{201} to R_{204} may be each independently,

[0149] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group; and/or

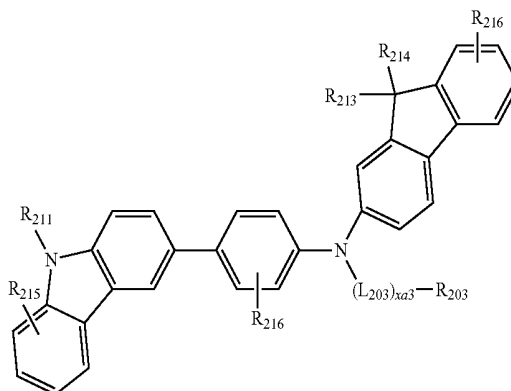
[0150] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, an azulenyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group. However, embodiments of the present disclosure are not limited thereto.

[0151] The compound of Formula 201 may be represented by Formula 201A:



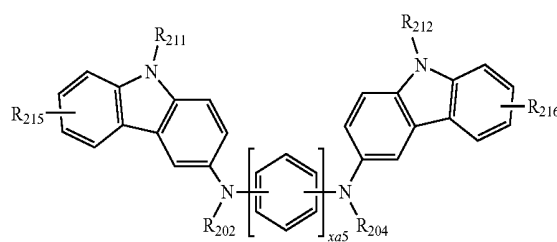
[0152] In one embodiment, the compound of Formula 201 may be represented by Formula 201A-1, but the compound of Formula 201 is not limited thereto:

Formula 201A-1



[0153] In one embodiment, the compound of Formula 202 may be represented by Formula 202A, but the compound of Formula 202 is not limited thereto:

Formula 202A



[0154] In Formulae 201A, 201A-1, and 202A,

[0155] L_{201} to L_{203} , x_{a1} to x_{a3} , x_{a5} , and R_{202} to R_{204} may be defined as described in connection with Formula 201;

[0156] R_{211} may be defined as R_{203} in Formula 201 described above;

[0157] R_{213} to R_{216} may be each independently a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{50} arylthio group, a C_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and/or a monovalent non-aromatic condensed heteropolycyclic group.

[0158] In some embodiments, in Formulae 201A, 201A-1, and 202A,

[0159] L_{201} to L_{203} may be each independently

[0160] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, a chrysenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a quinoxali-

group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

[0174] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazolinyl group, and/or a triazinyl group; and/or

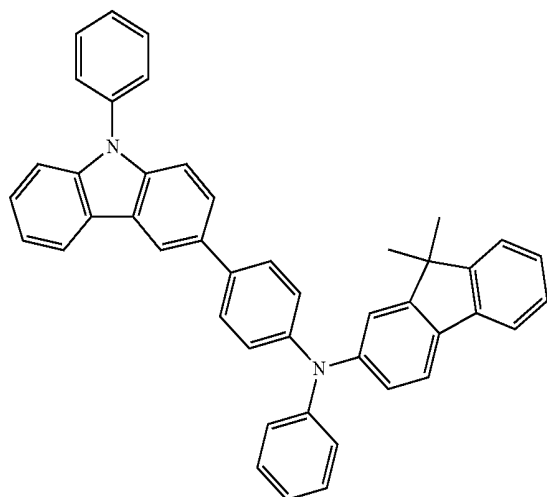
[0175] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxaliny group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, and

[0176] xa5 may be 1 or 2.

[0177] In Formulae 201A and 201A-1, R₂₁₃ and R₂₁₄ may be linked to each other to form a saturated or unsaturated ring.

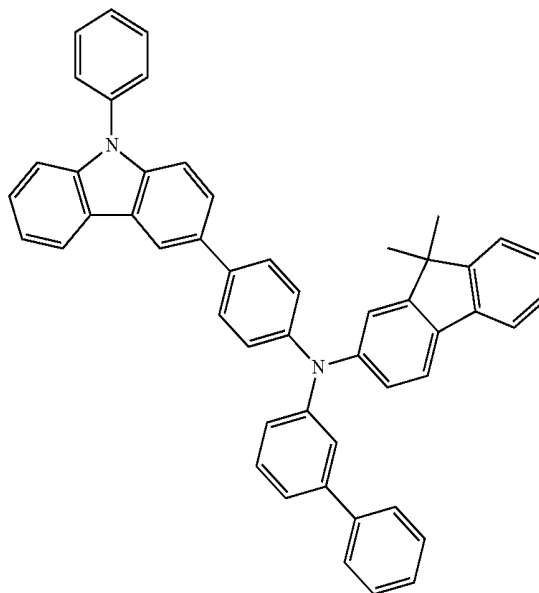
[0178] The compound represented by Formula 201 and the compound represented by Formula 202 may be each one of compounds HT1 to HT20 illustrated below, but are not limited thereto.

HT1

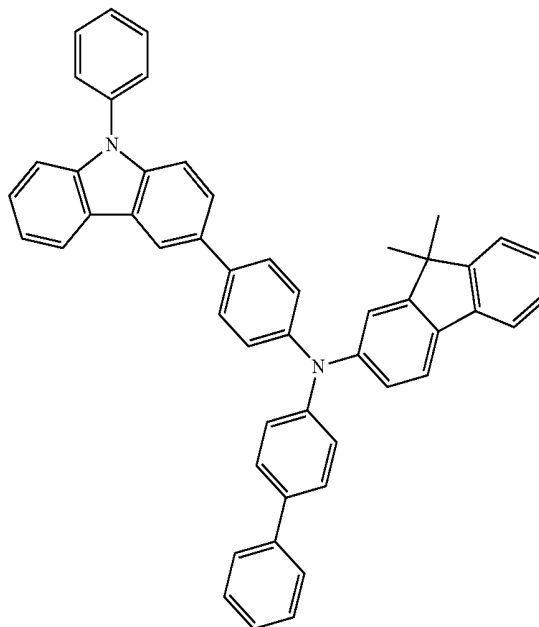


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HT2

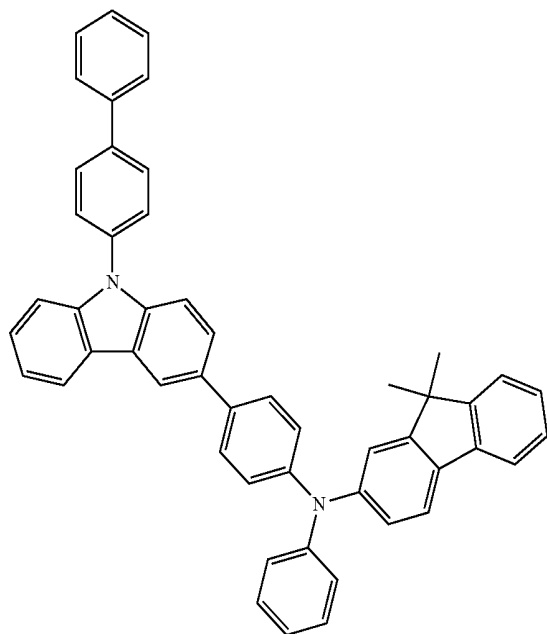


HT3



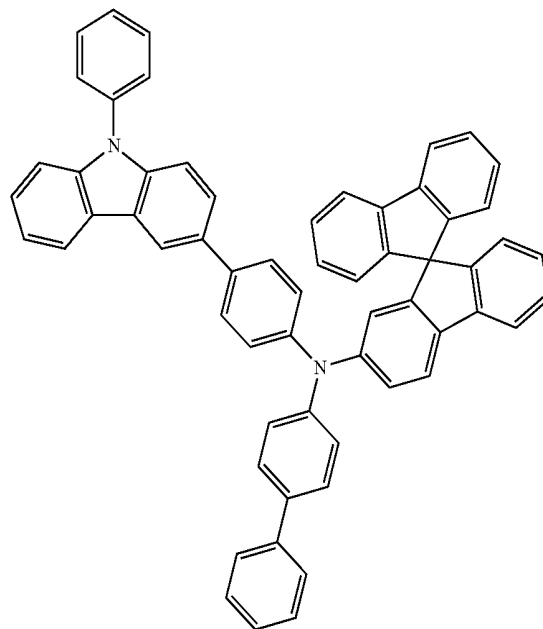
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HT4

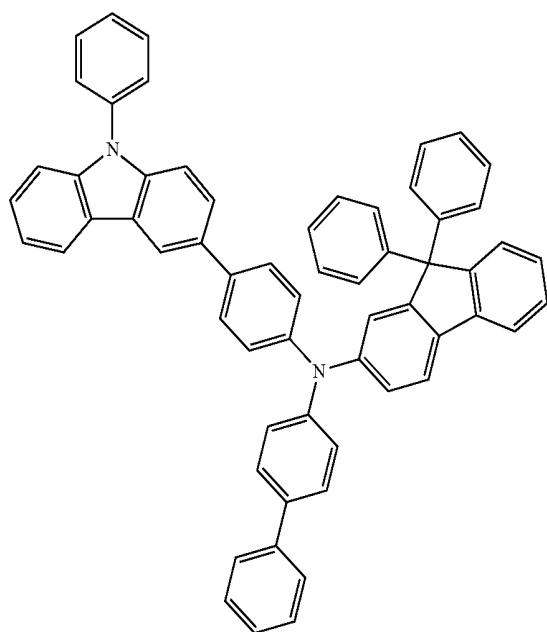


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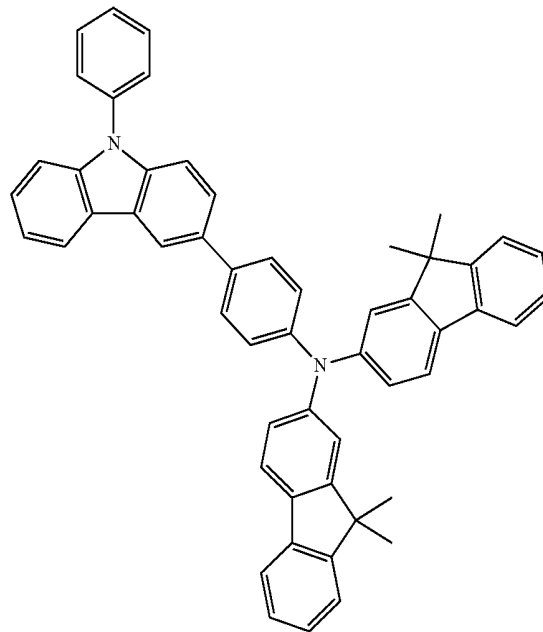
HT6



HT5

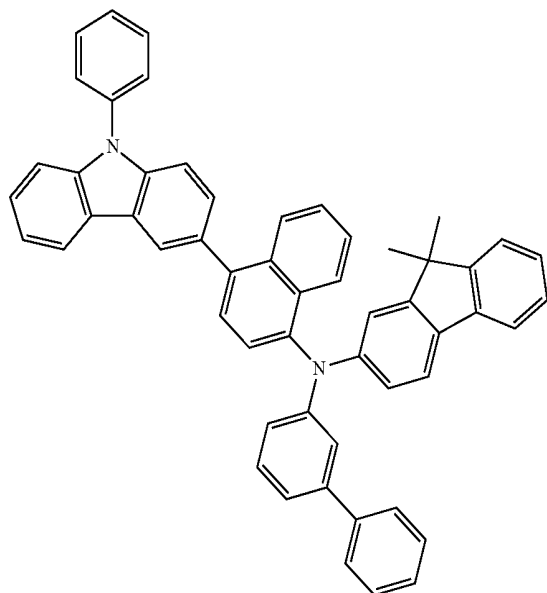


HT7



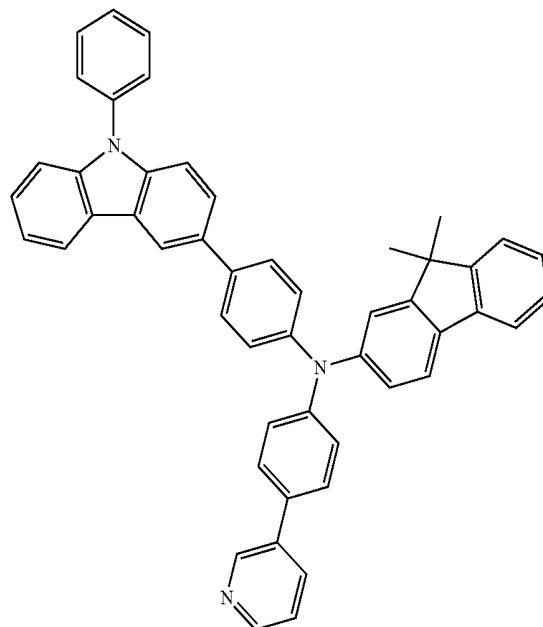
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HT8

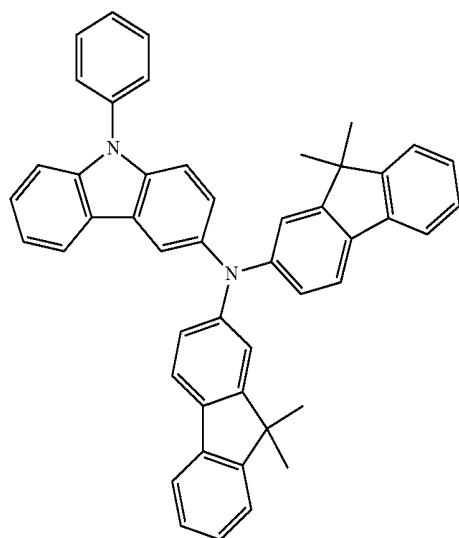


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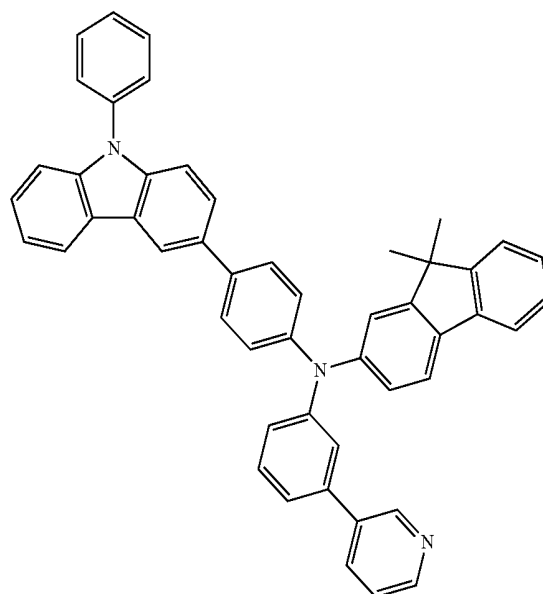
HT10



HT9

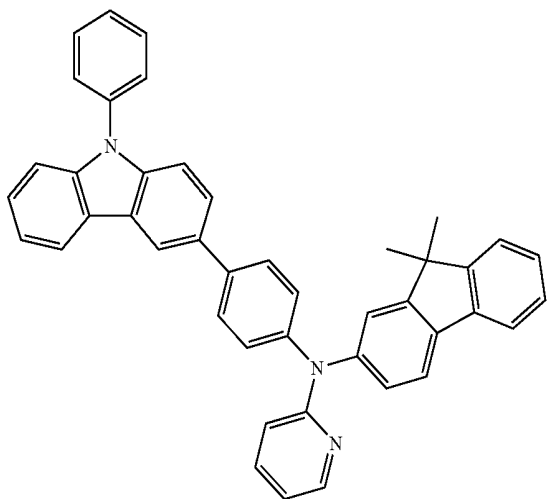


HT11



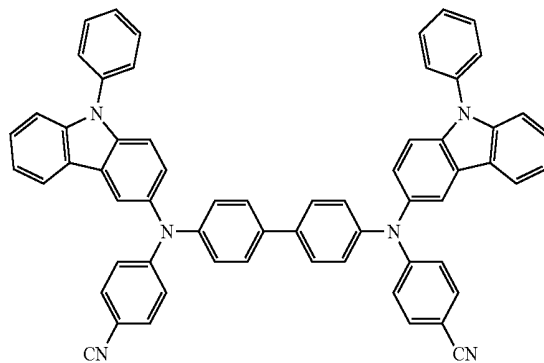
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HT12

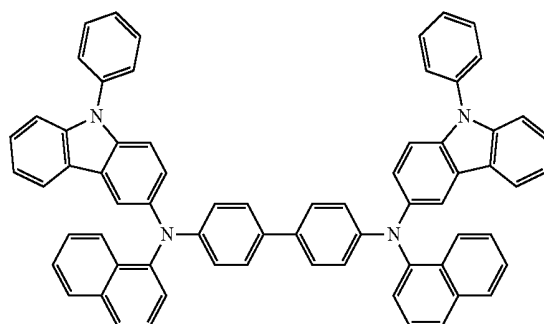


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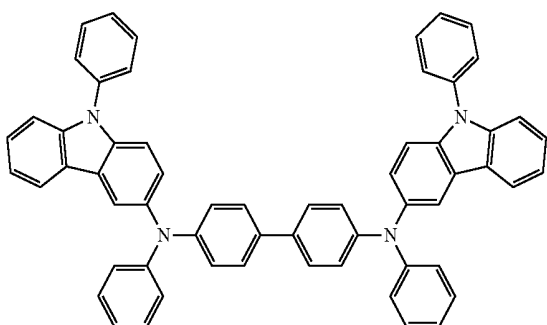
HT16



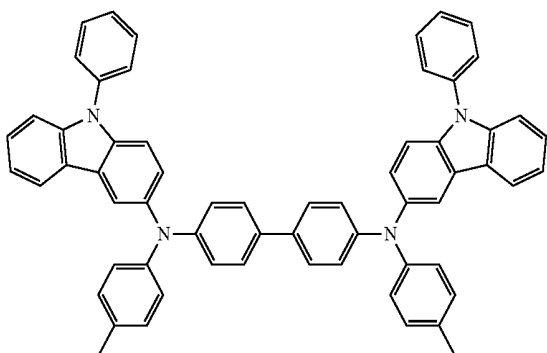
HT17



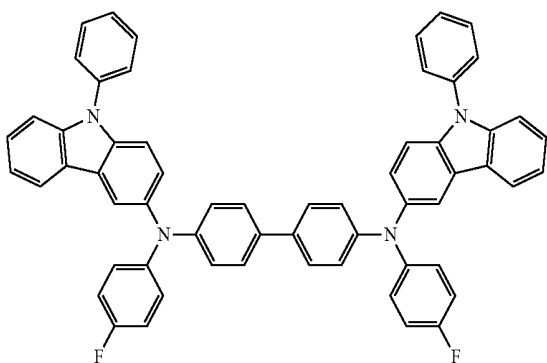
HT13



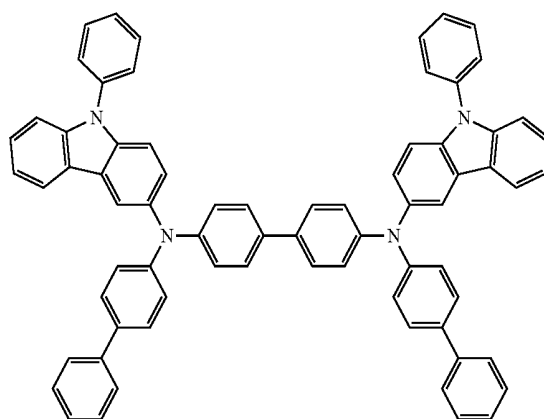
HT14



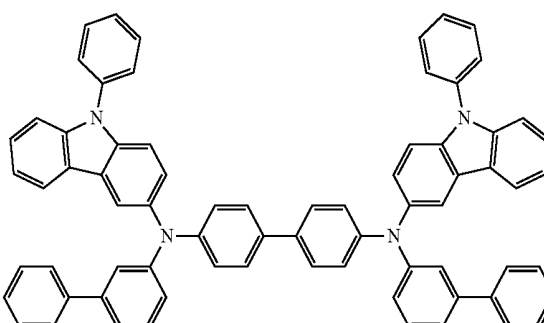
HT15



HT18

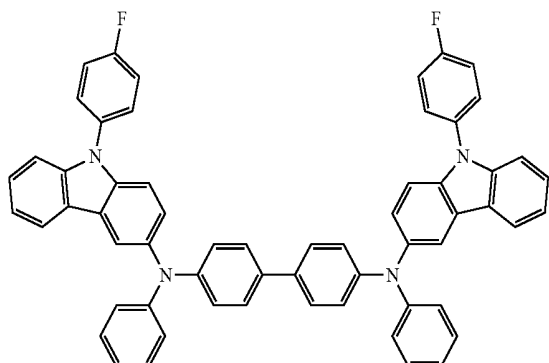


HT19



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HT20

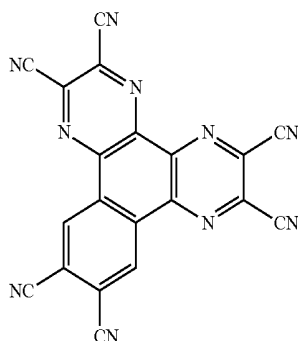


[0179] A thickness of the hole transport region may be from about 100 Å to about 10,000 Å, and in some embodiments, from about 100 Å to about 1,000 Å. When the hole transport region includes a HIL and a HTL, a thickness of the HIL may be from about 100 Å to about 10,000 Å, and in some embodiments, from about 100 Å to about 1,000 Å, and a thickness of the HTL may be from about 50 Å to about 2,000 Å, and in some embodiments, from about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the HIL, and the HTL are within these ranges, satisfactory hole transport characteristics may be obtained without a substantial increase in driving voltage.

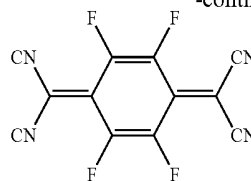
[0180] The hole transport region may further include a charge-generating material to improve conductivity, in addition to the materials described above. The charge-generating material may be homogeneously or inhomogeneously dispersed in the hole transport region.

[0181] The charge-generating material may be, for example, a p-dopant. The p-dopant may be one of quinone derivatives, metal oxides, and/or compounds with a cyano group, but is not limited thereto. Non-limiting examples of the p-dopant include quinone derivatives such as tetracyanoquinonodimethane (TCNQ), 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonodimethane (F4-TCNQ), and the like; metal oxides such as tungsten oxide, molybdenum oxide, and the like; and Compound HT-D1 below.

Compound HT-D1



-continued



F4-TCNQ

[0182] The hole transport region may further include at least one selected from a buffer layer and an EBL, in addition to the HIL and the HTL described above. The buffer layer may compensate for an optical resonance distance of light according to a wavelength of the light emitted from the EML, and thus may improve light-emission efficiency. A material in the buffer layer may be any material suitable for use in the hole transport region. The EBL may block migration of electrons from the electron transport region into the EML.

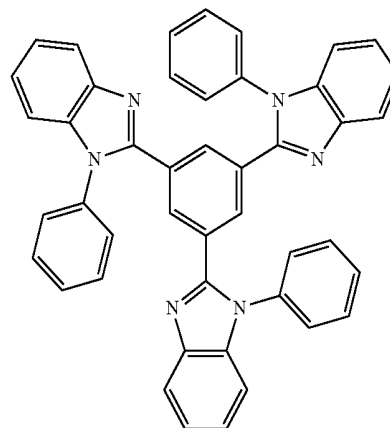
[0183] The EML may be formed on the first electrode 110 or on the hole transport region by using any of a variety of methods such as, for example, vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the EML is formed using vacuum deposition or spin coating, the deposition and coating conditions for forming the EML may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

[0184] When the organic light-emitting device 10 is a full color organic light-emitting device, the EML may be patterned into a red emission layer, a green emission layer, and a blue emission layer to correspond to individual subpixels, respectively. In some embodiments, the EML may emit white light and may have a structure in which a red emission layer, a green emission layer and a blue emission layer are stacked upon one another, or a structure including a mixture of a red light-emitting material, a green light-emitting material, and a blue light-emitting material.

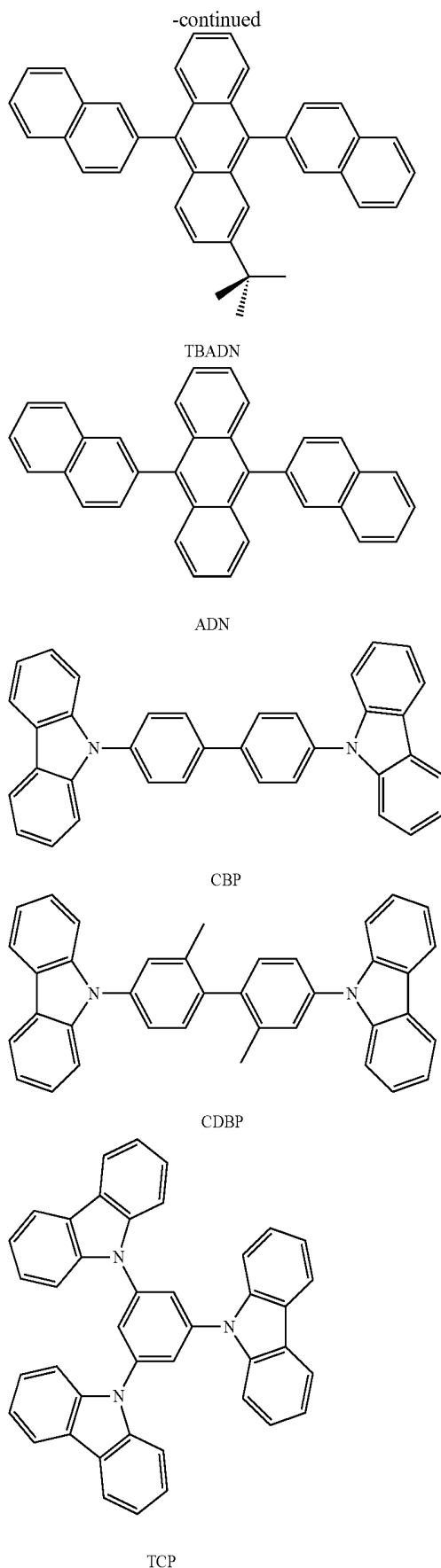
[0185] In one embodiment, the EML may include the condensed cyclic compound of Formula 1.

[0186] The EML may include a host and a dopant. In one embodiment, the dopant may include the condensed cyclic compound of Formula 1.

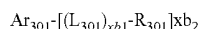
[0187] The host may include at least one selected from TPBi, TBADN, ADN (also referred to as "AND" or "DNA"), CBP, CDBP, and TCP.



TPBi



[0188] In some embodiments, the host may include a compound represented by Formula 301.



Formula 301

[0189] In Formula 301,

[0190] Ar_{301} may be

[0191] a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and/or an indenoanthracene; and/or

[0192] a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and/or an indenoanthracene, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_2\text{-C}_{60}$ alkynyl group, a $\text{C}_1\text{-C}_{60}$ alkoxy group, a $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{-C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, a $\text{C}_6\text{-C}_{60}$ aryloxy group, a $\text{C}_6\text{-C}_{60}$ arylthio group, a $\text{C}_2\text{-C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q_{301})(Q_{302})(Q_{303}) (where Q_{301} to Q_{303} may be each independently, a hydrogen, a $\text{C}_1\text{-C}_{60}$ alkyl group, a $\text{C}_2\text{-C}_{60}$ alkenyl group, a $\text{C}_6\text{-C}_{60}$ aryl group, and/or a $\text{C}_2\text{-C}_{60}$ heteroaryl group),

[0193] In one embodiment, L_{301} may be defined as L_{201} in Formula 201 described above,

[0194] R_{301} may be

[0195] a $\text{C}_1\text{-C}_{20}$ alkyl group and/or a $\text{C}_1\text{-C}_{20}$ alkoxy group;

[0196] a $\text{C}_1\text{-C}_{20}$ alkyl group and/or a $\text{C}_1\text{-C}_{20}$ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

[0197] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group; or

[0198] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl

group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group,

[0199] x_{b1} may be selected from 0, 1, 2, and 3;

[0200] x_{b2} may be selected from 1, 2, 3, and 4.

[0201] In one embodiment, in Formula 301,

[0202] L_{301} may be

[0203] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, and/or a chrysenylene group; and/or

[0204] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a pyrenylene group, and/or a chrysenylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group, and

[0205] R_{301} may be

[0206] a C_1 - C_{20} alkyl group and/or a C_1 - C_{20} alkoxy group;

[0207] a C_1 - C_{20} alkyl group and/or a C_1 - C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group;

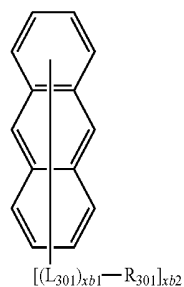
[0208] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and/or a chrysenyl group;

[0209] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and/or a chrysenyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof,

thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, and a chrysenyl group. However, embodiments of the present disclosure are not limited thereto.

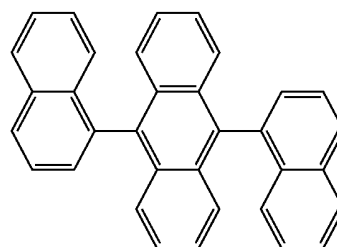
[0210] In one embodiment, the host may include a compound represented by Formula 301A:

Formula 301A

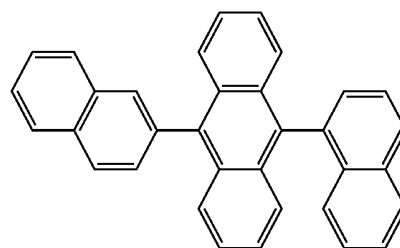


[0211] Substituents in Formula 301A may be as described above.

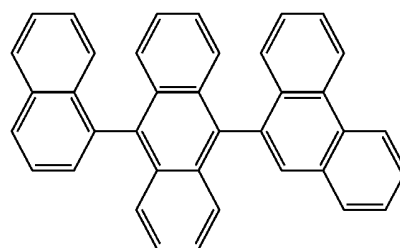
[0212] The compound of Formula 301 may include at least one of Compounds H1 to H42, but is not limited thereto:



H1

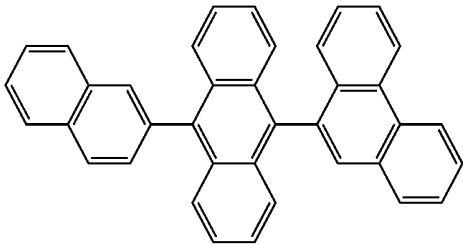


H2

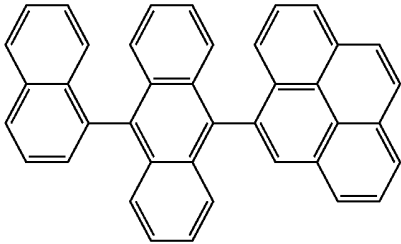


H3

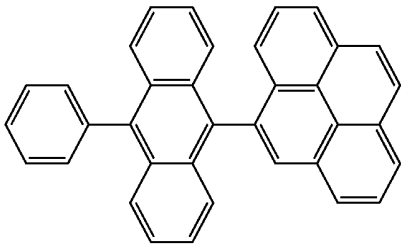
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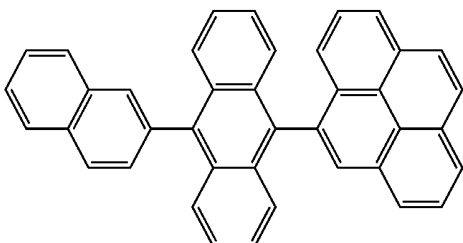
H4



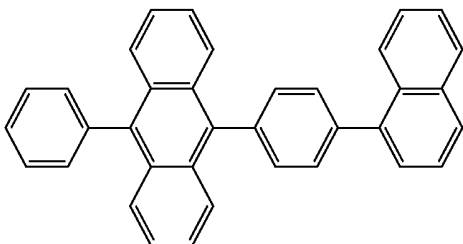
H5



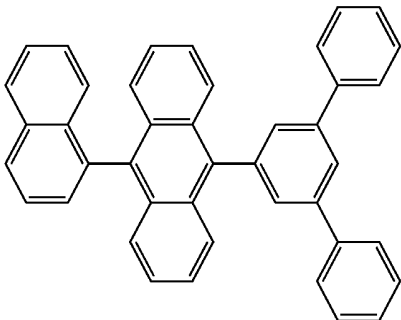
H6



H7

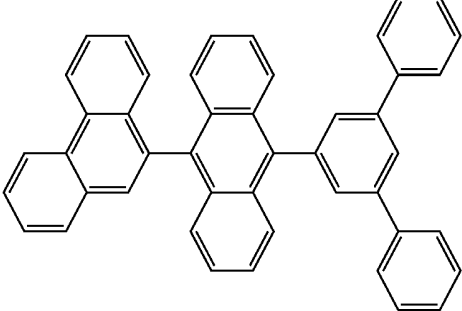


H8

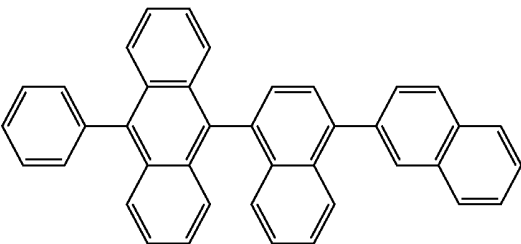


H9

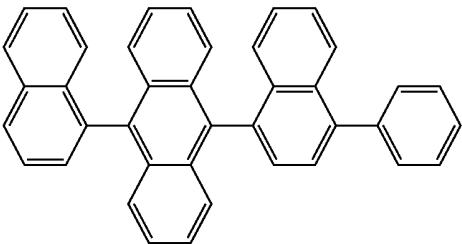
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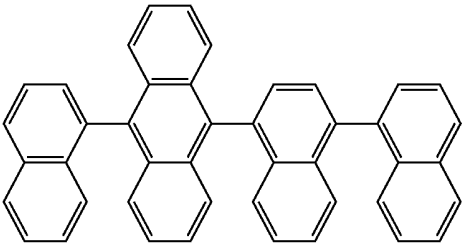
H10



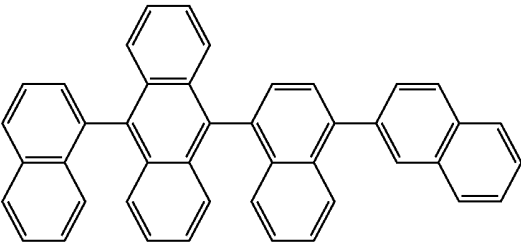
H11



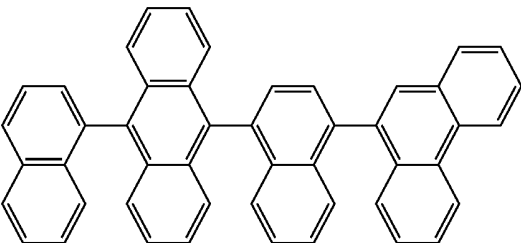
H12



H13

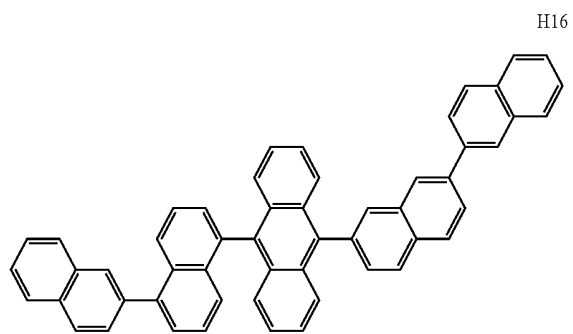


H14

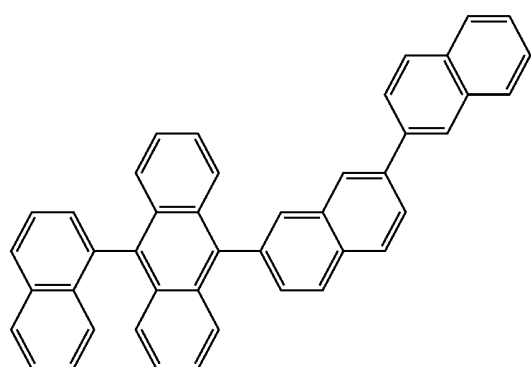


H15

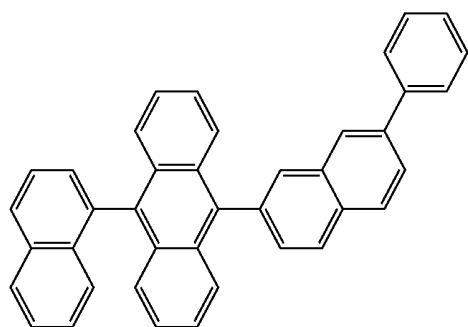
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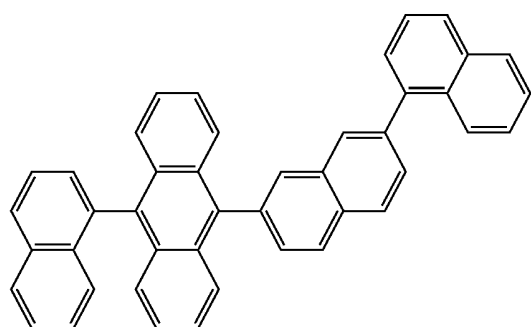
H16



H17

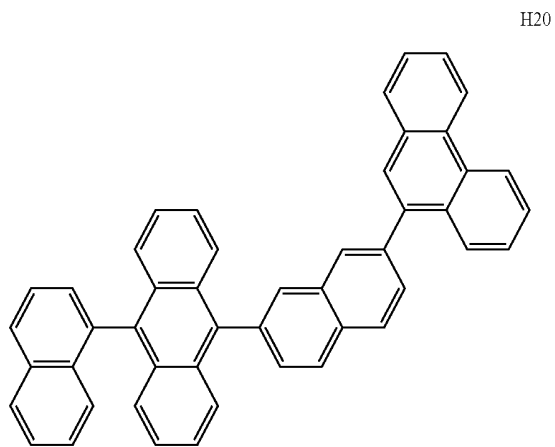


H18

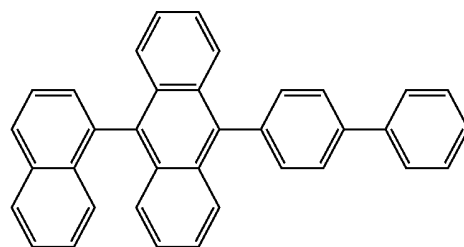


H19

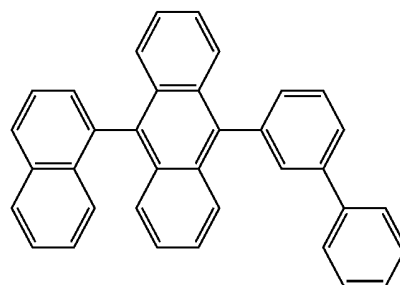
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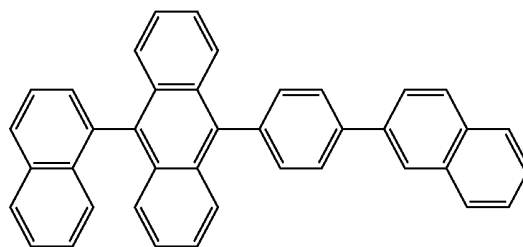
H20



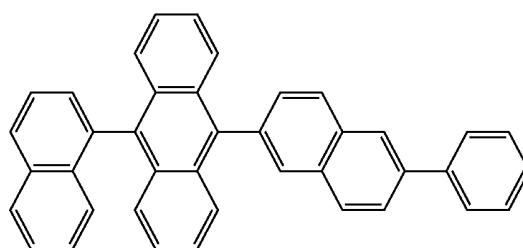
H21



H22

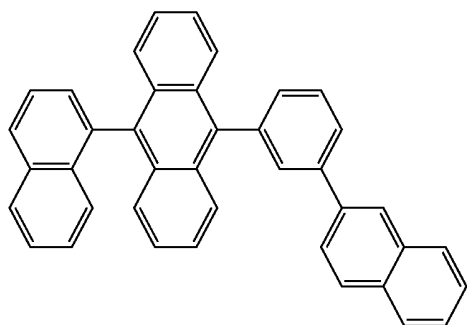


H23

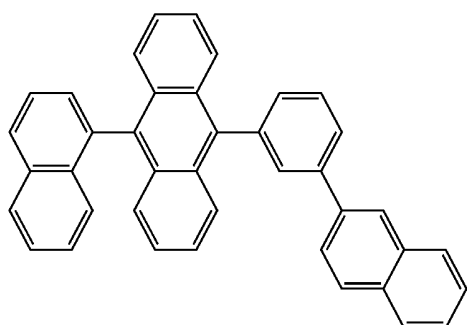


H24

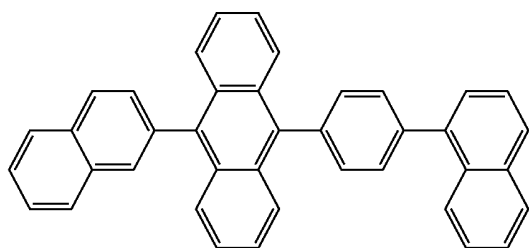
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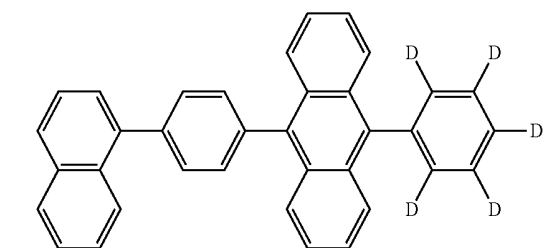
H25



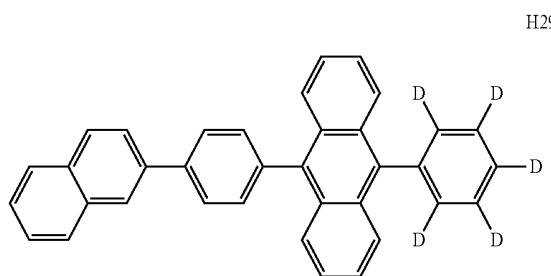
H26



H27

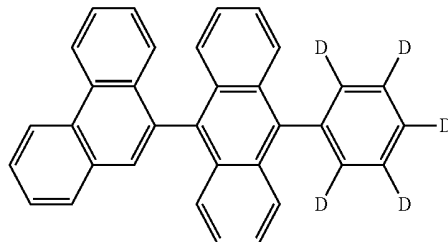


H28

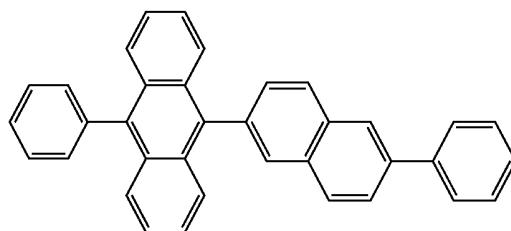


H29

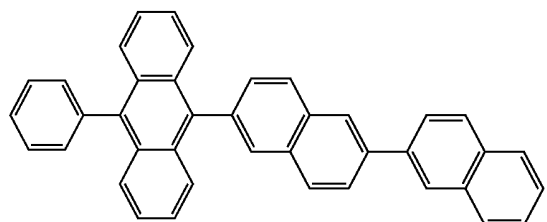
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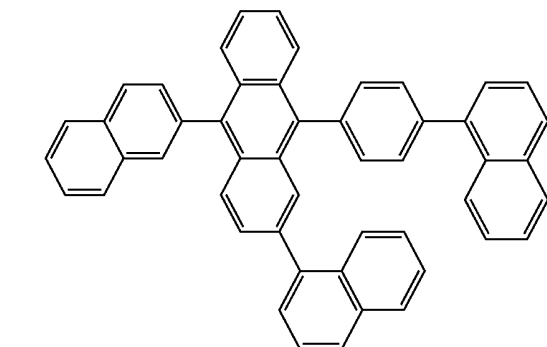
H30



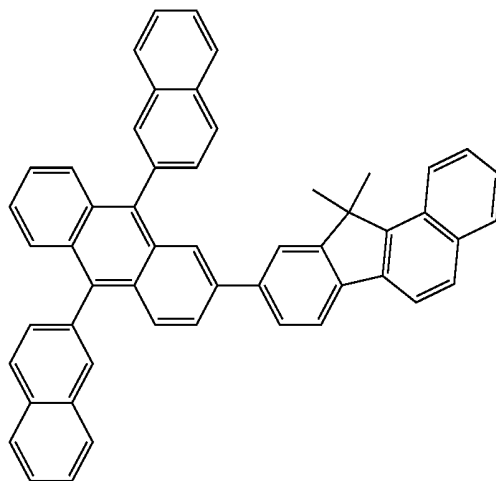
H31



H32

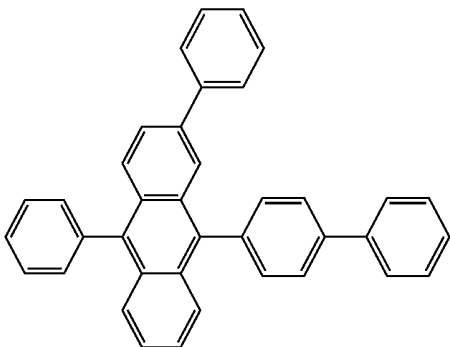


H33



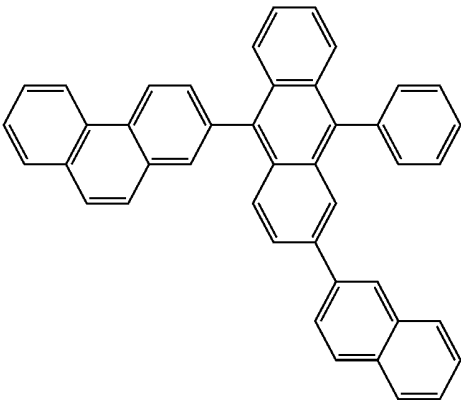
H34

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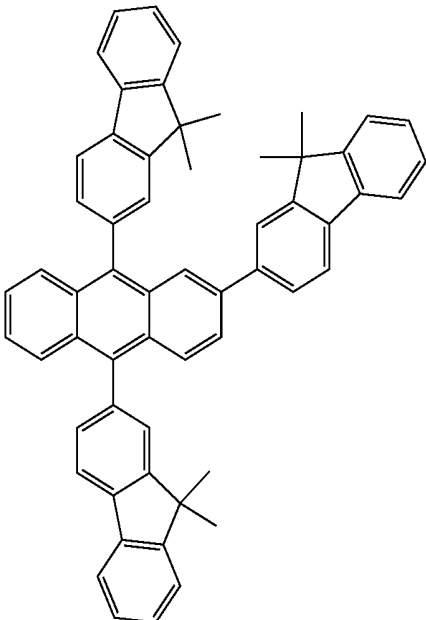
H35

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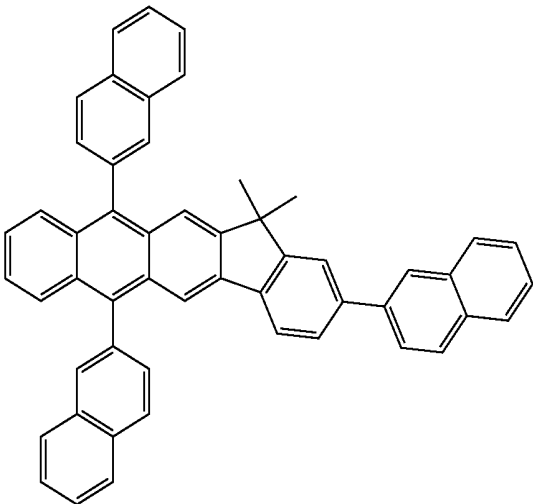


H38

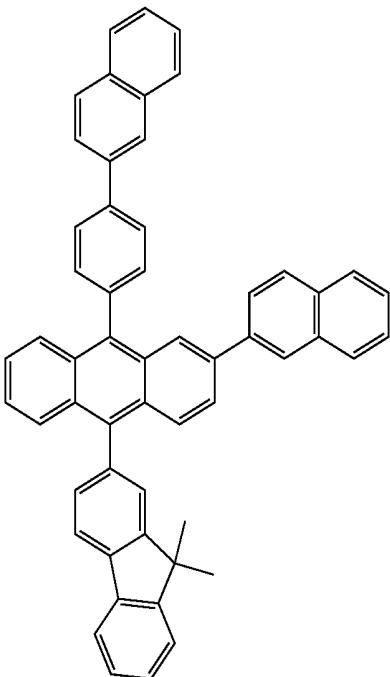
H36



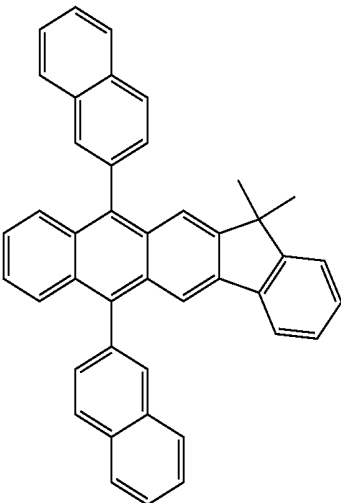
H39



H37

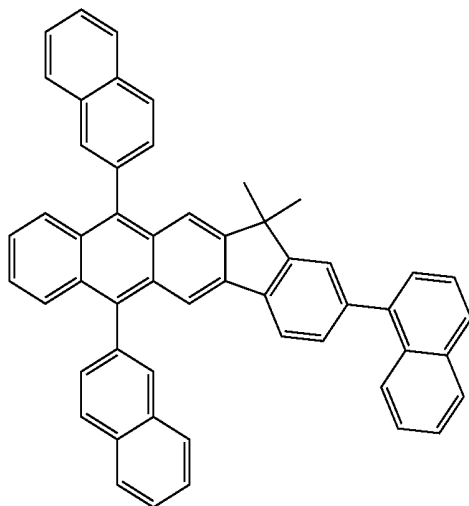


H40

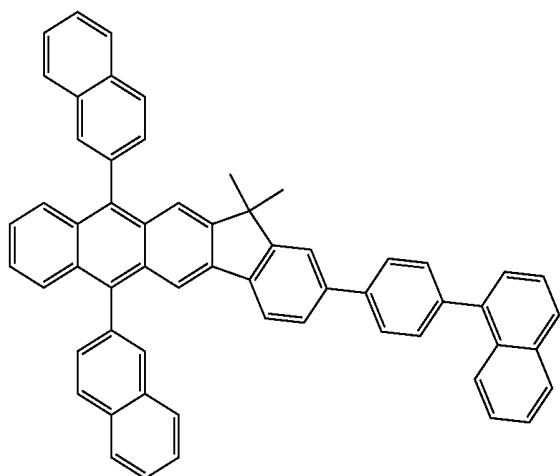


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H41

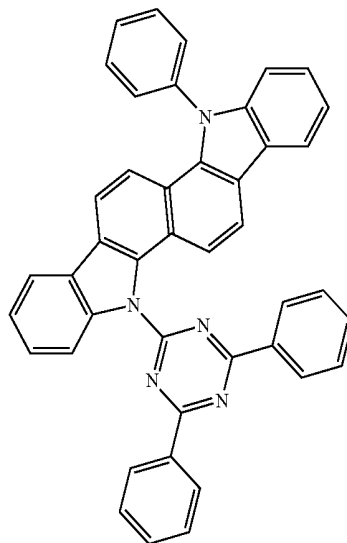


H42

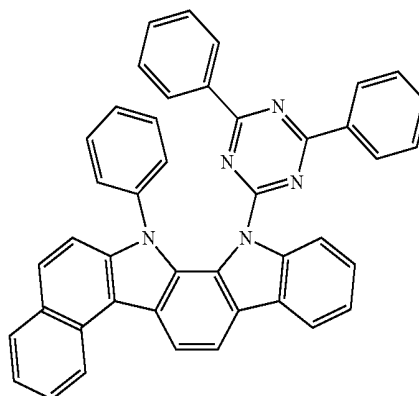


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H44

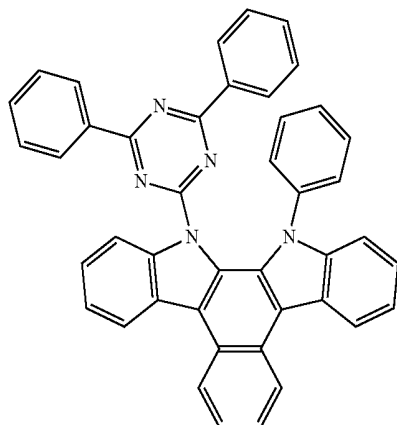


H45

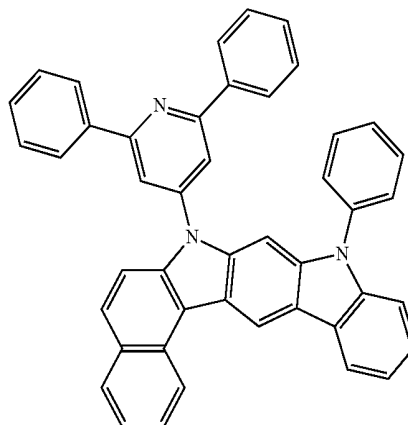


[0213] In some embodiments, the host may include at least one of Compounds H43 to H49, but is not limited thereto:

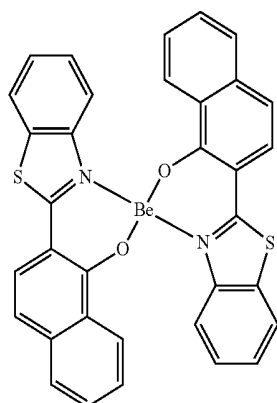
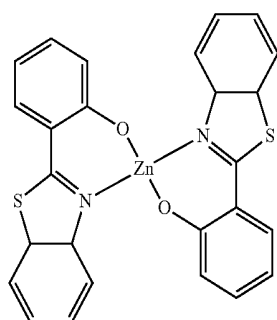
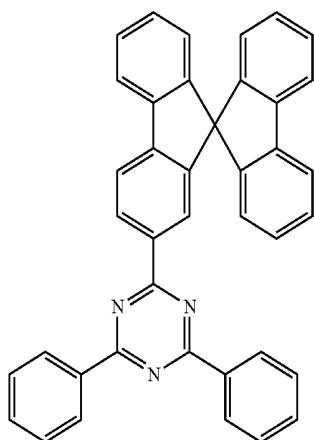
H43



H46



-continued

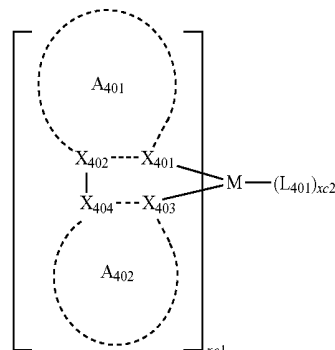


[0214] The dopant may include at least one of a fluorescent dopant and a phosphorescent dopant. When the dopant includes a fluorescent dopant, the fluorescent dopant may include the condensed cyclic compound of Formula 1.

[0215] The phosphorescent dopant may include an organo-metallic complex represented by Formula 401:

H47

Formula 401



[0216] In Formula 401,

[0217] M may be selected from iridium (Ir), platinum (Pt), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), and thulium (Tm);

[0218] X₄₀₁ to X₄₀₄ may be each independently a nitrogen or a carbon;

H48

[0219] rings A₄₀₁ and A₄₀₂ may be each independently selected from a substituted or unsubstituted benzene, a substituted or unsubstituted naphthalene, a substituted or unsubstituted fluorene, a substituted or unsubstituted spiro-fluorene, a substituted or unsubstituted indene, a substituted or unsubstituted pyrrole, a substituted or unsubstituted thiophene, a substituted or unsubstituted furan, a substituted or unsubstituted imidazole, a substituted or unsubstituted pyrazole, a substituted or unsubstituted thiazole, a substituted or unsubstituted isothiazole, a substituted or unsubstituted oxazole, a substituted or unsubstituted isoxazole, a substituted or unsubstituted pyridine, a substituted or unsubstituted pyrazine, a substituted or unsubstituted pyrimidine, a substituted or unsubstituted pyridazine, a substituted or unsubstituted quinoline, a substituted or unsubstituted isoquinoline, a substituted or unsubstituted benzoquinoline, a substituted or unsubstituted quinoxaline, a substituted or unsubstituted quinazoline, a substituted or unsubstituted carbazole, a substituted or unsubstituted benzoimidazole, a substituted or unsubstituted benzofuran, a substituted or unsubstituted benzothiophene, a substituted or unsubstituted isobenzothiophene, a substituted or unsubstituted benzoxazole, a substituted or unsubstituted isobenzoxazole, a substituted or unsubstituted triazole, a substituted or unsubstituted oxadiazole, a substituted or unsubstituted triazine, a substituted or unsubstituted dibenzofuran, and/or a substituted or unsubstituted dibenzothiophene;

H49

[0220] at least one substituent of the substituted benzene, the substituted naphthalene, the substituted fluorene, the substituted spiro-fluorene, the substituted indene, the substituted pyrrole, the substituted thiophene, the substituted furan, the substituted imidazole, the substituted pyrazole, the substituted thiazole, the substituted isothiazole, the substituted oxazole, the substituted isoxazole, the substituted pyridine, the substituted pyrazine, the substituted pyrimidine, the substituted pyridazine, the substituted quinoline, the substituted isoquinoline, the substituted benzoquinoline, the substituted quinoxaline, the substituted quinazoline, the substituted carbazole, the substituted benzoimidazole, the substituted benzofuran, the substituted benzothiophene, the substituted isobenzothiophene, the substituted benzoxazole, the substituted isobenzoxazole, the substituted triazole, the substituted oxadiazole, the substituted triazine, the substituted dibenzofuran, and/or the substituted dibenzothiophene may be selected from

[0221] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and C_1 - C_{60} alkoxy group;

[0222] 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 a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a C_3 - C_{10} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q_{401})(Q_{402}), —Si(Q_{403})(Q_{404})(Q_{405}), and —B(Q_{406})(Q_{407});

[0223] a C_3 - C_{10} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0224] a C_3 - C_{10} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_2 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_2 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_2 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q_{411})(Q_{412}), —Si(Q_{413})(Q_{414})(Q_{415}), and —B(Q_{416})(Q_{417}); and

[0225] —N(Q_{421})(Q_{422}), —Si(Q_{423})(Q_{424})(Q_{425}), and —B(Q_{426})(Q_{427});

[0226] L_{401} may be an organic ligand;

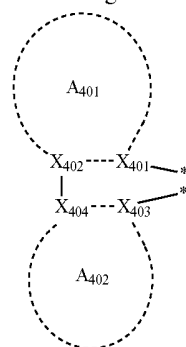
[0227] xc1 may be 1, 2, or 3;

[0228] xc2 may be 0, 1, 2, or 3. Descriptions for Q_{401} to Q_{407} , Q_{411} to Q_{417} and Q_{421} to Q_{427} are the same as the descriptions for Q_1 .

[0229] In one embodiment, in Formula 401, L_{401} may be a monovalent, divalent, or trivalent organic ligand. For example, L_{401} may be selected from a halogen ligand (for example, Cl or F), a diketone ligand (for example, acetylacetonate, 1,3-diphenyl-1,3-propanedionate, 2,2,6,6-tetramethyl-3,5-heptanedionate, or hexafluoroacetate), a carboxylic acid ligand (for example, picolinate, dimethyl-3-pyrazolocarboxylate, or benzoate), a carbon monoxide ligand, an isonitrile ligand, a cyano ligand, and/or a phosphorus ligand (for example, phosphine or phosphite). However, embodiments of the present disclosure are not limited thereto.

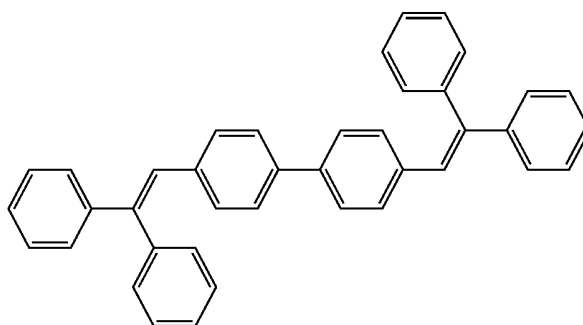
[0230] When A_{401} in Formula 401 has at least two substituent groups, the at least two substituent groups of A_{401} may be linked (i.e. fused) to each other to form a saturated or unsaturated ring.

[0231] When A_{402} in Formula 401 has at least two substituent groups, the at least two substituent groups of A_{402} may be linked (i.e. fused) to each other to form a saturated or unsaturated ring.



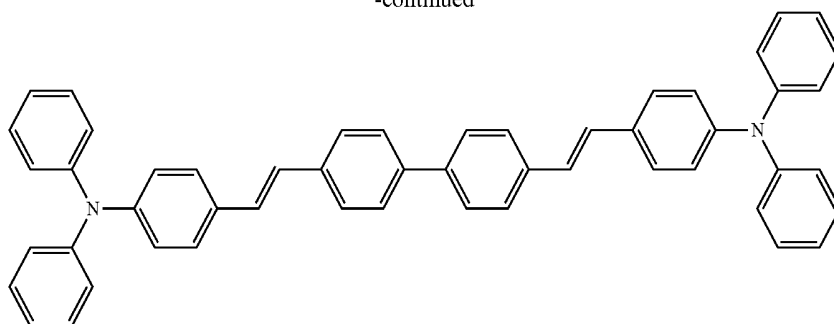
[0232] When xc1 in Formula 401 is 2 or greater, a plurality of ligands may be identical to or different from each other, and A_{401} and A_{402} of one ligand may be linked to A_{401} and A_{402} of an adjacent ligand, respectively, directly (e.g. via a single bond) or via a linking group (for example, a C_1 - C_5 alkylene group, —N(R')—(where R' is a C_1 - C_{10} alkyl group or a C_6 - C_{20} aryl group), or C(=O)—).

[0233] In one embodiment, the fluorescent dopant may include at least one of DPVBi, DPAVB, TBPe, DCM, DCJTb, Coumarin 6, and C545T, in addition to the condensed cyclic compound of Formula 1.

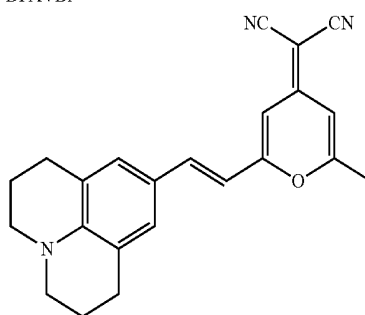
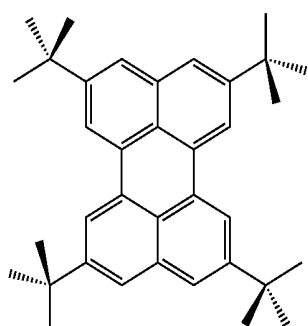


DPVBi

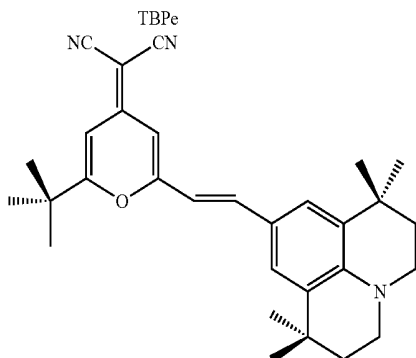
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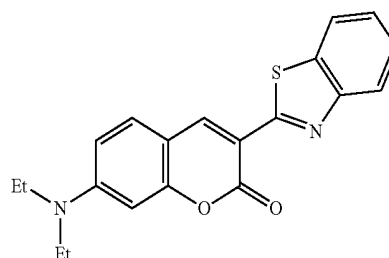
DPAVB1



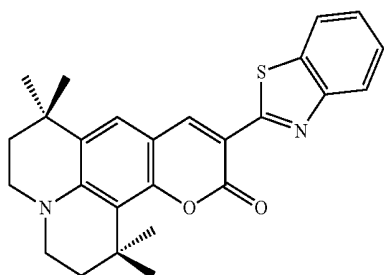
DCM



DCJTB



Coumarin 6



C545T

[0234] An amount of the dopant in the EML may be from about 0.01 parts to about 15 parts by weight based on 100 parts by weight of the host, but the amount of the dopant is not limited to this range.

[0235] The thickness of the EML may be from about 100 Å to about 1,000 Å, and in some embodiments, about 200 Å to about 600 Å. When the thickness of the EML is within these

ranges, the EML may have good light emitting ability without a substantial increase in driving voltage.

[0236] The electron transport region may be positioned on the EML.

[0237] The electron transport region may include at least one of a HBL, an ETL, and an EIL. However, embodiments of the present disclosure are not limited thereto.

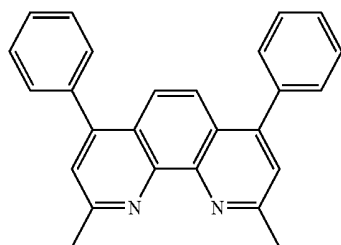
[0238] In some embodiments, the electron transport region may have a structure including an ETL/EIL, or a HBL/ETL/EIL, and the layers forming a structure of the electron transport region may be sequentially stacked on the EML in the order stated above. However, embodiments of the present disclosure are not limited thereto.

[0239] In some embodiments, the organic layer **150** of the organic light-emitting device **10** may include the electron transport region between the EML and the second electrode **190**, and the condensed cyclic compound of Formula 1 may be in the electron transport region.

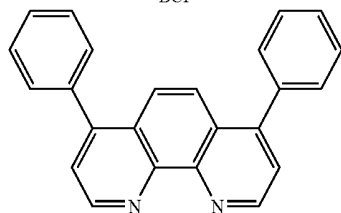
[0240] The electron transport region may include a HBL. When the EML includes a phosphorescent dopant, the HBL may prevent diffusion of triplet excitons or holes into the ETL from the EML.

[0241] When the electron transport region includes a HBL, the HBL may be formed on the EML by using any of a variety of methods such as, for example, vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the HBL is formed using vacuum deposition or spin coating, the deposition and coating conditions for forming the HBL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

[0242] In one embodiment, the HBL may include at least one of bathocuproine (BCP) below and bathophenanthroline (Bphen) below. However, embodiments of the present disclosure are not limited thereto.



BCP



Bphen

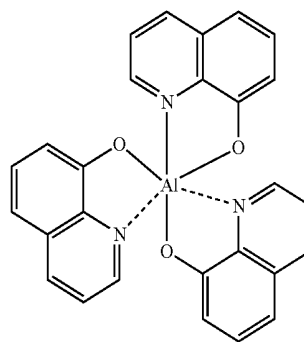
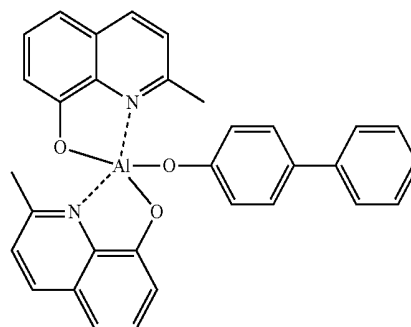
[0243] A thickness of the HBL may be from about 20 Å to about 1,000 Å, and in some embodiments, from about 30 Å to about 300 Å. When the thickness of the HBL is within these ranges, the HBL may have improved hole blocking ability without a substantial increase in driving voltage.

[0244] The electron transport region may include an ETL. The ETL may be formed on the EML or the HBL by using any of a variety of methods such as, for example, vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the ETL is formed using vacuum deposition or spin coating, the deposition and coating

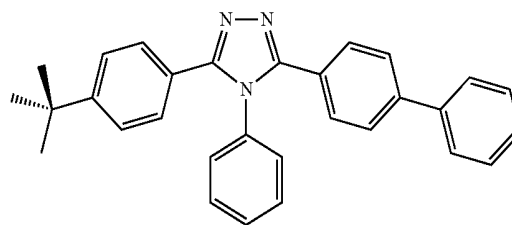
conditions for forming the ETL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

[0245] In embodiments where the organic layer **150** of the organic light-emitting device includes an electron transport region between the EML and the second electrode **190**, the electron transport region may include at least one of an ETL and an EIL.

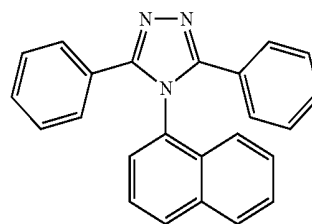
[0246] The ETL may further include at least one of Alq₃, Balq, TAZ, and NTAZ below, in addition to BCP and Bphen described above.

Alq₃

Balq

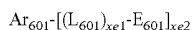


TAZ



NTAZ

[0247] In some embodiments, the ETL may include at least one compound selected from the compounds represented by Formula 601 and the compounds represented by Formula 602:



Formula 601

[0248] In Formula 601,

[0249] Ar_{601} may be selected from naphthalene, heptalene, fluorene, spiro-fluorene, benzofluorene, dibenzofluorene, phenalene, phenanthrene, anthracene, fluoranthene, triphenylene, pyrene, chrysene, naphthacene, picene, perylene, pentaphene, and/or indenoanthracene,

[0250] naphthalene, heptalene, fluorene, spiro-fluorene, benzofluorene, dibenzofluorene, phenalene, phenanthrene, anthracene, fluoranthene, triphenylene, pyrene, chrysene, naphthacene, picene, perylene, pentaphene, and/or indenoanthracene, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{--C}_{60}$ alkyl group, a $\text{C}_2\text{--C}_{60}$ alkenyl group, a $\text{C}_2\text{--C}_{60}$ alkynyl group, a $\text{C}_1\text{--C}_{60}$ alkoxy group, a $\text{C}_3\text{--C}_{10}$ cycloalkyl group, a $\text{C}_3\text{--C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{--C}_{10}$ cycloalkenyl group, a $\text{C}_3\text{--C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{--C}_{60}$ aryl group, a $\text{C}_6\text{--C}_{60}$ aryloxy group, a $\text{C}_6\text{--C}_{60}$ arylthio group, a $\text{C}_2\text{--C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q_{301})(Q_{302})(Q_{303}), wherein Q_{301} to Q_{303} may be each independently selected from a hydrogen, a $\text{C}_1\text{--C}_{60}$ alkyl group, a $\text{C}_2\text{--C}_{60}$ alkenyl group, a $\text{C}_6\text{--C}_{60}$ aryl group, and/or a $\text{C}_2\text{--C}_{60}$ heteroaryl group;

[0251] L_{601} may be defined as L_{201} described above;

[0252] E_{601} may be selected from

[0253] a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and/or an imidazopyrimidinyl group, and

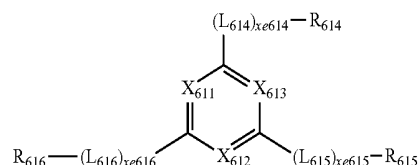
[0254] a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl

group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and/or an imidazopyrimidinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{--C}_{20}$ alkyl group, a $\text{C}_1\text{--C}_{20}$ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group;

[0255] $\text{xe}1$ may be selected from 0, 1, 2, and 3; and

[0256] $\text{xe}2$ may be selected from 1, 2, 3, and 4.

Formula 602



[0257] In Formula 602,

[0258] X_{611} may be N or C-(L_{611}) $_{\text{xe}611}$ - R_{611} , X_{612} may be N or C-(L_{612}) $_{\text{xe}612}$ - R_{612} , X_{613} may be N or C-(L_{613}) $_{\text{xe}613}$ - R_{613} , and at least one of X_{611} to X_{613} may be N,

[0259] L_{611} to L_{616} may be each independently defined as L_{201} described above,

[0260] R_{611} to R_{616} may be each independently

[0261] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group; and/or

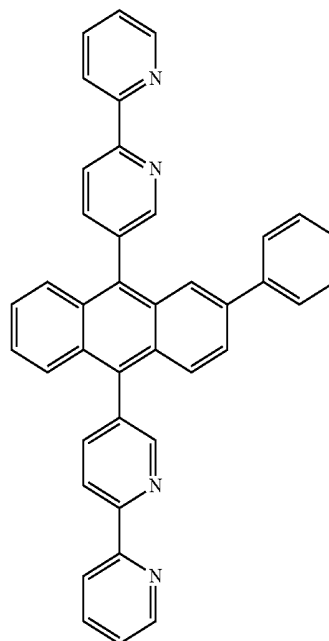
[0262] a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group, and

[0263] xe_{611} to xe_{616} may be each independently selected from, 0, 1, 2, and 3.

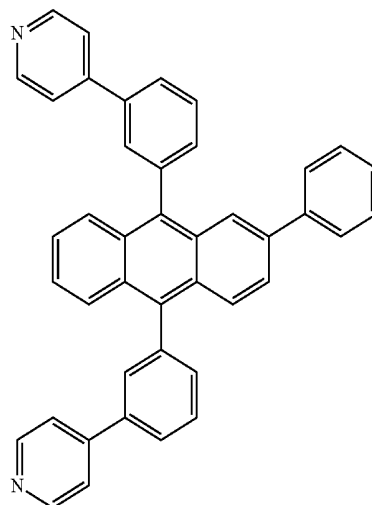
[0264] The compound represented by Formula 601 and the compound represented by Formula 602 may be selected from Compounds ET1 to ET15 illustrated below, but are not limited thereto.

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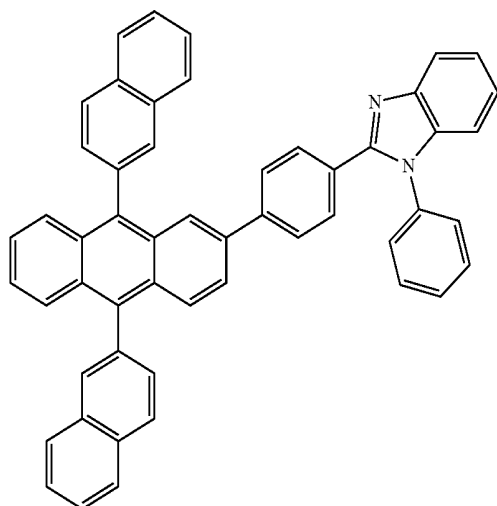
ET2



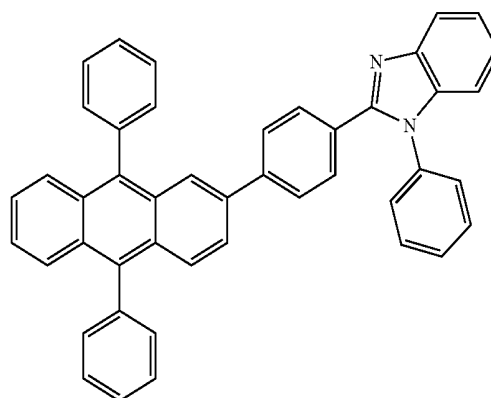
ET3



ET1

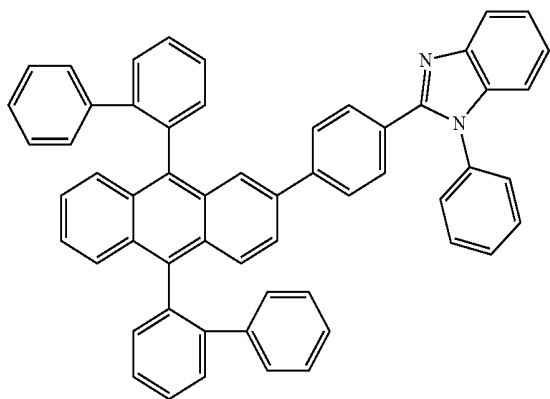


ET4



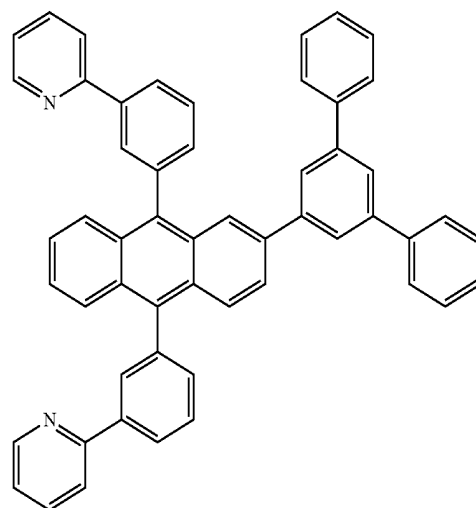
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ET5

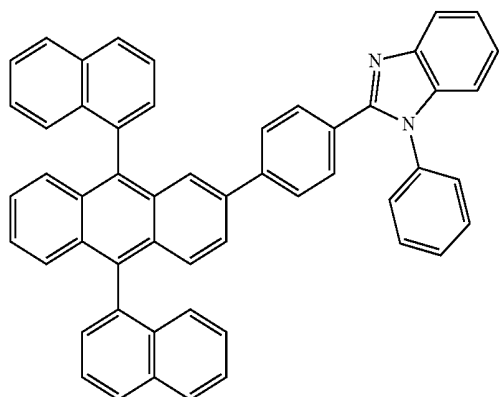


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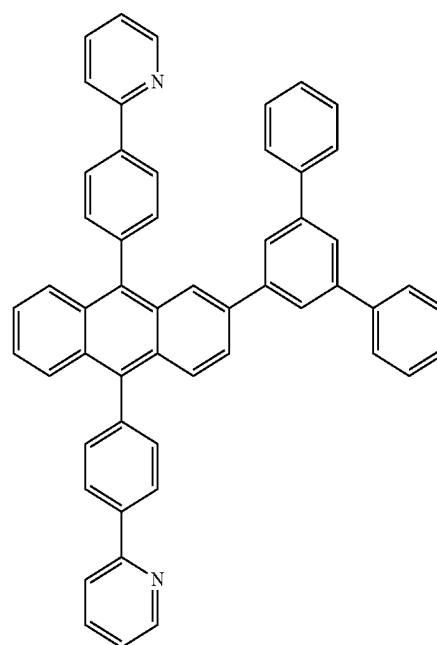
ET8



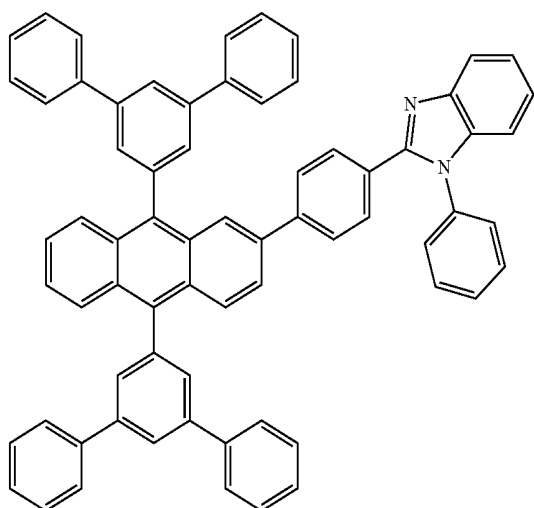
ET6



ET9

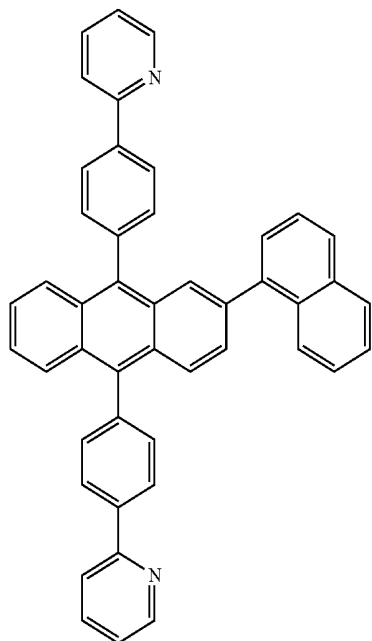


ET7



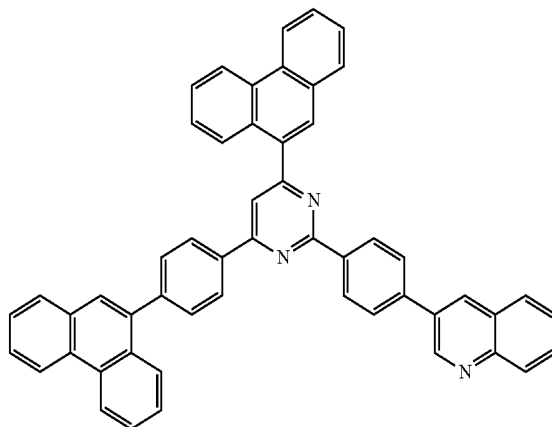
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ET10



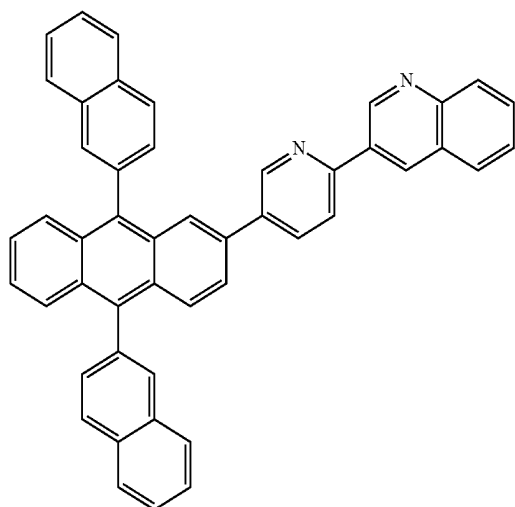
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ET13



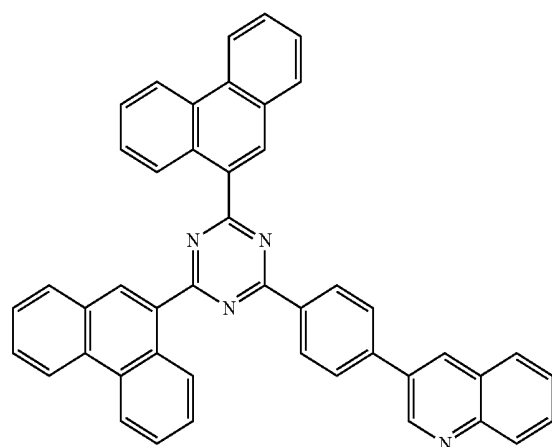
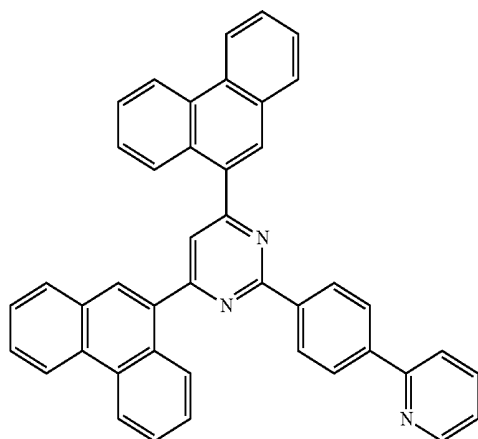
ET14

ET11



ET15

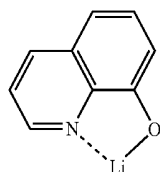
ET12



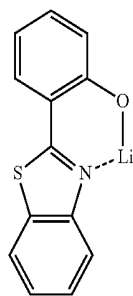
[0265] A thickness of the ETL may be from about 100 Å to about 1,000 Å, and in some embodiments, from about 150 Å to about 500 Å. When the thickness of the ETL is within these ranges, the ETL may have satisfactory electron transporting ability without a substantial increase in driving voltage.

[0266] In some embodiments the ETL may further include a metal-containing material, in addition to the above-described materials.

[0267] The metal-containing material may include a lithium (Li) complex. Non-limiting examples of the Li complex are compound ET-D1 below (lithium quinolate (LiQ)) and compound ET-D2 below.



ET-D1



ET-D2

[0268] In one embodiment, the electron transport region may include an EIL that may facilitate injection of electrons from the second electrode **190**.

[0269] The EIL may be formed on the ETL by using any of a variety of methods such as, for example, vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, inkjet printing, laser printing, laser induced thermal imaging (LITI), or the like. When the EIL is formed using vacuum deposition or spin coating, the deposition and coating conditions for forming the EIL may be similar to the above-described deposition and coating conditions for forming the HIL, and accordingly will not be described again.

[0270] The EIL may include at least one selected from LiF, NaCl, CsF, Li₂O, BaO, and/or LiQ.

[0271] A thickness of the EIL may be from about 1 Å to about 100 Å, and in some embodiments, from about 3 Å to about 90 Å. When the thickness of the EIL is within these ranges, the EIL may have satisfactory electron injection ability without a substantial increase in driving voltage.

[0272] The second electrode **190** may be positioned on the organic layer **150**, as described above. The second electrode **190** may be an electron injecting electrode (i.e. a cathode). A material for forming the second electrode **190** may be a metal, an alloy, an electrically conductive compound, which all have a low-work function, or a mixture thereof. Non-limiting examples of materials for forming the second electrode **190** are lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), and magnesium-silver (Mg—Ag). In some embodiments, a material for forming the second electrode **190** may be ITO or IZO. The second electrode **190** may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode.

[0273] Although the organic light-emitting device of the drawing is described above, embodiments of the present disclosure are not limited thereto.

[0274] As used herein, a C₁-C₆₀ alkyl group refers to a linear or branched aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms in the main chain. Non-limiting

examples of the C₁-C₆₀ alkyl group are a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an iso-amyl group, and a hexyl group. A C₁-C₆₀ alkylene group refers to a divalent group having the same structure as the C₁-C₆₀ alkyl.

[0275] As used herein, a C₁-C₆₀ alkoxy group refers to a monovalent group represented by OA₁₀₁ (where A₁₀₁ is the C₁-C₆₀ alkyl group as described above). Non-limiting examples of the C₁-C₆₀ alkoxy group are a methoxy group, an ethoxy group, and an isopropoxy group.

[0276] As used herein, a C₂-C₆₀ alkenyl group refers to a hydrocarbon group including at least one carbon double bond at one or more positions along a carbon chain of the C₂-C₆₀ alkyl group. For example, the C₂-C₆₀ alkenyl group may include a terminal alkene and/or an internal alkene. Non-limiting examples of the C₂-C₆₀ alkenyl group are an ethenyl group, a propenyl group, and a butenyl group. A C₂-C₆₀ alkylene group refers to a divalent group having the same structure as the C₂-C₆₀ alkenyl group.

[0277] As used herein, a C₂-C₆₀ alkynyl group refers to a hydrocarbon group including at least one carbon triple bond at one or more positions along a carbon chain of the C₂-C₆₀ alkyl group. For example, the C₂-C₆₀ alkynyl group may include a terminal alkyne and/or an internal alkyne. Non-limiting examples of the C₂-C₆₀ alkynyl group are an ethynyl group and a propynyl group. A C₂-C₆₀ alkynylene group used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkynyl group.

[0278] As used herein, a C₃-C₁₀ cycloalkyl group refers to a monovalent, monocyclic hydrocarbon group having 3 to 10 carbon atoms as ring-forming atoms. Non-limiting examples of the C₃-C₁₀ cycloalkyl group are a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. A C₃-C₁₀ cycloalkylene group refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkyl group.

[0279] As used herein, a C₂-C₁₀ heterocycloalkyl group refers to a monovalent monocyclic group having 2 to 10 carbon atoms and at least one hetero atom selected from N, O, P, and S as ring-forming atoms. Non-limiting examples of the C₂-C₁₀ heterocycloalkyl group are a tetrahydrofuranlyl group and a tetrahydrothiophenyl group. A C₂-C₁₀ heterocycloalkylene group refers to a divalent group having the same structure as the C₂-C₁₀ heterocycloalkyl group.

[0280] As used herein, a C₃-C₁₀ cycloalkenyl group refers to a monovalent monocyclic group having 3 to 10 carbon atoms as ring-forming atoms and including at least one carbon-carbon double bond in the ring, but not having aromaticity. Non-limiting examples of the C₃-C₁₀ cycloalkenyl group are a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. A C₃-C₁₀ cycloalkenylene group refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkenyl group.

[0281] As used herein, a C₂-C₁₀ heterocycloalkenyl group used herein refers to a monovalent monocyclic group having 2 to 10 carbon atoms and at least one hetero atom selected from N, O, P, and S as ring-forming atoms, and at least one double bond in the ring. Non-limiting examples of the C₂-C₁₀ heterocycloalkenyl group are a 2,3-hydrofuranlyl group and a 2,3-hydrothiophenyl group. A C₂-C₁₀ heterocycloalkenylene group used herein refers to a divalent group having the same structure as the C₂-C₁₀ heterocycloalkenyl group.

[0282] As used herein, a C₆-C₆₀ aryl group refers to a monovalent, carbocyclic aromatic group having 6 to 60 car-

bon atoms as ring-forming atoms, and a C₆-C₆₀ arylene group refers to a divalent, carbocyclic aromatic group having 6 to 60 carbon atoms as ring-forming atoms. Non-limiting examples of the C₆-C₆₀ aryl group are a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C₆-C₆₀ aryl group and/or the C₆-C₆₀ arylene group include at least two rings, the rings may be fused to each other.

[0283] As used herein, a C₁-C₆₀ heteroaryl group refers to a monovalent, carbocyclic aromatic group having 2 to 60 carbon atoms and at least one hetero atom selected from N, O, P, and S as a ring-forming atoms. A C₁-C₆₀ heteroarylene group refers to a divalent group having the same structure as the C₁-C₆₀ heteroaryl group. Non-limiting examples of the C₁-C₆₀ heteroaryl group are a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and/or an isoquinolinyl group. When the C₁-C₆₀ heteroaryl and/or the C₁-C₆₀ heteroarylene include at least two rings, the rings may be fused to each other.

[0284] As used herein, a C₆-C₆₀ aryloxy group refers to a group represented by —OA₁₀₂ (where A₁₀₂ is the C₆-C₆₀ aryl group as described above), and a C₆-C₆₀ arylthio group refers to a group represented by —SA₁₀₃ (where A₁₀₃ is the C₆-C₆₀ aryl group as described above).

[0285] As used herein, a monovalent non-aromatic condensed polycyclic group refers to a monovalent group having at least two rings condensed to each other, in which only carbon atoms (for example, 8 to 60 carbon atoms) are exclusively included as ring-forming atoms, and the entire molecule does not have aromaticity. A non-limiting example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. A divalent non-aromatic condensed polycyclic group refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0286] As used herein, a monovalent non-aromatic condensed heteropolycyclic group refers to a monovalent group having at least two rings condensed to each other, in which carbon atoms (for example, 2 to 60 carbon atoms) and at least one hetero atom selected from N, O, P, and S are as ring-forming atoms, and the entire molecule does not have aromaticity. A non-limiting example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. A divalent non-aromatic condensed heteropolycyclic group refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0287] As used herein, at least one substituent of the substituted C₃-C₁₀ cycloalkylene group, the substituted C₂-C₁₀ heterocycloalkylene group, the substituted C₃-C₁₀ cycloalkenylene group, the substituted C₂-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₁-C₆₀ heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed

polycyclic group, and/or the substituted monovalent non-aromatic condensed heteropolycyclic group, may be selected from

[0288] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group,

[0289] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and C₁-C₆₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇), C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group,

[0290] a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one of a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇), and

[0291] —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇).

[0292] wherein Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group.

monovalent non-aromatic condensed polycyclic group, and/or a monovalent non-aromatic condensed heteropolycyclic group.

[0293] In one embodiment, at least one substituent of the substituted C_3 - C_{10} cycloalkylene group, the substituted C_2 - C_{10} heterocycloalkylene group, the substituted C_3 - C_{10} cycloalkenylene group, the substituted C_2 - C_{10} heterocycloalkenylene group, the substituted C_6 - C_{60} heteroarylene group, the substituted C_1 - C_{60} heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_2 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_2 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, the substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_1 - C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and/or the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from

[0294] a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group,

[0295] a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and/or a C_1 - C_{60} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzo-fluorenyl 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 ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuran group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuran group, a dibenzothiophenyl group, a benzo-

carbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —N(Q_{11})(Q_{12}), —Si(Q_{13})(Q_{14})(Q_{15}), and —B(Q_{16})(Q_{17}),

[0296] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzo-fluorenyl 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 ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuran group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuran group, a dibenzothiophenyl group, a benzo-carbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group,

[0297] a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzo-fluorenyl 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 ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuran group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuran group, a dibenzothiophenyl group, a benzo-carbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from a

deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenaziny group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzo-carbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and/or an imidazopyrimidinyl group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇), and

[0298] —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇),

[0299] wherein Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ may be each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovarenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a

purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenaziny group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzo-carbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and/or an imidazopyrimidinyl group.

[0300] The acronym “Ph” used herein refers to phenyl, the acronym “Me” used herein refers to methyl, the acronym “Et” used herein refers to ethyl, and the acronym “ter-Bu” or Bu^t used herein refers to tert-butyl.

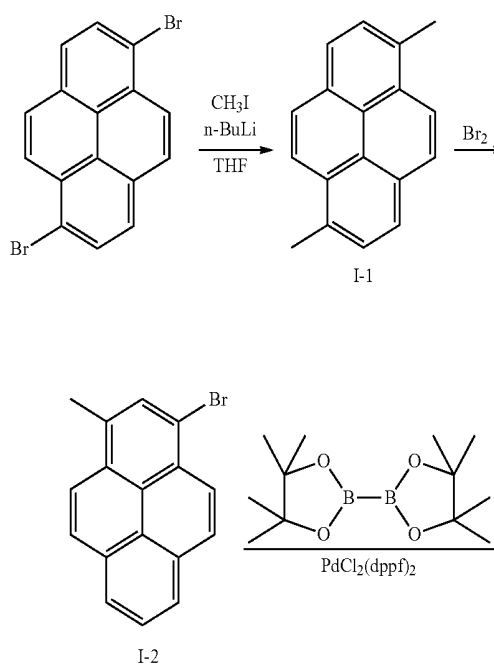
[0301] Condensed cyclic compounds, and organic light-emitting devices including the same, of embodiments of the present disclosure will now be described with reference to the following examples. However, these examples are only for illustrative purposes and are not intended to limit the scope of the one or more embodiments of the present disclosure. In the following synthesis examples, the expression that “B” instead of “A” was used” means that “B” and “A” were used in equivalent amounts.

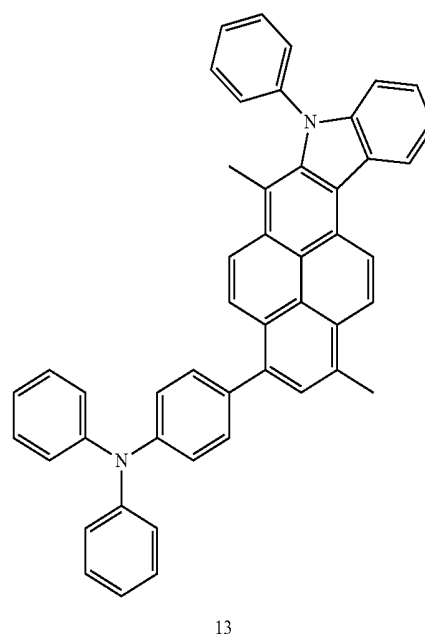
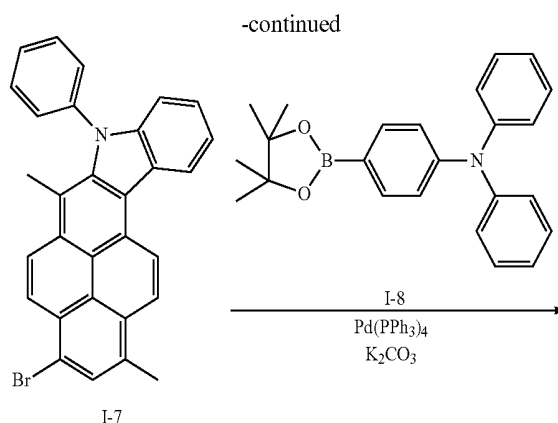
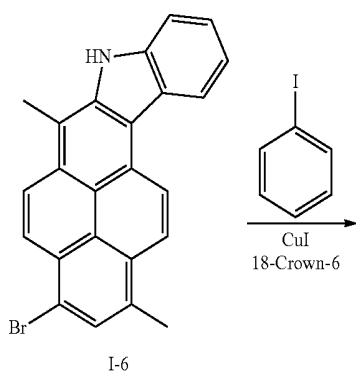
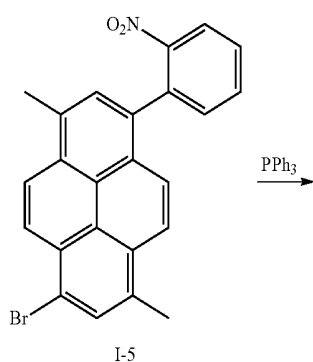
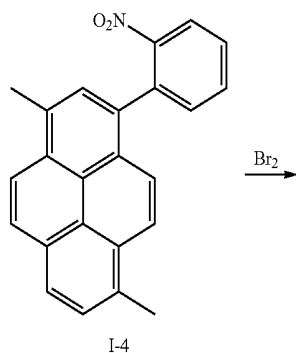
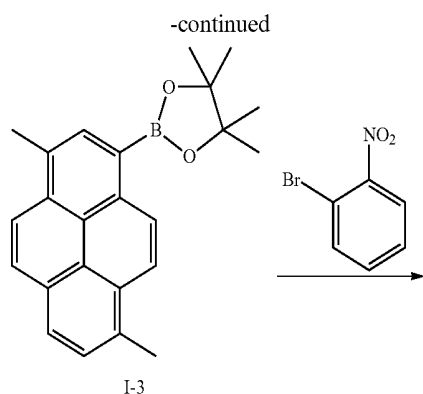
EXAMPLES

Synthesis Example 1

Synthesis of Compound 13

[0302]





Synthesis of Intermediate I-1

[0303] 3.6 g (10.0 mmol) of 1,6-dibromopyrene was dissolved in 100 mL of tetrahydrofuran (THF) 100 mL, and 60 mmol of a 2.6M n-BuLi solution in THF was dropwise added thereto at 0° C. in a nitrogen atmosphere, and the resulting solution was stirred while maintaining the temperature constant for about 6 hours. Then, 5.53 g (60.0 mmol) of iodomethane was dropwise added thereto. The temperature of the resulting reaction solution was raised to room temperature, and the solution was stirred for about 3 hours. 100 mL of water was added to the reaction solution, which was then extracted three times with 50 mL of ethylether. An organic layer was collected and was dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified by silica gel column chromatography, followed by recrystallization with ethanol to obtain 1.73 g of Intermediate I-1 (Yield: 85%). This compound was identified using high-resolution mass spectrometry (HR-MS) and nuclear magnetic resonance (NMR).

Synthesis of Intermediate I-2

[0304] 3.45 g (15.0 mmol) of Intermediate I-1 was dissolved in 100 mL of dichloromethane to obtain a solution, and

1.75 mL (15.0 mmol) of bromine (Br_2) was slowly dropwise added to the solution at about 0° C. The resulting reaction solution was stirred at room temperature for about 12 hours, and 60 mL water and 30 mL of a 20% aqueous thiosodium sulfate solution were added to the reaction solution, which was then extracted three times with 80 mL of dichloromethane. An organic layer was collected and dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified by silica gel column chromatography, followed by recrystallization with a dichloromethane/hexane solution to obtain 2.92 g of Intermediate I-2 (Yield: 63%). This compound was identified using high-resolution mass spectrometry (HR-MS) and nuclear magnetic resonance (NMR).

Synthesis of Intermediate I-3

[0305] 3.09 g (10.0 mmol) of Intermediate I-2, 2.54 g (10.0 mmol) of bis(pinacolato)diboron, 0.36 g (0.5 mmol) of [1,1'-bis(diphenylphosphino)ferrocene]dichloro palladium (II) ($\text{PdCl}_2(\text{dppf})_2$), and 2.94 g (30.0 mmol) of KOAc were dissolved in 40 mL of dimethylsulfoxide (DMSO), and then stirred at about 80° C. for about 6 hours. The resulting reaction solution was cooled down to room temperature, and then extracted three times with 50 mL of water and 50 mL of diethylether. An organic layer was collected and dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified using silica gel column chromatography to obtain 2.53 g of Intermediate I-3 (Yield: 71%). This compound was identified using high-resolution mass spectrometry (HR-MS) and nuclear magnetic resonance (NMR).

Synthesis of Intermediate I-4

[0306] 7.13 g (20.0 mmol) of Intermediate I-3, 4.04 g (20.0 mmol) of 2-bromonitrobenzene, 1.15 g (1.0 mmol) of tetrakis(triphenylphosphine)palladium ($\text{Pd}(\text{PPh}_3)_4$), and 8.29 g (60.0 mmol) of K_2CO_3 were dissolved in 60 mL of a mixed solution of THF and H_2O (2:1 by volume), and then stirred at about 70° C. for about 5 hours. The resulting reaction solution was cooled down to room temperature, and 40 mL of water was added thereto, followed by extraction three times with 50 mL of diethylether. An organic layer was collected and dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified using silica gel column chromatography to obtain 4.78 g of Intermediate I-4 (Yield: 68%). This compound was identified using high-resolution mass spectrometry (HR-MS) and nuclear magnetic resonance (NMR).

Synthesis of Intermediate I-5

[0307] 5.27 g (15.0 mmol) of Intermediate I-4 was dissolved in 100 mL of dichloromethane to obtain a solution, and 1.75 mL (15.0 mmol) of bromine (Br_2) was slowly dropwise added to the solution at about 0° C. The resulting reaction solution was stirred at room temperature for about 12 hours, and 60 mL water and 30 mL of a 20% aqueous thiosodium sulfate solution were added to the reaction solution, which was then extracted three times with 80 mL of dichloromethane. An organic layer was collected and dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified by silica gel column chromatography, followed by recrystallization with a dichloromethane/hexane solution to obtain 4.84 g of Intermediate I-5 (Yield: 75%).

This compound was identified using high-resolution mass spectrometry (HR-MS) and nuclear magnetic resonance (NMR).

Synthesis of Intermediate I-6

[0308] 4.30 g (10.0 mmol) of Intermediate I-5 and 5.77 g (22 mmol) of triphenylphosphine (PPh_3) were dissolved in 30 mL of 1,2-dichlorobenzene, and then stirred at about 170° C. for about 12 hours. The resulting reaction solution was cooled down to room temperature, and the solvent was removed therefrom in a vacuum, followed by extraction three times with 50 mL of water and 50 mL of dichloromethane. An organic layer was collected and dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified using silica gel column chromatography to obtain 2.67 g of Intermediate I-6 (Yield: 67%). This compound was identified using high-resolution mass spectrometry (HR-MS) and nuclear magnetic resonance (NMR).

Synthesis of Intermediate I-7

[0309] 3.98 g (10.0 mmol) of Intermediate I-6, 3.06 g (15.0 mmol) of iodobenzene, 0.19 g (1.0 mmol) of CuI , 0.05 g (0.2 mmol) of 18-Crown-6, and 4.15 g (30.0 mmol) of K_2CO_3 were dissolved in 30 mL of 1,3-dimethyl-3,4,5,6-tetrahydro-2(1H)-pyrimidinone (DMPU) and stirred at about 170° C. for about 12 hours. The resulting reaction solution was cooled down to room temperature, and then extracted three times with 50 mL of water and 50 mL of dichloromethane. An organic layer was collected and dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified using silica gel column chromatography to obtain 3.84 g of Intermediate I-7 (Yield: 81%). This compound was identified using high-resolution mass spectrometry (HR-MS) and nuclear magnetic resonance (NMR).

Synthesis of Intermediate I-8

[0310] 3.24 g (10.0 mmol) of 4-bromotriphenylamine, 2.54 g (10.0 mmol) of bis(pinacolato)diboron, 0.36 g (0.5 mmol) of $\text{PdCl}_2(\text{dppf})_2$, and 2.94 g (30.0 mmol) of KOAc were dissolved in 40 mL of DMSO, and stirred at about 80° C. for about 6 hours. The resulting reaction solution was cooled down to room temperature, and then extracted three times with 50 mL of water and 50 mL of diethylether. An organic layer was collected and dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified using silica gel column chromatography to obtain 2.57 g of Intermediate I-8 (Yield: 89%). This compound was identified using high-resolution mass spectrometry (HR-MS) and nuclear magnetic resonance (NMR).

Synthesis of Compound 13

[0311] 2.37 g (5.0 mmol) of Intermediate I-7, 1.86 g (5.0 mmol) of Intermediate I-8, 0.29 g (0.25 mmol) of tetrakis(triphenylphosphine)palladium ($\text{Pd}(\text{PPh}_3)_4$), and 2.07 g (15.0 mmol) of K_2CO_3 were dissolved in 30 mL of a mixed solution of THF and H_2O (2:1 by volume), and then stirred at about 70° C. for about 5 hours. The resulting reaction solution was cooled down to room temperature, and then extracted three times with 50 mL of water and 50 mL of diethylether. An organic layer was collected and dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified using silica gel column chromatography to obtain 2.11 g of Compound 13 (Yield: 66%). This compound was

identified using high-resolution mass spectrometry (HR-MS) and nuclear magnetic resonance (NMR).

[0312] $C_{48}H_{34}N_2$ calc.: 638.27. found [M+1] 639.26.

Synthesis Example 2

Synthesis of Compound 7

[0313] 1.90 g (4.0 mmol) of Intermediate I-7, 1.34 g (4.0 mmol) of Intermediate I-9 (illustrated below), 37 mg (0.04 mmol) of $Pd_2(dba)_3$, 8 mg (0.04 mmol) of $PtBu_3$, and 0.58 g (6.0 mmol) of $KOtBu$ were dissolved in 30 mL of toluene, and then stirred at about 85° C. for about 5 hours. The resulting reaction solution was cooled down to room temperature, and then extracted three times with 50 mL of water and 50 mL of diethylether. An organic layer was collected and dried using magnesium sulfate to evaporate the solvent. The residue was separated and purified using silica gel column chromatography to obtain 2.07 g of Compound 7 (Yield: 71%).

Synthesis Example 3

Synthesis of Compound 9

[0314] Compound 9 was synthesized as in Synthesis Example 2, except that $C(CH_3)_3Cl$, instead of iodomethane, was used to synthesize Intermediate I-1, and Intermediate I-10 (illustrated below) was used, instead of Intermediate I-9 used to synthesize Compound 7.

Synthesis Example 4

Synthesis of Compound 12

[0315] Compound 12 was synthesized as in Synthesis Example 2, except that Intermediate I-11 (illustrated below) was used instead of Intermediate I-9.

Synthesis Example 5

Synthesis of Compound 21

[0316] Compound 21 was synthesized as in Synthesis Example 1, except that trimethylsilylchloride, instead of iodomethane, was used to synthesize Intermediate I-1, and Intermediate I-12 (illustrated below) was used, instead of Intermediate I-8 used to synthesize Compound 7.

Synthesis Example 6

Synthesis of Compound 1

[0317] Compound 1 was synthesized as in Synthesis Example 2, except that diphenylamine, instead of Intermediate I-9, was used.

Synthesis Example 7

Synthesis of Compound 2

[0318] Compound 2 was synthesized as in Synthesis Example 2, except that bis(4-tert-butylphenyl)amine, instead of Intermediate I-9, was used.

Synthesis Example 8

Synthesis of Compound 3

[0319] Compound 3 was synthesized as in Synthesis Example 2, except that bis(4-(trimethylsilyl)phenyl)amine, instead of Intermediate I-9, was used.

Synthesis Example 9

Synthesis of Compound 4

[0320] Compound 4 was synthesized as in Synthesis Example 2, except that Intermediate I-13 (illustrated below), instead of Intermediate I-9, was used.

Synthesis Example 10

Synthesis of Compound 5

[0321] Compound 5 was synthesized as in Synthesis Example 9, except that $C(CH_3)_3Cl$, instead of iodomethane, was used to synthesize Intermediate I-1.

Synthesis Example 11

Synthesis of Compound 6

[0322] Compound 11 was synthesized as in Synthesis Example 2, except that

[0323] $C(CH_3)_3Cl$, instead of iodomethane, was used to synthesize Intermediate I-1, and Intermediate I-14 (illustrated below) was used, instead of Intermediate I-9 used to synthesize Compound 7.

Synthesis Example 12

Synthesis of Compound 8

[0324] Compound 8 was synthesized as in Synthesis Example 2, except that Intermediate I-10, instead of Intermediate I-9, was used.

Synthesis Example 13

Synthesis of Compound 10

[0325] Compound 10 was synthesized as in Synthesis Example 2, except that Intermediate I-15 (illustrated below), instead of Intermediate I-9, was used.

Synthesis Example 14

Synthesis of Compound 11

[0326] Compound 11 was synthesized as in Synthesis Example 2, except that Intermediate I-16 (illustrated below), instead of Intermediate I-9, was used.

Synthesis Example 15

Synthesis of Compound 14

[0327] Compound 14 was synthesized as in Synthesis Example 1, except that $C(CH_3)_3Cl$, instead of iodomethane, was used to synthesize Intermediate I-1.

Synthesis Example 16

Synthesis of Compound 15

[0328] Compound 15 was synthesized as in Synthesis Example 1, except that

[0329] Intermediate I-17 (illustrated below) was used, instead of Intermediate I-8 used to synthesize Compound 13.

Synthesis Example 17

Synthesis of Compound 16

[0330] Compound 16 was synthesized as in Synthesis Example 1, except that Intermediate I-18 (illustrated below), instead of Intermediate I-8, was used.

Synthesis Example 18

Synthesis of Compound 17

[0331] Compound 17 was synthesized as in Synthesis Example 1, except that $C(CH_3)_3Cl$, instead of iodomethane, was used to synthesize Intermediate I-1, and Intermediate I-19 (illustrated below) was used, instead of Intermediate I-8 used to synthesize Compound 13.

Synthesis Example 19

Synthesis of Compound 18

[0332] Compound 18 was synthesized as in Synthesis Example 1, except that Intermediate I-20 (illustrated below), instead of Intermediate I-8, was used.

Synthesis Example 20

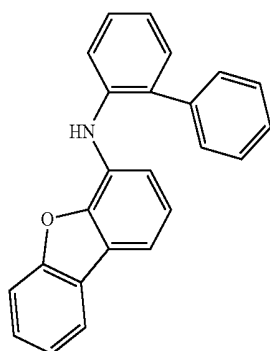
Synthesis of Compound 19

[0333] Compound 19 was synthesized as in Synthesis Example 1, except that Intermediate I-12, instead of Intermediate I-8, was used.

Synthesis Example 21

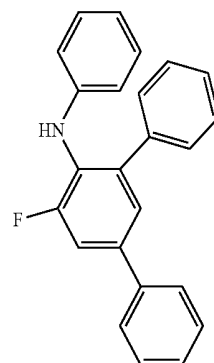
Synthesis of Compound 20

[0334] Compound 20 was synthesized as in Synthesis Example 1, except that Intermediate I-21 (illustrated below), instead of Intermediate I-8, was used.

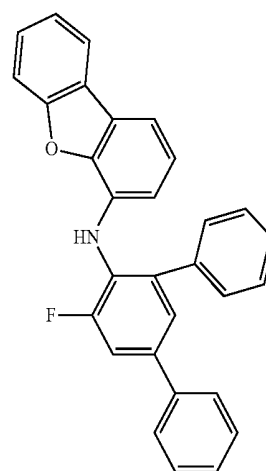


Intermediate I-9

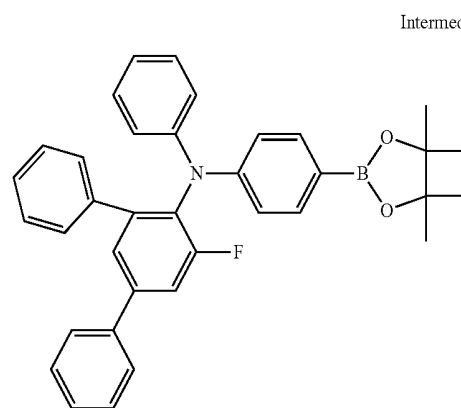
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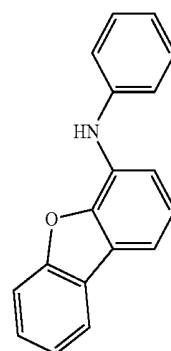
Intermediate I-10



Intermediate I-11

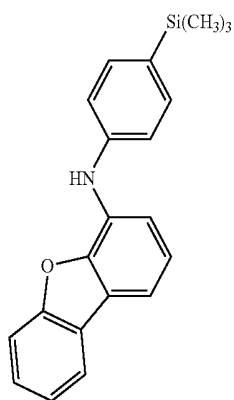


Intermediate I-12



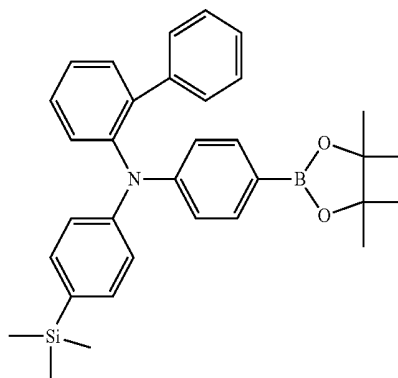
Intermediate I-13

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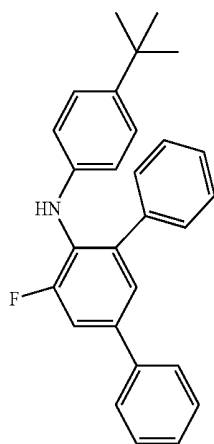
Intermediate I-14

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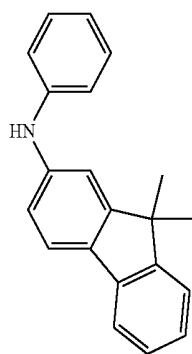
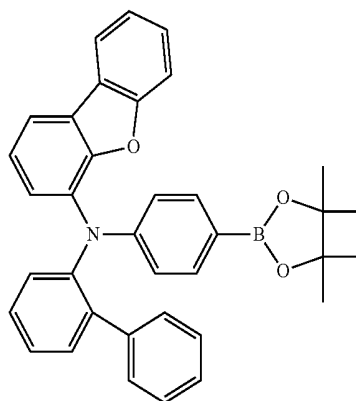
Intermediate I-18

Intermediate I-15



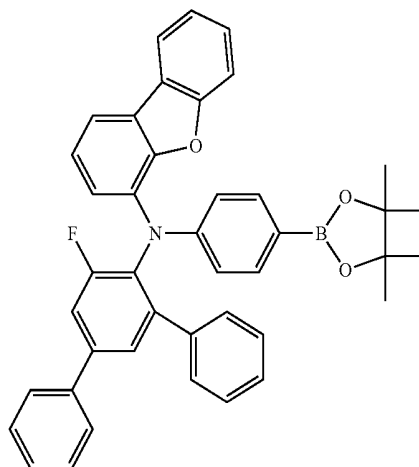
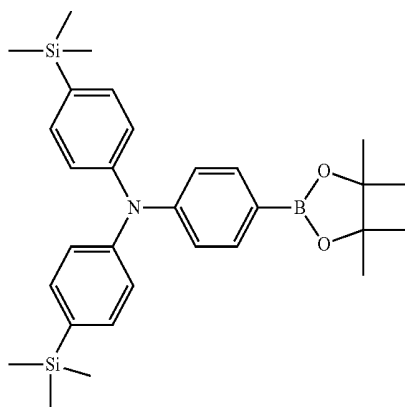
Intermediate I-16

Intermediate I-19



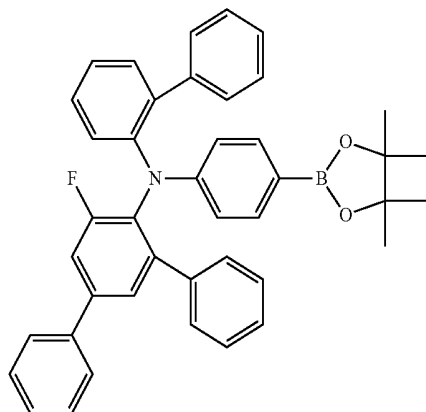
Intermediate I-17

Intermediate I-20



-continued

Intermediate I-21



[0335] The results of analyses of Compounds 1 to 21 of Synthesis Examples 1 to 21 by ^1H NMR and mass spectroscopy/fast atom bombardment (MS/FAB) are shown in Table 1.

TABLE 1

Com-	pound ^1H NMR (CDCl_3 , 400 MHz)	MS/FAB	
		found	calc.
1	$\sigma = 8.41$ (d, 1H), 8.34 (d, 1H), 8.24-8.22 (m, 1H), 8.15 (d, 1H), 8.04-8.01 (m, 1H), 7.52-7.48 (m, 2H), 7.45-7.42 (m, 2H), 7.38-7.27 (m, 4H), 7.12-7.03 (m, 5H), 6.65 (t, 2H), 6.20-6.18 (m, 4H), 2.78 (s, 3H), 2.57 (s, 3H)	563.25	562.24
2	$\sigma = 8.42$ (d, 1H), 8.34 (d, 1H), 8.26-8.24 (m, 1H), 8.16 (d, 1H), 8.04-8.02 (m, 1H), 7.53-7.48 (m, 2H), 7.46-7.43 (m, 2H), 7.36-7.22 (m, 8H), 7.09-7.07 (m, 1H), 6.48-6.46 (m, 4H), 2.78 (s, 3H), 2.57 (s, 3H), 1.50 (s, 18H)	675.36	674.37
3	$\sigma = 8.41$ (d, 1H), 8.33 (d, 1H), 8.25-8.23 (m, 1H), 8.17-8.16 (m, 1H), 8.04-8.02 (m, 1H), 7.52-7.48 (m, 2H), 7.45-7.26 (m, 10H), 7.08-7.07 (m, 1H), 6.56-6.54 (m, 4H), 2.78 (s, 3H), 2.57 (s, 3H), 0.24 (s, 18H)	707.31	706.32
4	$\sigma = 8.42$ (d, 1H), 8.32 (d, 1H), 8.25-8.15 (m, 3H), 7.82 (d, 1H), 7.70-7.64 (m, 2H), 7.52-7.25 (m, 11H), 7.06-7.02 (m, 2H), 6.97-6.92 (m, 2H), 6.63-6.60 (m, 1H), 6.24 (d, 2H), 2.78 (s, 3H), 2.57 (s, 3H)	653.26	652.25
5	$\sigma = 8.48$ (d, 1H), 8.46 (d, 1H), 8.36-8.31 (m, 3H), 7.82 (d, 1H), 7.71-7.65 (m, 2H), 7.61-7.53 (m, 2H), 7.50-7.28 (m, 8H), 7.09-7.01 (m, 3H), 6.95-6.91 (m, 2H), 6.64-6.61 (m, 1H), 6.23 (d, 2H), 1.55 (s, 9H), 1.48 (s, 9H)	737.34	736.35
6	$\sigma = 8.48$ (d, 1H), 8.46 (d, 1H), 8.37-8.32 (m, 3H), 7.83-7.82 (m, 1H), 7.71-7.64 (m, 2H), 7.59-7.53 (m, 2H), 7.50-7.29 (m, 10H), 7.21-7.20 (m, 1H), 6.95-6.91 (m, 2H), 6.53-6.51 (m, 2H), 1.56 (s, 9H), 1.49 (s, 9H), 0.25 (s, 9H)	809.37	808.38
7	$\sigma = 8.42$ (d, 1H), 8.32 (d, 1H), 8.26-8.24 (m, 1H), 8.16 (d, 1H), 7.98-7.96 (m, 1H),	729.27	728.28

TABLE 1-continued

Com-	pound ^1H NMR (CDCl_3 , 400 MHz)	MS/FAB	
		found	calc.
	7.82 (d, 1H), 7.72-7.64 (m, 2H), 7.61-7.25 (m, 15H), 7.14-7.12 (m, 1H), 7.09-6.94 (m, 4H), 6.91-6.87 (m, 1H), 6.75-6.74 (m, 1H), 2.77 (s, 3H), 2.56 (s, 3H)		
8	$\sigma = 8.41$ (d, 1H), 8.31 (d, 1H), 8.25-8.24 (m, 1H), 8.11 (d, 1H), 7.96 (d, 1H), 7.69-7.55 (m, 6H), 7.53-7.48 (m, 5H), 7.46-7.25 (m, 8H), 7.11-7.02 (m, 3H), 6.67 (s, 1H), 6.60 (t, 1H), 6.08 (d, 2H), 2.78 (s, 3H), 2.57 (s, 3H)	733.30	732.29
9	$\sigma = 8.53$ (d, 1H), 8.42 (d, 1H), 8.33-8.27 (m, 2H), 8.16 (d, 1H), 7.69-7.28 (m, 19H), 7.11-7.02 (m, 4H), 6.62-6.58 (m, 1H), 6.11-6.09 (m, 2H), 1.55 (s, 9H), 1.48 (s, 9H)	817.38	816.39
10	$\sigma = 8.42$ (d, 1H), 8.32 (d, 1H), 8.26-8.24 (m, 1H), 8.13-8.11 (m, 1H), 7.97 (d, 1H), 7.69-7.61 (m, 4H), 7.59-7.55 (m, 2H), 7.53-7.48 (m, 5H), 7.45-7.25 (m, 8H), 7.14-7.08 (m, 3H), 6.88-6.87 (m, 1H), 6.40-6.38 (m, 2H), 2.78 (s, 3H), 2.57 (s, 3H), 1.50 (s, 9H)	789.35	788.36
11	$\sigma = 8.41$ (d, 1H), 8.32 (d, 1H), 8.27-8.25 (m, 1H), 8.16 (d, 1H), 8.01 (d, 1H), 7.76 (d, 1H), 7.52-7.48 (m, 2H), 7.45-7.26 (m, 8H), 7.11-7.03 (m, 5H), 6.70 (d, 1H), 6.65-6.61 (m, 1H), 6.40-6.39 (m, 1H), 6.17 (d, 2H), 2.77 (s, 3H), 2.56 (s, 3H), 1.61 (s, 6H)	679.31	678.30
12	$\sigma = 8.42$ (d, 1H), 8.36-8.33 (m, 2H), 8.26-8.24 (m, 1H), 8.02 (d, 1H), 7.83-7.80 (m, 2H), 7.69-7.64 (m, 7H), 7.54-7.24 (m, 16H), 7.01-6.99 (m, 1H), 6.90-6.86 (m, 1H), 6.70 (s, 1H), 2.78 (s, 3H), 2.57 (s, 3H)	823.31	822.30
13	$\sigma = 8.45$ (d, 1H), 8.38-8.36 (m, 1H), 8.29-8.17 (m, 3H), 7.60 (s, 1H), 7.52-7.25 (m, 10H), 7.08-7.04 (m, 4H), 6.89-6.86 (m, 2H), 6.65 (t, 2H), 6.16-6.13 (m, 4H), 2.78 (s, 3H), 2.72 (s, 3H)	639.26	638.27
14	$\sigma = 8.46$ (d, 1H), 8.38-8.31 (m, 3H), 8.17 (d, 1H), 7.81 (s, 1H), 7.57-7.54 (m, 2H), 7.48-7.28 (m, 8H), 7.08-7.04 (m, 4H), 6.90-6.88 (m, 2H), 6.66-6.63 (m, 2H), 6.16-6.13 (m, 4H), 1.55 (s, 9H), 1.51 (s, 9H)	723.36	722.37
15	$\sigma = 8.45$ (d, 1H), 8.38 (d, 1H), 8.28-8.20 (m, 3H), 7.61-7.60 (m, 1H), 7.52-7.28 (m, 14H), 6.88-6.86 (m, 2H), 6.59 (d, 4H), 2.77 (s, 3H), 2.71 (s, 3H), 0.25 (s, 18H)	783.34	782.35
16	$\sigma = 8.46$ (d, 1H), 8.39 (d, 1H), 8.29-8.20 (m, 3H), 7.61-7.55 (m, 3H), 7.53-7.40 (m, 7H), 7.38-7.27 (m, 8H), 7.21-7.15 (m, 2H), 7.00-6.96 (m, 1H), 6.87-6.82 (m, 3H), 6.49-6.47 (m, 2H), 2.78 (s, 3H), 2.72 (s, 3H), 0.24 (s, 9H)	787.33	786.34
17	$\sigma = 8.45$ (d, 1H), 8.38-8.30 (m, 3H), 8.18 (d, 1H), 7.83-7.81 (m, 2H), 7.70-7.27 (m, 19H), 7.15-7.13 (m, 1H), 7.06-6.88 (m, 5H), 6.30-6.28 (m, 2H), 1.55 (s, 9H), 1.51 (s, 9H)	889.40	888.41
18	$\sigma = 8.45$ (d, 1H), 8.36 (d, 1H), 8.28-8.17 (m, 3H), 7.82 (d, 1H), 7.70-7.56 (m, 9H), 7.54-7.23 (m, 18H), 7.01-6.99 (m, 1H), 6.93-6.89 (m, 1H), 6.35-6.33 (m, 2H), 2.78 (s, 3H), 2.72 (s, 3H)	899.35	898.34
19	$\sigma = 8.44$ (d, 1H), 8.35 (d, 1H), 8.29-8.17 (m, 3H), 7.69-7.60 (m, 5H), 7.54-7.25 (m, 17H), 7.13-7.03 (m, 3H), 6.91-6.89 (m, 2H), 6.62 (t, 1H), 6.16-6.14 (m, 2H), 2.79 (s, 3H), 2.73 (s, 3H)	809.32	808.33

TABLE 1-continued

Com- pound	¹ H NMR (CDCl ₃ , 400 MHz)	MS/FAB	
		found	calc.
20	σ = 8.45 (d, 1H), 8.36 (d, 1H), 8.29-8.18 (m, 3H), 7.69-7.55 (m, 11H), 7.54-7.27 (m, 16H), 7.20-7.15 (m, 2H), 7.07-6.98 (m, 2H), 6.93-6.85 (m, 3H), 2.78 (s, 3H), 2.72 (s, 3H)	885.37	884.36
21	σ = 8.58 (d, 1H), 8.47 (d, 1H), 8.37-8.31 (m, 3H), 8.18 (s, 1H), 7.69-7.60 (m, 5H), 7.55-7.32 (m, 16H), 7.13-7.03 (m, 3H), 6.63-6.60 (m, 1H), 6.26-6.19 (m, 4H), 0.61 (s, 9H), 0.45 (s, 9H)	925.36	924.37

Example 1

[0336] A corning 15 Ω/cm^2 (1200 Å) ITO glass substrate was cut to a size of 50 mm×50 mm×0.7 mm and then sonicated in isopropyl alcohol and pure water each for five minutes, and then cleaned by irradiation of ultraviolet rays for 30 minutes and exposure to ozone. The resulting ITO glass substrate was mounted into a vacuum deposition device.

[0337] After 2-TNATA was vacuum-deposited on the ITO anode of the ITO glass substrate to form an HIL having a thickness of 600 Å, NPB was deposited on the HIL to form a HTL having a thickness of about 300 Å, and then ADN (host) and Compound 13 (dopant) were co-deposited in a weight ratio of 98:2 on the HTL to form an EML having a thickness of about 300 Å.

[0338] Then, Alq₃ was deposited on the EML to form an ETL having a thickness of about 300 Å, and then LiF was deposited on the ETL to form an EIL having a thickness of about 10 Å. Then, Al was deposited on the EIL to form a cathode having a thickness of about 3000 Å, thereby completing the manufacture of an organic light-emitting device.

Example 2

[0339] An organic light-emitting device was manufactured as in Example 1, except that Compound 7 instead of Compound 13 was used as a dopant to form the EML.

Example 3

[0340] An organic light-emitting device was manufactured as in Example 1, except that Compound 9 instead of Compound 13 was used as a dopant to form the EML.

Example 4

[0341] An organic light-emitting device was manufactured as in Example 1, except that Compound 12 instead of Compound 13 was used as a dopant to form the EML.

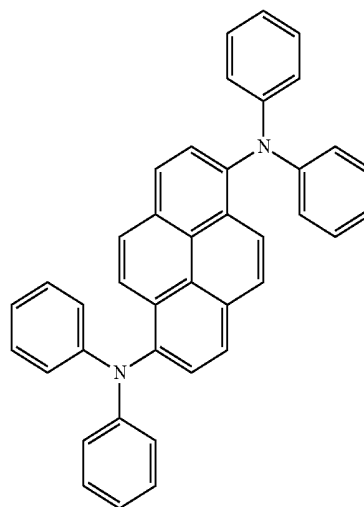
Example 5

[0342] An organic light-emitting device was manufactured as in Example 1, except that Compound 21, instead of Compound 13, was used as a dopant to form the EML.

Comparative Example 1

[0343] An organic light-emitting device was manufactured as in Example 1, except that Compound A instead of Compound 13 was used as a dopant to form the EML.

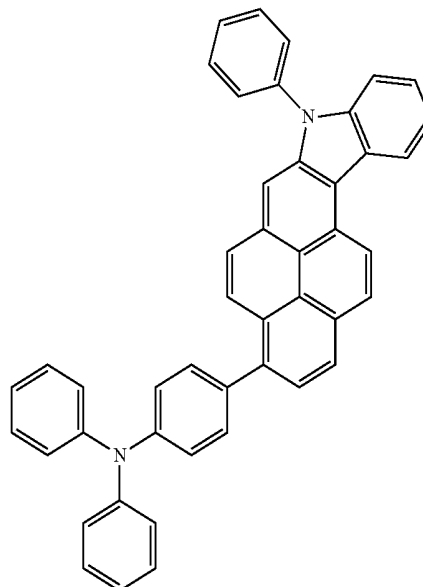
Compound A



Comparative Example 2

[0344] An organic light-emitting device was manufactured as in Example 1, except that Compound B, instead of Compound 13, was used as a dopant to form the EML.

Compound B

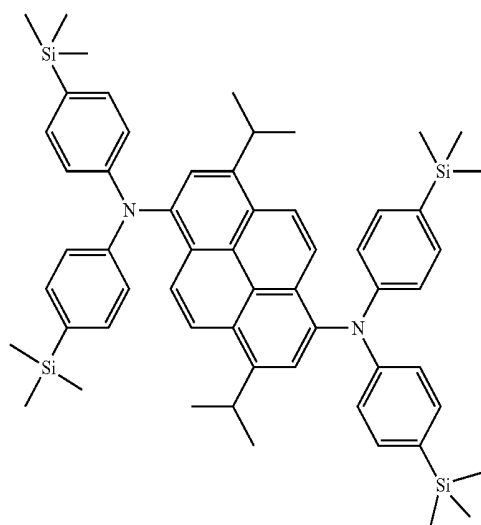


Comparative Example 3

[0345] An organic light-emitting device was manufactured as in Example 1, except that Compound C, instead of Compound 13, was used as a dopant to form the EML.

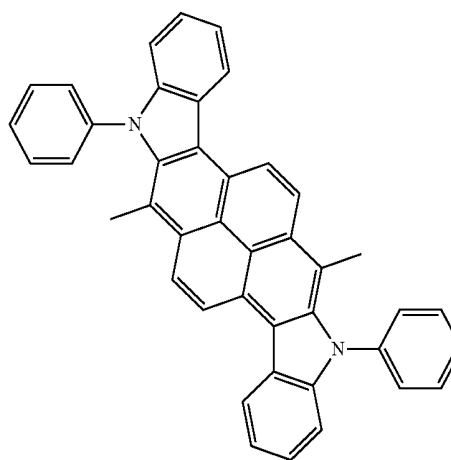
Comparative Example 5

Compound C



[0347] An organic light-emitting device was manufactured as in Example 1, except that Compound E, instead of Compound 13, was used as a dopant to form the EML.

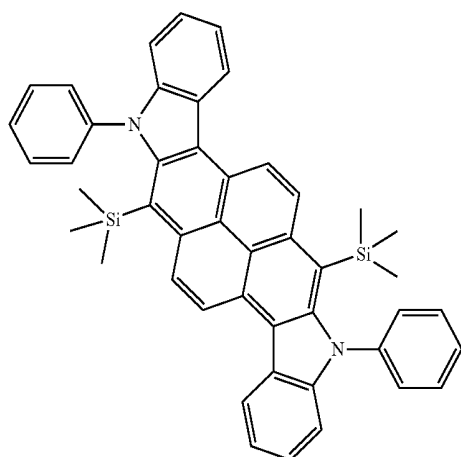
Compound E



Comparative Example 4

[0346] An organic light-emitting device was manufactured as in Example 1, except that Compound D, instead of Compound 13, was used as a dopant to form the EML.

Compound D



Evaluation Example 1

[0348] Driving voltages, current densities, luminances, efficiencies, and half-lifetimes of the organic light-emitting devices of Examples 1 to 5 and Comparative Examples 1 to 5 were evaluated using a Keithley Source-Measure Unit (SMU 236) and a PR650 (Spectrascan) Colorimeter. (available from Photo Research, Inc.). The results are shown in Table 2 below. A half-lifetime was measured as the time taken until a measured initial luminance (assumed as 100%) is reduced to 50%.)

TABLE 2

Example	Dopant in EML	Driving voltage (V)	Current density (mA/cm ²)	Luminance (cd/m ²)	Efficiency (cd/A)	Emission color	Half-lifetime (hr @100 mA/cm ²)
Example 1	Compound 13	6.10	50	3160	6.32	Blue	322
Example 2	Compound 7	5.98	50	3565	7.13	Blue	345
Example 3	Compound 9	6.03	50	3505	7.01	Blue	338
Example 4	Compound 12	5.93	50	3670	7.34	Blue	351
Example 5	Compound 21	6.12	50	3205	6.41	Blue	316
Comparative Example 1	Compound A	7.01	50	2695	5.39	Blue	258
Comparative Example 2	Compound B	6.57	50	2830	5.66	Blue	263

TABLE 2-continued

Example	Dopant in EML	Driving voltage (V)	Current density (mA/cm ²)	Luminance (cd/m ²)	Efficiency (cd/A)	Emission color	Half-lifetime (hr @100 mA/cm ²)
Comparative Example 3	Compound C	6.65	50	2875	5.75	Blue	280
Comparative Example 4	Compound D	7.46	50	1095	2.19	Blue	96
Comparative Example 5	Compound E	7.61	50	990	1.98	Blue	87

[0349] Referring to Table 2, the organic light-emitting devices of Examples 1 to 5 were found to have improved driving voltages, improved luminances, improved efficiencies, and improved half-lifetimes, compared to those of the organic light-emitting devices of Comparative Examples 1 to 5.

[0350] According to one or more embodiments of the present disclosure, an organic light-emitting device including the condensed cyclic compound of Formula 1 may have low driving voltage, high efficiency, a high luminance, and long lifetime.

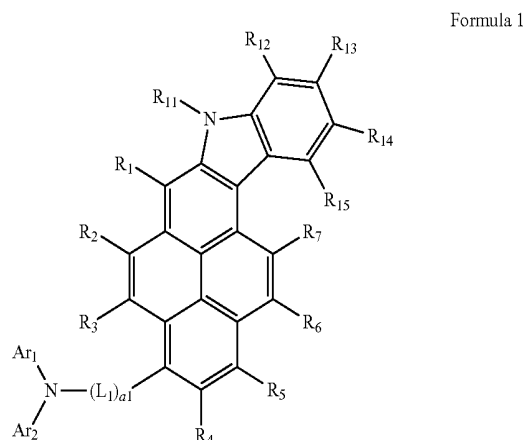
[0351] It should be understood that the exemplary embodiments described therein should be considered in a descriptive sense only and not for purposes of limitation.

[0352] Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

[0353] While one or more embodiments of the present disclosure have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present disclosure as defined by the following claims and equivalents thereof.

What is claimed is:

1. A condensed cyclic compound represented by Formula 1:



wherein

R_1 to R_7 , and R_{12} to R_{15} are each independently selected from

a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an

amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, and/or a C_1 - C_{60} alkoxy group,

a C_1 - C_{60} alkyl group and a C_1 - C_{60} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof,

a phenyl group and/or a naphthyl group,

a phenyl and/or a naphthyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{60} alkyl group, a C_1 - C_{60} alkoxy group, a phenyl group, and a naphthyl group, and/or

—Si(Q_1)(Q_2)(Q_3), wherein Q_1 to Q_3 are each independently selected from a C_1 - C_{60} alkyl group, and/or a C_1 - C_{60} alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof;

at least one of R_1 to R_7 is selected from

a C_1 - C_{60} alkyl group,

a C_1 - C_{60} alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

—Si(Q_1)(Q_2)(Q_3);

L_1 is selected from a substituted or unsubstituted C_3 - C_{10} cycloalkylene group, a substituted or unsubstituted C_2 - C_{10} heterocycloalkylene group, a substituted or unsubstituted C_3 - C_{10} cycloalkenylene group, a substituted or unsubstituted C_2 - 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/or a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group;

a_1 is selected from 0, 1, 2, and 3;

R₁₁ is selected from a substituted or unsubstituted C₁-C₆₀ alkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₂-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group; and

Ar₁ and Ar₂ are each independently selected from a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted C₂-C₁₀ heterocycloalkenyl group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

wherein at least one substituent of the substituted C₃-C₁₀ cycloalkylene group, the substituted C₂-C₁₀ heterocycloalkylene group, the substituted C₃-C₁₀ cycloalkenylene group, the substituted C₂-C₁₀ heterocycloalkenylene group, the substituted C₆-C₆₀ arylene group, the substituted C₁-C₆₀ heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C₁-C₆₀ alkyl group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₂-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₂-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₂-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and/or the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from

a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group,

a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₃₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₁₁)(Q₁₂), —Si(Q₁₃)(Q₁₄)(Q₁₅), and —B(Q₁₆)(Q₁₇),

a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group,

a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —N(Q₂₁)(Q₂₂), —Si(Q₂₃)(Q₂₄)(Q₂₅), and —B(Q₂₆)(Q₂₇), and —N(Q₃₁)(Q₃₂), —Si(Q₃₃)(Q₃₄)(Q₃₅), and —B(Q₃₆)(Q₃₇),

wherein Q₁₁ to Q₁₇, Q₂₁ to Q₂₇, and Q₃₁ to Q₃₇ are each independently a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₂-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₂-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₂-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and/or a monovalent non-aromatic condensed heteropolycyclic group.

2. The condensed cyclic compound of claim 1, wherein R₁ to R₇, and R₁₂ to R₁₅ are each independently selected from

a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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 C₁-C₂₀ alkyl group, and/or a C₁-C₂₀ alkoxy group,

a C₁-C₂₀ alkyl group and/or a C₁-C₂₀ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

—Si(Q₁)(Q₂)(Q₃), wherein Q₁ to Q₃ are each independently selected from a C₁-C₂₀ alkyl group and/or a C₁-C₂₀ alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof; and

at least one of R₁ to R₇ is selected from

a C₁-C₂₀ alkyl group,

a C₁-C₂₀ alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic

acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

—Si(Q₁)(Q₂)(Q₃).

3. The condensed cyclic compound of claim 1, wherein two of R₁ to R₇ are each independently selected from

a C₁-C₆₀ alkyl group,

a C₁-C₆₀ alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

—Si(Q₁)(Q₂)(Q₃).

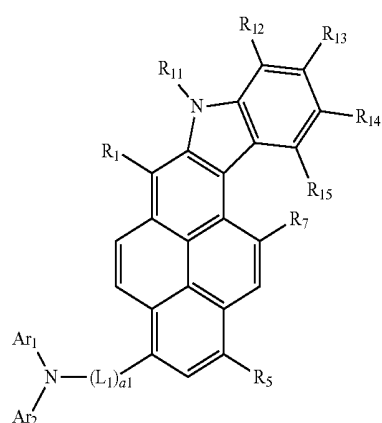
4. The condensed cyclic compound of claim 1, wherein at least one of R₁ to R₅ is selected from

a C₁-C₂₀ alkyl group,

a C₁-C₂₀ alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

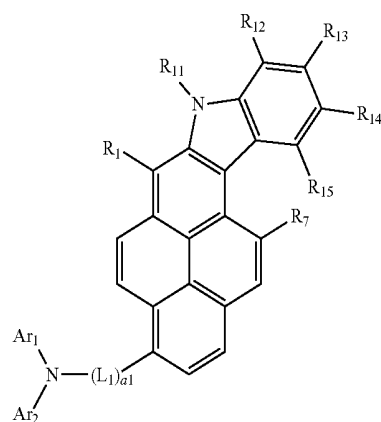
—Si(Q₁)(Q₂)(Q₃), wherein Q₁ to Q₃ are each independently selected from a C₂₀ alkyl group and/or a C₁-C₂₀ alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof.

5. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound of Formula 1 is a compound represented by one of Formulae 1(1), 1(2), and 1(3):

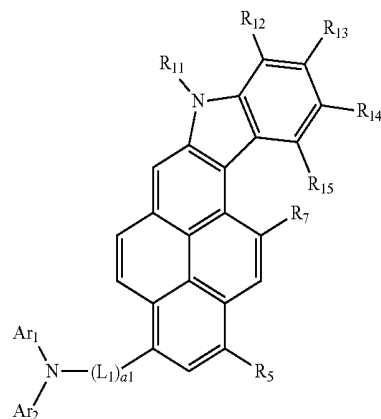


Formula 1(1)

-continued



Formula 1(2)



Formula 1(3)

wherein

R₁₁ to R₁₅, L₁, a₁, Ar₁, and Ar₂ are as defined in claim 1; and

R₁ and R₅ are each independently selected from

a C₁-C₂₀ alkyl group,

a C₁-C₂₀ alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, and/or

—Si(Q₁)(Q₂)(Q₃), wherein Q₁ to Q₃ are each independently selected from a C₁-C₂₀ alkyl group and/or a C₁-C₂₀ alkyl group substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof.

6. The condensed cyclic compound of claim 5, wherein R₁ and R₅ are each independently selected from

a methyl group, an ethyl group, a propyl group, a n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a n-pentyl group, an isopentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isohexyl group, a sec-heptyl group, a tert-heptyl group, a n-octyl, an isooctyl group, a sec-octyl group, a tert-octyl

group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-decanyl group, an isodecanyl group, a sec-decanyl group, and/or a tert-decanyl group, and/or

—Si(Q₁)(Q₂)(Q₃), wherein Q₁ to Q₃ are each independently selected from a methyl group, an ethyl group, a propyl group, a n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a n-pentyl group, an isopentyl group, a tert-pentyl group, an n-hexyl group, an isohexyl group, a sec-hexyl group, a tert-hexyl group, an n-heptyl group, an isoheptyl group, a sec-heptyl group, a tert-heptyl group, a n-octyl, an isooctyl group, a sec-octyl group, a tert-octyl group, an n-nonyl group, an isononyl group, a sec-nonyl group, a tert-nonyl group, an n-decanyl group, an isodecanyl group, a sec-decanyl group, and/or a tert-decanyl group.

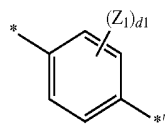
7. The condensed cyclic compound of claim 1, wherein L₁ is selected from

a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylenylene group, a picenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylenylene group, an indolylenylene group, an indazolylenylene group, a purinylenylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylenylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoimidazolylenylene group, a benzofuranylenylene group, a benzothiophenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an oxadiazolylenylene group, a triazinylene group, a dibenzofuranylenylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a thiadiazolylenylene group, an imidazopyridinylene group, and/or an imidazopyrimidinylene group; and/or

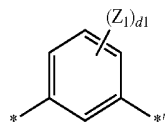
a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-fluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylenylene group, a picenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pen-

tacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylenylene group, an indolylenylene group, an indazolylenylene group, a purinylenylene group, a quinolinylene group, an isoquinolinylene group, a benzoquinolinylene group, a phthalazinylene group, a naphthyridinylene group, a quinoxalinylene group, a quinazolinylene group, a cinnolinylene group, a carbazolylenylene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzoimidazolylenylene group, a benzofuranylenylene group, a benzothiophenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an oxadiazolylenylene group, a triazinylene group, a dibenzofuranylenylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a thiadiazolylenylene group, an imidazopyridinylene group, and/or an imidazopyrimidinylene group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, an a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group.

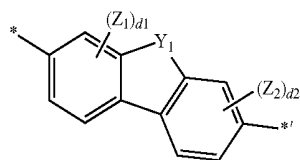
8. The condensed cyclic compound of claim 1, wherein L_1 is represented by one of Formulae 3-1 to 3-32:



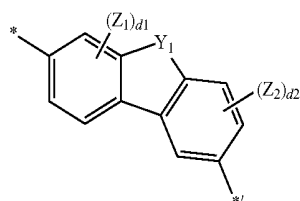
Formula 3-1



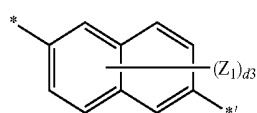
Formula 3-2



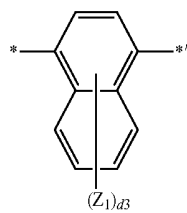
Formula 3-3



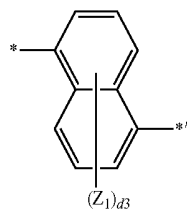
Formula 3-4



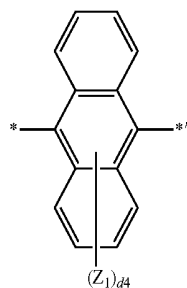
Formula 3-5



Formula 3-6

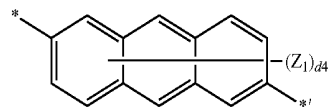


Formula 3-7

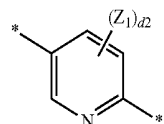


Formula 3-8

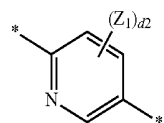
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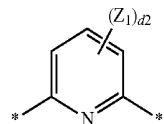
Formula 3-9



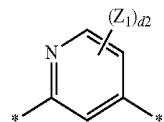
Formula 3-10



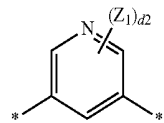
Formula 3-11



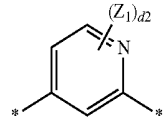
Formula 3-12



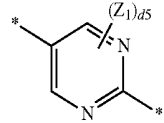
Formula 3-13



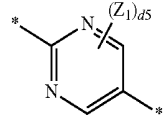
Formula 3-14



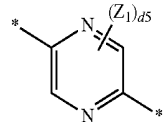
Formula 3-15



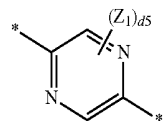
Formula 3-16



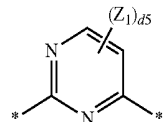
Formula 3-17



Formula 3-18

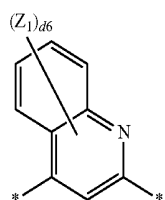
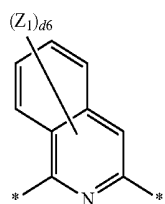
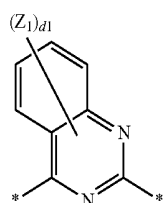
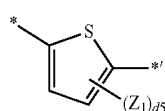
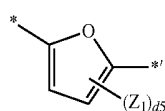
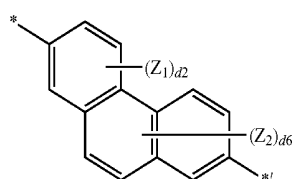
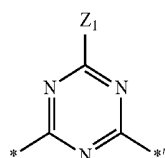
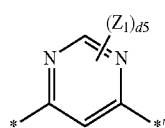
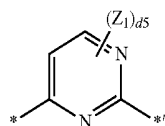
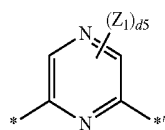


Formula 3-19



Formula 3-20

-continued



Formula 3-21

Formula 3-22

Formula 3-23

Formula 3-24

Formula 3-25

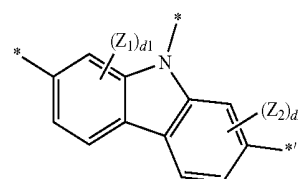
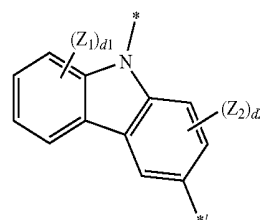
Formula 3-26

Formula 3-27

Formula 3-28

Formula 3-29

-continued



Formula 3-31

Formula 3-32

wherein

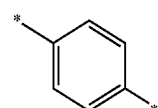
Y₁ is O, S, C(Z₃)(Z₄), N(Z₅), or Si(Z₆)(Z₇);

Z₁ to Z₇ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spirofluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group;

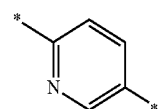
d₁ is an integer selected from 1 to 4;d₂ is an integer selected from 1 to 3;d₃ is an integer selected from 1 to 6;d₄ is an integer selected from 1 to 8;d₅ is 1 or 2;d₆ is an integer selected from 1 to 5; and

* and *' are binding sites with adjacent atoms

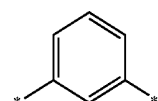
9. The condensed cyclic compound of claim 1, wherein L₁ is represented by one of Formulae 4-1 to 4-23:



Formula 4-1



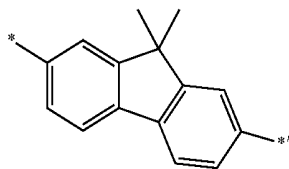
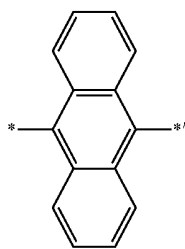
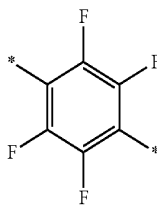
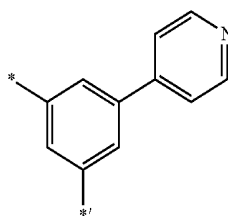
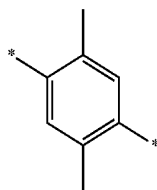
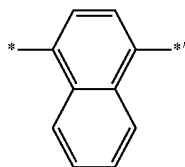
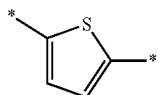
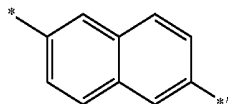
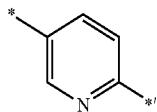
Formula 4-2



Formula 4-3

Formula 3-30

-continued



Formula 4-4

Formula 4-5

Formula 4-6

Formula 4-7

Formula 4-8

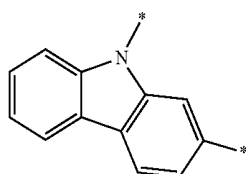
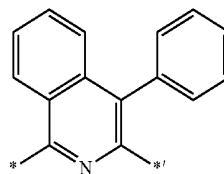
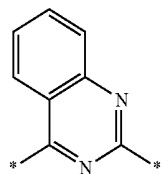
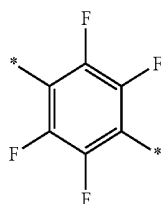
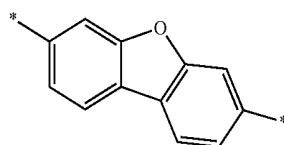
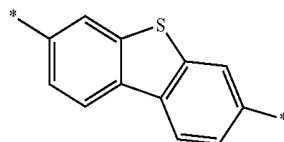
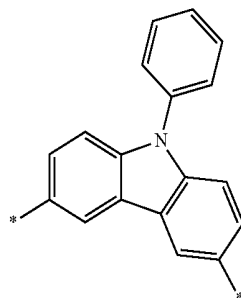
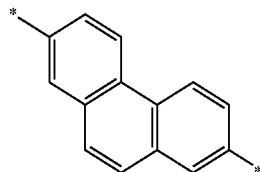
Formula 4-9

Formula 4-10

Formula 4-11

Formula 4-12

-continued



Formula 4-13

Formula 4-14

Formula 4-15

Formula 4-16

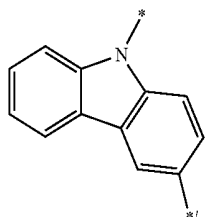
Formula 4-17

Formula 4-18

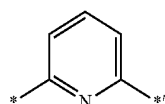
Formula 4-19

Formula 4-20

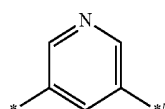
-continued



Formula 4-21



Formula 4-22



Formula 4-23

wherein * and *' are binding sites with adjacent atoms.

10. The condensed cyclic compound of claim 1, wherein a is 0 or 1.

11. The condensed cyclic compound of claim 1, wherein R_{11} , Ar_1 , and Ar_2 are each independently selected from

a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothienophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and/or an imidazopyrimidinyl group, and/or

a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl

group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, and/or an imidazopyrimidinyl group, each substituted with at least one selected from a deuterium —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentenyl group, a cyclohexyl group, a cycloheptyl, a cyclopentenyl, a cyclohexenyl group, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a pycenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzoimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and $Si(Q_{33})(Q_{34})(Q_{35})$,

wherein Q_{33} to Q_{35} are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group.

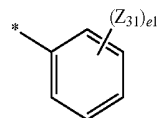
12. The condensed cyclic compound of claim 1, wherein R₁₁, Ar₁ and Ar₂ are each independently selected from

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and/or a dibenzocarbazolyl group, and/or

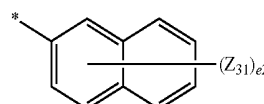
a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, and/or a dibenzocarbazolyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and —Si(Q₃₃)(Q₃₄)(Q₃₅),

wherein Q₃₃ to Q₃₅ are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, 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 C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group.

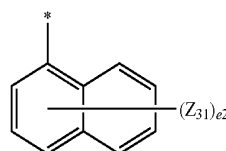
13. The condensed cyclic compound of claim 1, wherein R₁₁, Ar₁, and Ar₂ are each independently selected from the groups represented by Formulae 5-1 to 5-14:



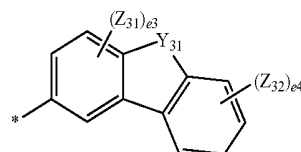
Formula 5-1



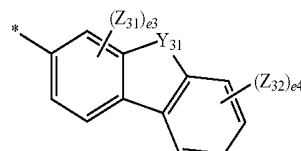
Formula 5-2



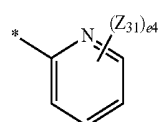
Formula 5-3



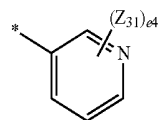
Formula 5-4



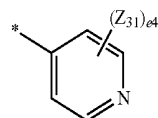
Formula 5-5



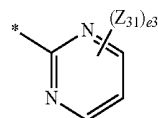
Formula 5-6



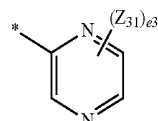
Formula 5-7



Formula 5-8

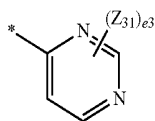


Formula 5-9

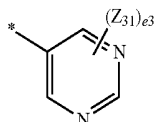


Formula 5-10

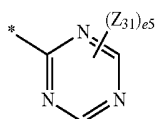
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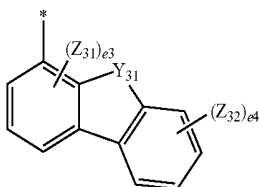
Formula 5-11



Formula 5-12



Formula 5-13



Formula 5-14

wherein

 Y_{31} is O, S, C(Z_{33})(Z_{34}), or N(Z_{35}); Z_{31} to Z_{35} are each independently selected from

a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, and/or a C_1 - C_{20} alkoxy group,

a C_1 - C_{20} alkyl group and/or a C_1 - C_{20} alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof,

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a benzothiophenyl group, a benzocarbazolyl group, and/or a dibenzocarbazolyl group,

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a triazinyl group, a benzofuranyl group, a benzothiophenyl group, a benzocarbazolyl group, and/or a dibenzocarbazolyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine

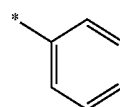
group, a hydrazone group, a carboxylic group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, and a naphthyl group, and/or

—Si(Q_{33})(Q_{34})(Q_{35}),

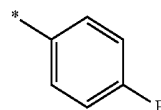
wherein Q_{33} to Q_{35} are each independently selected from a hydrogen, a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric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

e_1 is an integer of 1 to 5; e_2 is an integer of 1 to 7; e_3 is an integer of 1 to 3; e_4 is an integer of 1 to 4; e_5 is 1 or 2; and * is a binding site with an adjacent atom.

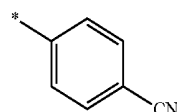
14. The condensed cyclic compound of claim 1, wherein R_{11} , Ar_1 and Ar_2 are each independently selected from the groups represented by Formulae 6-1 to 6-22:



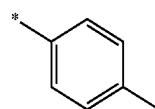
Formula 6-1



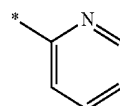
Formula 6-2



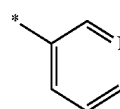
Formula 6-3



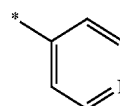
Formula 6-4



Formula 6-5

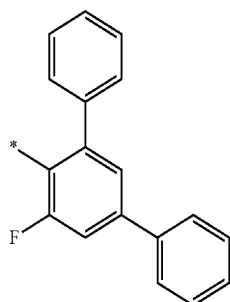
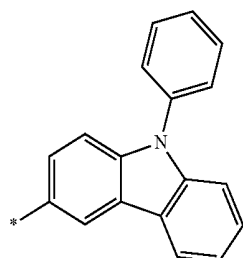
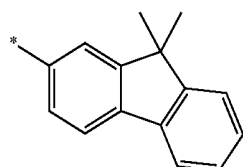
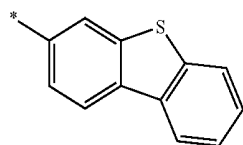
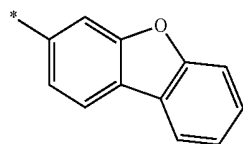
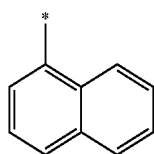
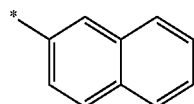
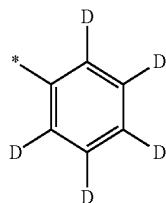


Formula 6-6



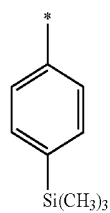
Formula 6-7

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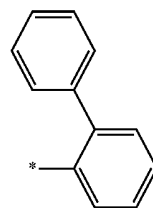


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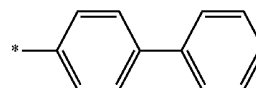
Formula 6-8



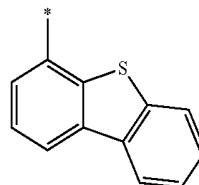
Formula 6-9



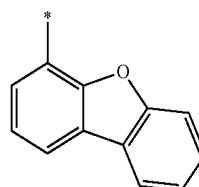
Formula 6-10



Formula 6-11

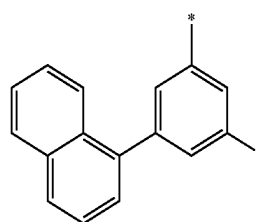


Formula 6-12

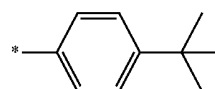


Formula 6-13

Formula 6-14



Formula 6-15



Formula 6-16

Formula 6-17

Formula 6-18

Formula 6-19

Formula 6-20

Formula 6-21

Formula 6-22

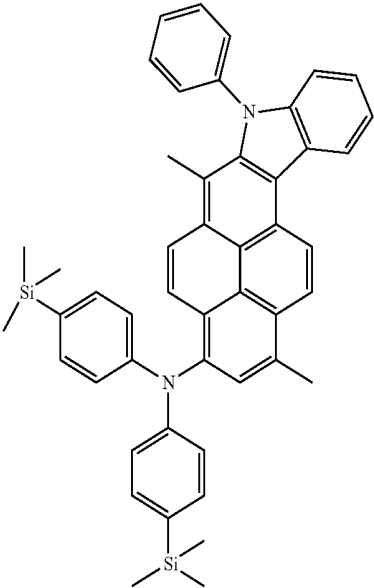
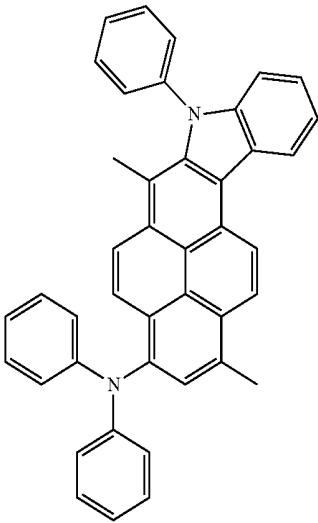
wherein * is a binding site with an adjacent atom.

15. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound of Formula 1 is one of Compounds 1 to 21:

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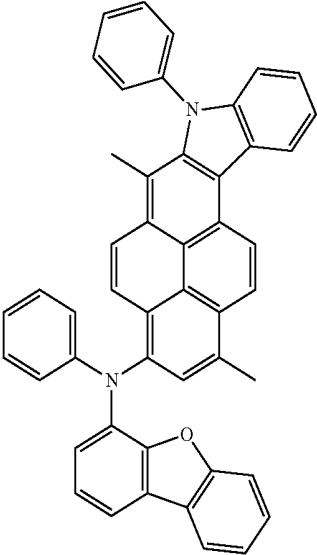
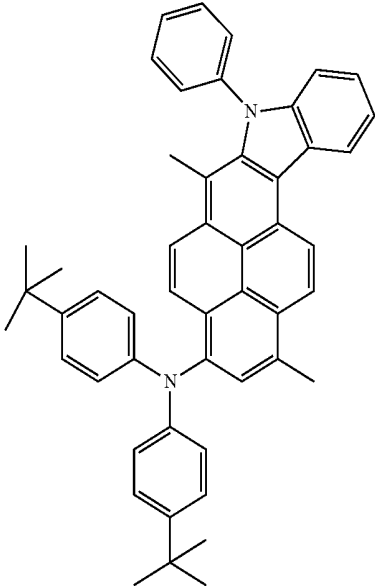
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3

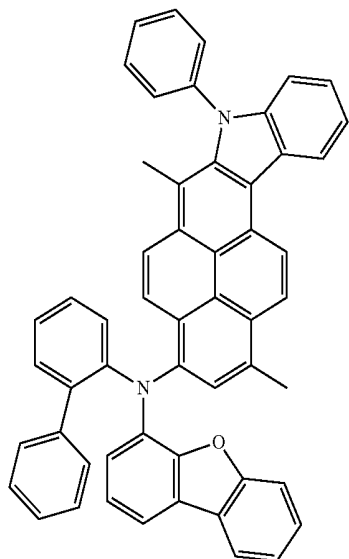
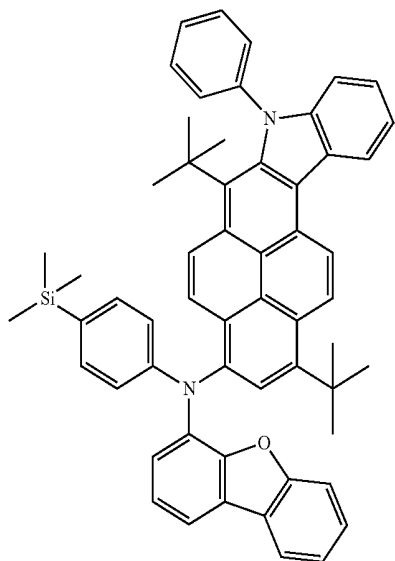
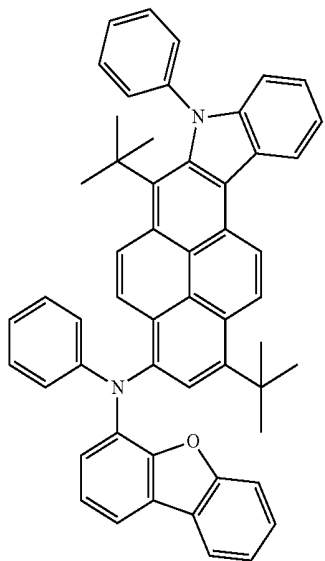


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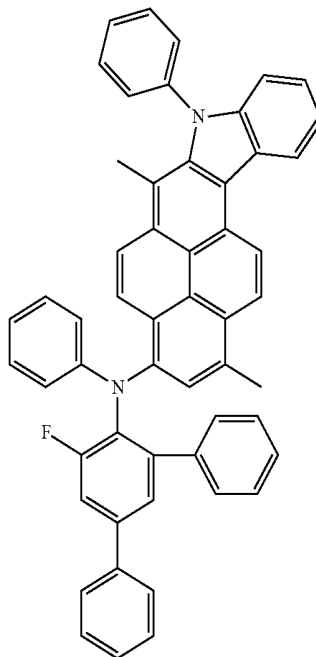
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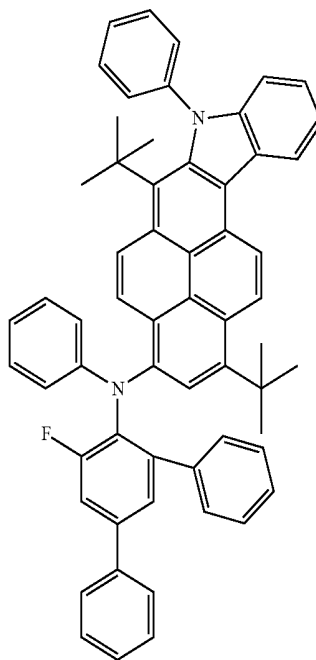


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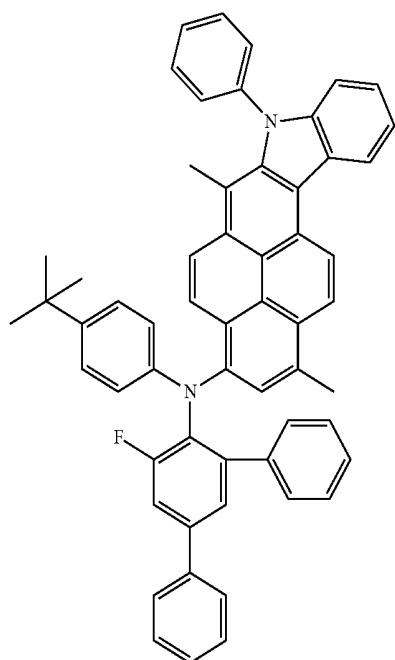
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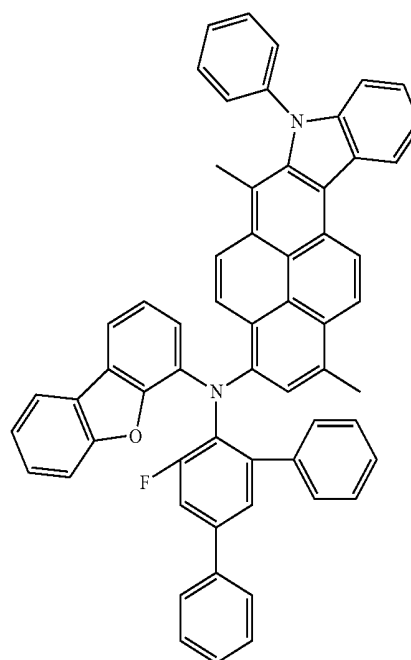


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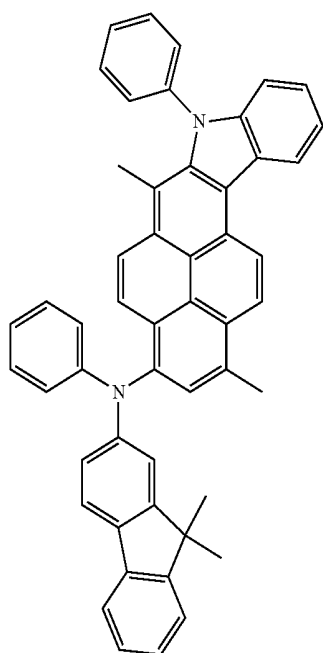
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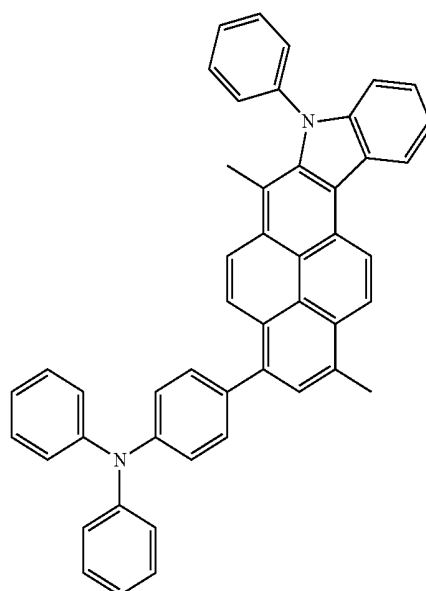


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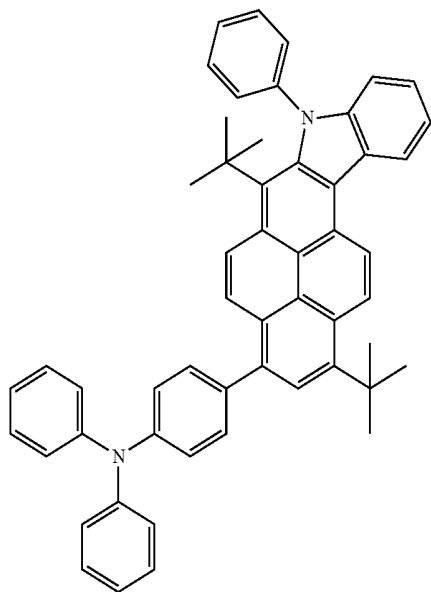


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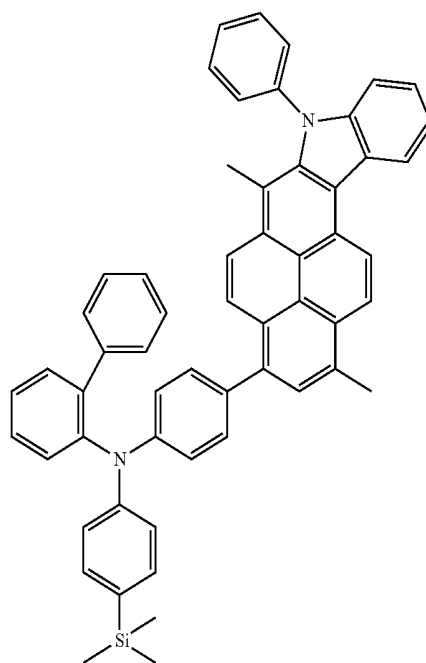
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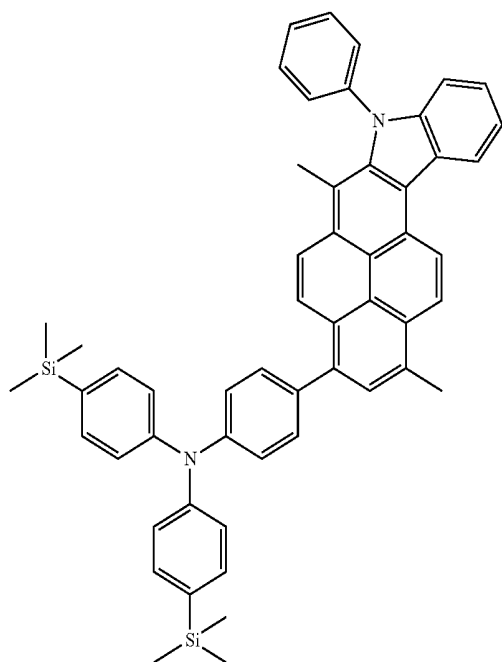


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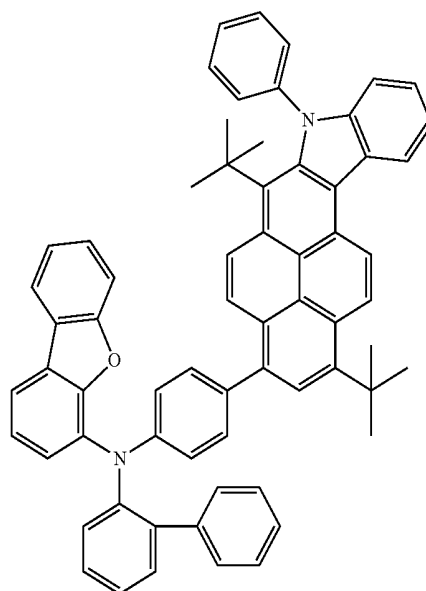
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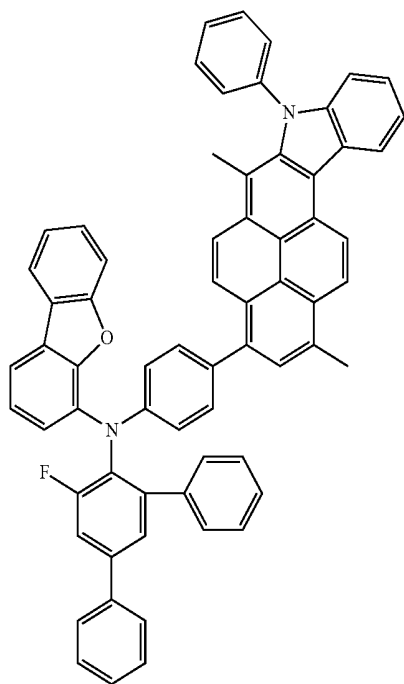
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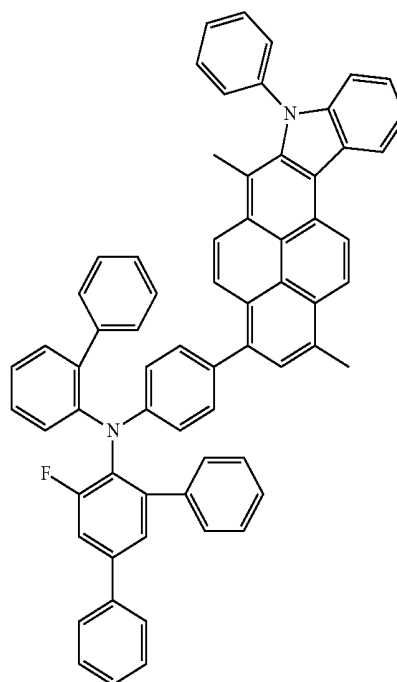


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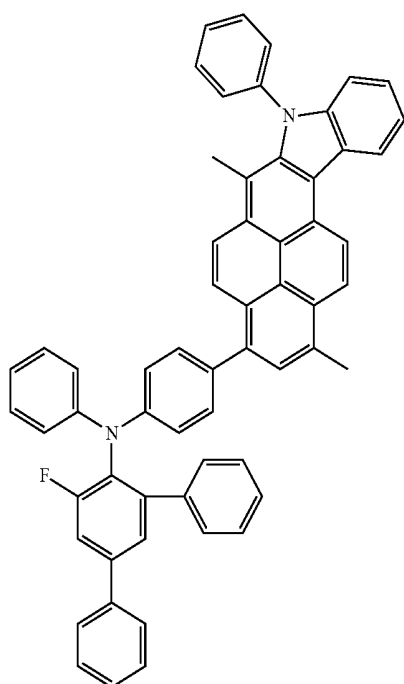


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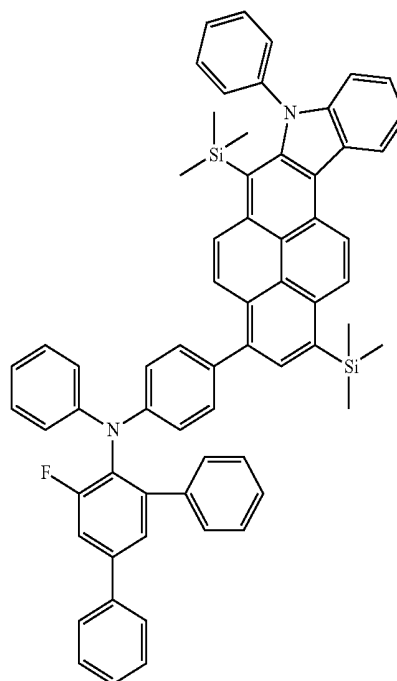
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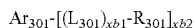
16. An organic light-emitting device comprising: a first electrode; a second electrode; and an organic layer between the first electrode and the second electrode, the organic layer comprising an emission layer and the condensed cyclic compound of claim 1.

17. The organic light-emitting device of claim 16, wherein the first electrode is an anode, the second electrode is a cathode, and the organic layer comprises i) a hole transport region between the first electrode and the emission layer, the hole transport region comprising at least one of a hole injection layer, a hole transport layer, a buffer layer, and an electron blocking layer, and ii) an electron transport region between

the emission layer and the second electrode, electron transport region comprising at least one of a hole blocking layer, an electron transport layer, and an electron injection layer.

18. The organic light-emitting device of claim **17**, wherein the emission layer comprises the at least one of the condensed cyclic compounds.

19. The organic light-emitting device of claim **18**, wherein the emission layer further comprises a compound represented by Formula 301:



Formula 301

wherein Ar_{301} is selected from

a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and/or an indenoanthracene, and/or

a naphthalene, a heptalene, a fluorene, a spiro-fluorene, a benzofluorene, a dibenzofluorene, a phenalene, a phenanthrene, an anthracene, a fluoranthene, a triphenylene, a pyrene, a chrysene, a naphthacene, a picene, a perylene, a pentaphene, and/or an indenoanthracene, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{--C}_{60}$ alkyl group, a $\text{C}_2\text{--C}_{60}$ alkenyl group, a $\text{C}_2\text{--C}_{60}$ alkynyl group, a $\text{C}_1\text{--C}_{60}$ alkoxy group, a $\text{C}_3\text{--C}_{10}$ cycloalkyl group, a $\text{C}_2\text{--C}_{10}$ heterocycloalkyl group, a $\text{C}_3\text{--C}_{10}$ cycloalkenyl group, a $\text{C}_2\text{--C}_{10}$ heterocycloalkenyl group, a $\text{C}_6\text{--C}_{60}$ aryl group, a $\text{C}_6\text{--C}_{60}$ aryloxy group, a $\text{C}_6\text{--C}_{60}$ arylthio group, a $\text{C}_2\text{--C}_{60}$ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, and —Si(Q_{301})(Q_{302})(Q_{303}), wherein Q_{301} to Q_{303} are each independently selected from a hydrogen, $\text{C}_1\text{--C}_{60}$ alkyl group, a $\text{C}_2\text{--C}_{60}$ alkenyl group, a $\text{C}_6\text{--C}_{60}$ aryl group, and a $\text{C}_2\text{--C}_{60}$ heteroaryl group;

L_{301} is selected from a substituted or unsubstituted $\text{C}_3\text{--C}_{10}$ cycloalkylene group, a substituted or unsubstituted $\text{C}_2\text{--C}_{10}$ heterocycloalkylene group, a substituted or unsubstituted $\text{C}_3\text{--C}_{10}$ cycloalkenylene group, a substituted or unsubstituted $\text{C}_2\text{--C}_{10}$ heterocycloalkenylene group, a substituted or unsubstituted $\text{C}_6\text{--C}_{60}$ arylene group, a substituted or unsubstituted $\text{C}_2\text{--C}_{60}$ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and/or a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group;

R_{301} is selected from

a $\text{C}_1\text{--C}_{20}$ alkyl group and/or a $\text{C}_1\text{--C}_{20}$ alkoxy group,

a $\text{C}_1\text{--C}_{20}$ alkyl group and/or a $\text{C}_1\text{--C}_{20}$ alkoxy group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a

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

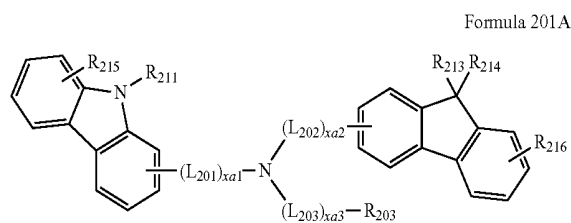
a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group, and/or

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a $\text{C}_1\text{--C}_{20}$ alkyl group, a $\text{C}_1\text{--C}_{20}$ alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group;

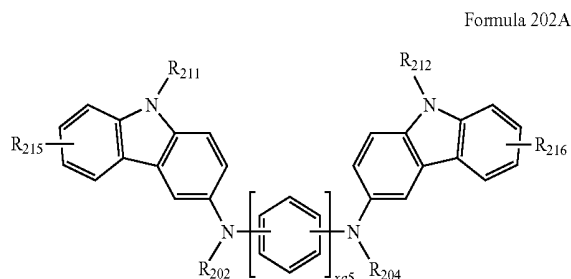
xb1 is selected from 0, 1, 2, and 3; and

xb2 is selected from 1, 2, 3, and 4.

20. The organic light-emitting device of claim **18**, wherein the hole transport region comprises at least one of a compound represented by Formula 201A and a compound represented by Formula 202A:



Formula 201A



Formula 202A

a C₁-C₂₀ alkyl group and/or a C₁-C₂₀ alkoxy group, each substituted with at least one selected from a deuterium,

—F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group,

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group, and/or

a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a diben-

zofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and/or a triazinyl group, each substituted with at least one selected from a deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a naphthyl group, a fluorenyl group, a spiro-fluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, and a triazinyl group; and

xa5 is 1 or 2.

* * * * *

专利名称(译)	缩合环状化合物和包含其的有机发光器件		
公开(公告)号	US20150263293A1	公开(公告)日	2015-09-17
申请号	US14/477565	申请日	2014-09-04
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO. , LTD.		
[标]发明人	HWANG SEOK HWAN JUNG HYE JIN KIM KWANG HYUN KIM YOUNG KOOK KIM JONG WOO KIM HYOUNG KUN		
发明人	HWANG, SEOK-HWAN JUNG, HYE-JIN KIM, KWANG-HYUN KIM, YOUNG-KOOK KIM, JONG-WOO KIM, HYOUNG-KUN		
IPC分类号	H01L51/00 C07F7/08 C07D405/12 C07D209/56		
CPC分类号	H01L51/0061 H01L51/0072 H01L51/0094 H01L51/0073 C07D209/56 H01L51/5092 C07D405/12 H01L51/5088 H01L51/5056 H01L51/5012 H01L51/5072 C07F7/0812 C07F7/081 C07F7/0814 H01L51/ /0059 H01L51/0081		
优先权	1020140029762 2014-03-13 KR		
其他公开文献	US9660197		
外部链接	Espacenet USPTO		

摘要(译)

由式1表示的稠合环状化合物：还公开了一种包括第一电极的有机发光装置;第二个电极;第一电极和第二电极之间的有机层，有机层包括发光层和式1的稠环化合物。包含式1的稠环化合物的有机发光装置可具有低驱动电压，高效率，亮度高，寿命长。

