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KIM et al.(10) **Pub. No.: US 2017/0256721 A1**(43) **Pub. Date: Sep. 7, 2017**(54) **CONDENSED CYCLIC COMPOUND AND
ORGANIC LIGHT-EMITTING DEVICE
INCLUDING THE SAME****C07D 471/22** (2006.01)**C09K 11/02** (2006.01)(52) **U.S. CL.**CPC **H01L 51/0072** (2013.01); **C09K 11/025**
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Hyein JEONG, Yongin-si (KR)(21) Appl. No.: **15/452,392**(22) Filed: **Mar. 7, 2017**(30) **Foreign Application Priority Data**

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Publication Classification(51) **Int. Cl.****H01L 51/00** (2006.01)**C09K 11/06** (2006.01)(57) **ABSTRACT**

A condensed cyclic compound and an organic light-emitting device including the same are provided. The compound may be represented by the following structure:

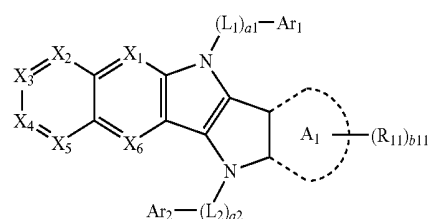
wherein X₁ is N or C(R₁), X₂ is N or C(R₂), X₃ is N or C(R₃), X₄ is N or C(R₄), X₅ is N or C(R₅), and X₆ is N or C(R₆), and ring A₁ is a C₅-C₆₀ carbocyclic group or a C₂-C₆₀ heterocyclic group, provided that ring A₁ is not a benzene.**10****190****150****110**

FIG. 1

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FIG. 2

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FIG. 3

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FIG. 4

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

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of Korean Patent Application No. 10-2016-0027153 filed on Mar. 7, 2016 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 embodiments relate to a condensed cyclic compound and an organic light-emitting device including the same.

[0004] 2. Description of the Related Art

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

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

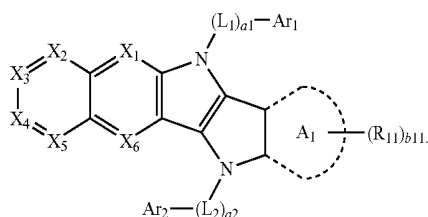
SUMMARY

[0007] One or more embodiments include 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, a condensed cyclic compound is represented by Formula 1:

<Formula 1>



[0010] In Formula 1,

[0011] X_1 may be N or C(R_1), X_2 may be N or C(R_2), X_3 may be N or C(R_3), X_4 may be N or C(R_4), X_5 may be N or C(R_5), and X_6 may be N or C(R_6),

[0012] ring A_1 may be a C_5 - C_{60} carbocyclic group or a C_2 - C_{60} heterocyclic group, provided that ring A_1 is not a benzene,

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

[0014] a_1 and a_2 are each independently an integer between 0 and 3, inclusive, wherein, when a_1 is two or more, two or more $L_1(s)$ are identical to or different from each other and a_2 is two or more, two or more $L_2(s)$ are identical to or different from each other,

[0015] Ar_1 and Ar_2 may each independently be selected from a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

[0016] R_1 to R_6 and R_{11} may each independently be selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-C(=O)(Q_2)$, $-S(=O)_2(Q_1)$, and $-P(=O)(Q_1)(Q_2)$,

[0017] b_{11} may be an integer between 0 and 6, inclusive, wherein, when b_{11} is two or more, two or more $R_{11}(s)$ may be identical to or different from each other, and

[0018] at least one substituent of the substituted C_3 - C_{10} cycloalkylene group, the substituted C_1 - C_{10} heterocycloalkylene group, the substituted C_3 - C_{10} cycloalkenylene group, the substituted C_1 - C_{10} heterocycloalkenylene group, the substituted C_6 - C_{60} arylene group, the substituted C_1 - C_{60} heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted

C₁-C₆₀ alkyl group, the substituted C₂-C₆₀ alkenyl group, the substituted C₂-C₆₀ alkynyl group, the substituted C₁-C₆₀ alkoxy group, the substituted C₃-C₁₀ cycloalkyl group, the substituted C₁-C₁₀ heterocycloalkyl group, the substituted C₃-C₁₀ cycloalkenyl group, the substituted C₁-C₁₀ heterocycloalkenyl group, the substituted C₆-C₆₀ aryl group, the substituted C₆-C₆₀ aryloxy group, the substituted C₆-C₆₀ arylthio group, the substituted C₁-C₆₀ heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

[0019] deuterium (-D), -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group;

[0020] a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, and a C₁-C₆₀ alkoxy group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, -Si(Q₁₁)(Q₁₂)(Q₁₃), -N(Q₁₁)(Q₁₂), -B(Q₁₁)(Q₁₂), -C(=O)(Q₁₁), -S(=O)₂(Q₁₁), and -P(=O)(Q₁₁)(Q₁₂),

[0021] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0022] a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, -Si(Q₂₁)(Q₂₂)(Q₂₃), -N(Q₂₁)(Q₂₂), -B(Q₂₁)(Q₂₂), -C(=O)(Q₂₁), -S(=O)₂(Q₂₁), and -P(=O)(Q₂₁)(Q₂₂), and -Si(Q₃₁)(Q₃₂)(Q₃₃), -N(Q₃₁)(Q₃₂), -B(Q₃₁)(Q₃₂), -C(=O)(Q₃₁), -S(=O)₂(Q₃₁), and -P(=O)(Q₃₁)(Q₃₂),

[0023] wherein Q₁ to Q₃, Q₁₁ to Q₁₃, Q₂₁ to Q₂₃, and Q₃₁ to Q₃₃ may each independently be selected from hydrogen, deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl

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

[0024] According to one or more embodiments, an organic light-emitting device includes: a first electrode; a second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode, the organic layer including an emission layer, wherein the organic layer includes at least one condensed cyclic compound described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0025] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the accompanying drawings in which:

[0026] FIG. 1 is a schematic cross-sectional view of an organic light-emitting device according to an embodiment;

[0027] FIG. 2 is a schematic cross-sectional view of an organic light-emitting device according to an embodiment;

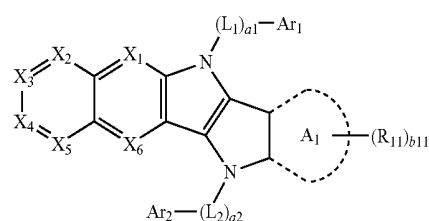
[0028] FIG. 3 is a schematic cross-sectional view of an organic light-emitting device according to an embodiment; and

[0029] FIG. 4 is a schematic cross-sectional view of an organic light-emitting device according to an embodiment.

DETAILED DESCRIPTION

[0030] A condensed cyclic compound according to an embodiment may be represented by Formula 1:

<Formula 1>



[0031] In Formula 1, X₁ may be N or C(R₁), X₂ may be N or C(R₂), X₃ may be N or C(R₃), X₄ may be N or C(R₄), X₅ may be N or C(R₅), and X₆ may be N or C(R₆).

[0032] For example, at least one of X₁ to X₆ may be N.

[0033] In one or more embodiments, one of X₁ to X₆ may be N, and the others may not be N.

[0034] In one or more embodiments, X₁ may be N, X₂ may be C(R₂), X₃ may be C(R₃), X₄ may be C(R₄), X₅ may be C(R₅), and X₆ may be C(R₆), but embodiments of the present disclosure are not limited thereto.

[0035] Ring A₁ in Formula 1 may be a C₅-C₆₀ carbocyclic group or a C₂-C₆₀ heterocyclic group, provided that ring A₁ is not a benzene.

[0036] For example, ring A₁ in Formula 1 may be a pyridine group, a pyrimidine group, a naphthalene group, a quinoline group, or an isoquinoline group, but embodiments of the present disclosure are not limited thereto.

[0037] In one or more embodiments, ring A₁ in Formula 1 may be a pyridine group, a quinoline group, or an isoquinoline group.

[0038] L₁ and L₂ in Formula 1 may each independently be selected from a substituted or unsubstituted C₃-C₁₀ cycloalkylene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkenylene group, a substituted or unsubstituted C₃-C₁₀ heterocycloalkenylene group, a substituted or unsubstituted C₆-C₆₀ arylene group, a substituted or unsubstituted C₁-C₆₀ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group.

[0039] For example, L₁ and L₂ in Formula 1 may each independently be selected from:

[0040] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, an isoindolylenylene group, an indolylenylene group, an indazolylenylene group, a purinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a carbazolylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzimidazolylenylene 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 dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a thiadiazolylenylene group, an imidazopyridinylenylene group, and an imidazopyrimidinylenylene group; and

[0041] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an

isoxazolylenylene group, a pyridinylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, an isoindolylenylene group, an indolylenylene group, an indazolylenylene group, a purinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a carbazolylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzimidazolylenylene 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 dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a thiadiazolylenylene group, an imidazopyridinylenylene group, and an imidazopyrimidinylenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolynyl group, an isoquinolynyl group, a benzoquinolynyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalynyl group, a quinazolynyl group, a cinnolynyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and —Si(Q₃₁)(Q₃₂)(Q₃₃),

[0042] wherein Q₃₁ to Q₃₃ may each independently be selected from a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0043] In one or more embodiments, L₁ and L₂ in Formula 1 may each independently be selected from:

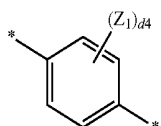
[0044] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an

anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a thiophenylene group, a furanylene group, a carbazolylenylene group, a benzofuranylenylene group, a benzothiophenylene group, a dibenzofuranylenylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, and a benzocarbazolylenylene group; and

[0045] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylenylene group, a fluorenylenylene group, a spiro-bifluorenylenylene group, a benzofluorenylenylene group, a dibenzofluorenylenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a thiophenylene group, a furanylene group, a carbazolylenylene group, a benzofuranylenylene group, a benzothiophenylene group, a dibenzofuranylenylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, and a benzocarbazolylenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a benzocarbazolyl group, and —Si(Q_{31})(Q_{32})(Q_{33}).

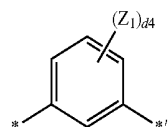
[0046] wherein Q_{31} to Q_{33} may each independently be selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0047] In one or more embodiments, L_1 and L_2 in Formula 1 may each independently be selected from groups represented by Formulae 3-1 to 3-46:

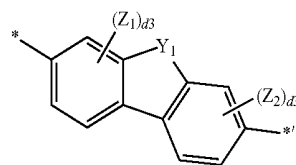


Formula 3-1

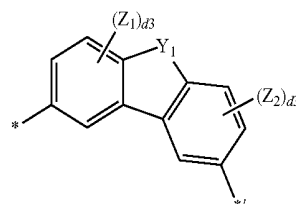
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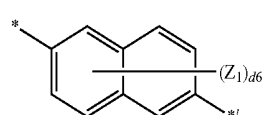
Formula 3-2



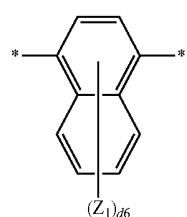
Formula 3-3



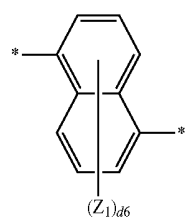
Formula 3-4



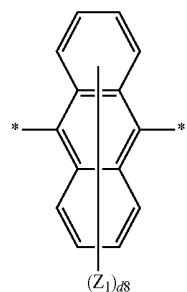
Formula 3-5



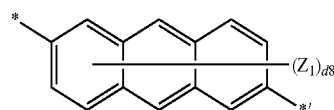
Formula 3-6



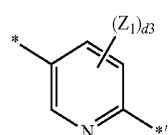
Formula 3-7



Formula 3-8

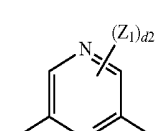
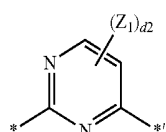
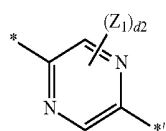
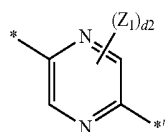
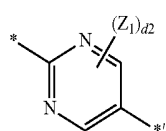
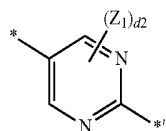
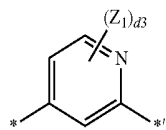
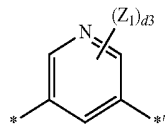
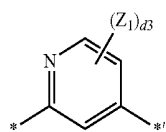
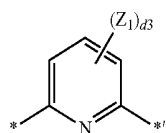
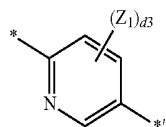


Formula 3-9



Formula 3-10

-continued



Formula 3-11

Formula 3-12

Formula 3-13

Formula 3-14

Formula 3-15

Formula 3-16

Formula 3-17

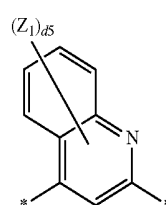
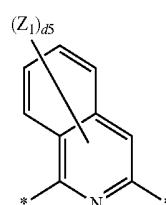
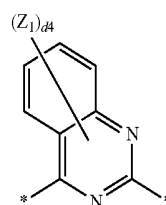
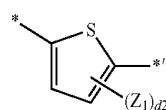
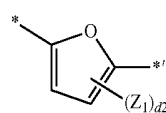
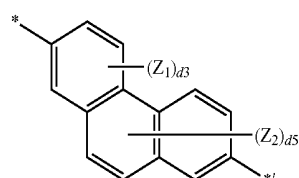
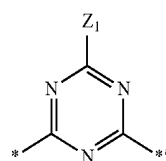
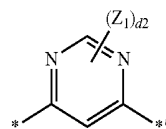
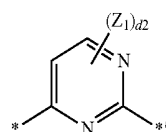
Formula 3-18

Formula 3-19

Formula 3-20

Formula 3-21

-continued



Formula 3-22

Formula 3-23

Formula 3-24

Formula 3-25

Formula 3-26

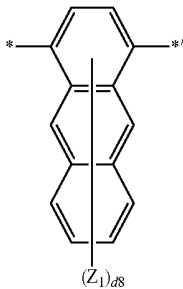
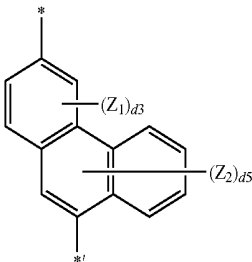
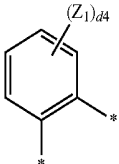
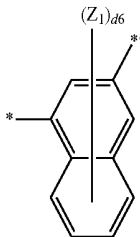
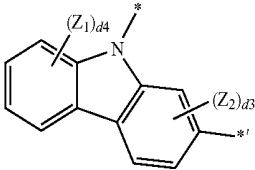
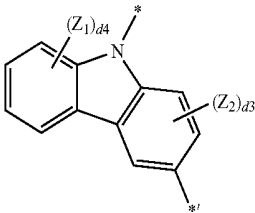
Formula 3-27

Formula 3-28

Formula 3-29

Formula 3-30

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Formula 3-31

Formula 3-32

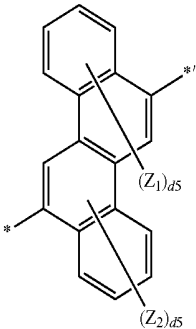
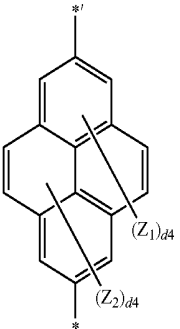
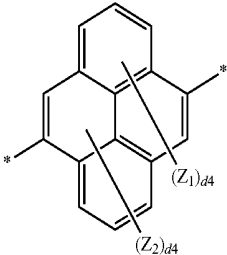
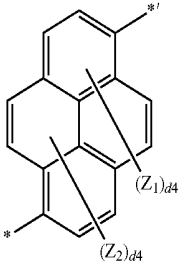
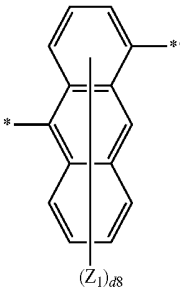
Formula 3-33

Formula 3-34

Formula 3-35

Formula 3-36

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Formula 3-37

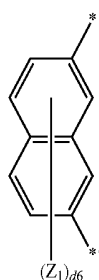
Formula 3-38

Formula 3-39

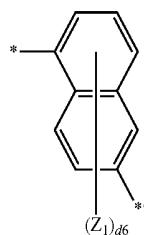
Formula 3-40

Formula 3-41

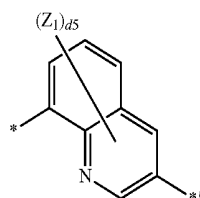
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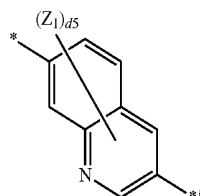
Formula 3-42



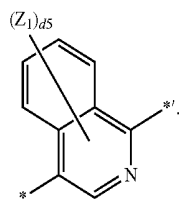
Formula 3-43



Formula 3-44



Formula 3-45



Formula 3-46

[0048] In Formulae 3-1 to 3-46,

[0049] Y_1 may be O, S, $C(Z_3)(Z_4)$, $N(Z_5)$, or $Si(Z_6)(Z_7)$,

[0050] Z_1 to Z_7 may each independently be selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a triazinyl group, a benzimidazolyl group, a phenanthrolinyl group, and $-Si(Q_{31})(Q_{32})(Q_{33})$,

[0051] Q_{31} to Q_{33} may each independently be selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

[0052] d2 may be an integer between 0 and 2, inclusive,

[0053] d3 may be an integer between 0 and 3, inclusive

[0054] d4 may be an integer between 0 and 4, inclusive,

[0055] d5 may be an integer between 0 and 5, inclusive

[0056] d6 may be an integer between 0 and 6, inclusive,

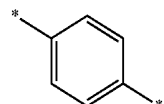
[0057] d8 may be an integer between 0 and 8, inclusive, and

[0058] * and *' each indicate a binding site to a neighboring atom.

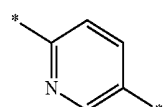
[0059] In one or more embodiments, L_1 and L_2 in Formula 1 may each independently be selected from groups represented by Formulae 3-1 to 3-9, 3-25 to 3-27, and 3-31 to 3-43,

[0060] Z_1 to Z_7 in Formulae 3-1 to 3-9, 3-25 to 3-27, and 3-31 to 3-43 may each independently be selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, but embodiments of the present disclosure are not limited thereto.

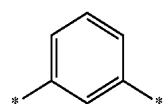
[0061] In one or more embodiments, L_1 and L_2 in Formula 1 may each independently be selected from groups represented by Formulae 4-1 to 4-45, but embodiments of the present disclosure are not limited thereto:



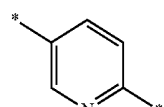
Formula 4-1



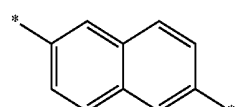
Formula 4-2



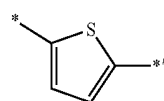
Formula 4-3



Formula 4-4

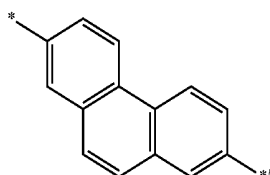
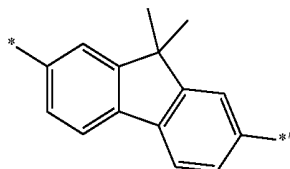
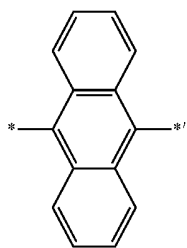
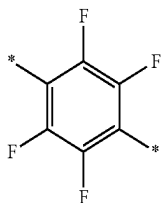
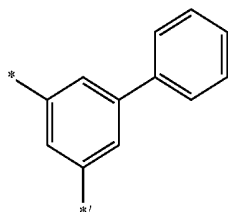
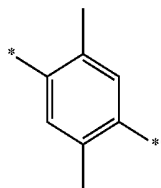
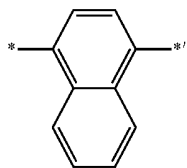


Formula 4-5



Formula 4-6

-continued



Formula 4-7

Formula 4-8

Formula 4-9

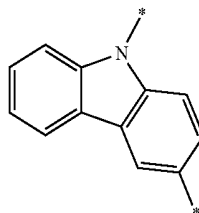
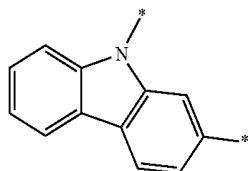
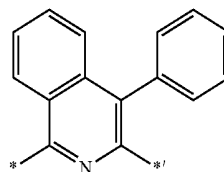
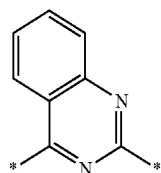
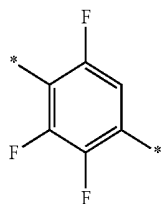
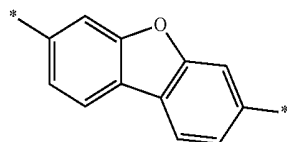
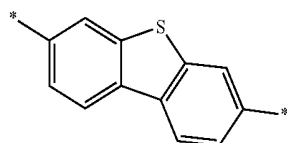
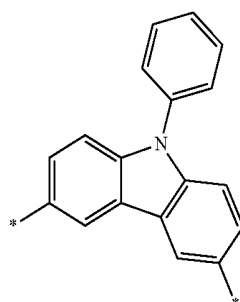
Formula 4-10

Formula 4-11

Formula 4-12

Formula 4-13

-continued



Formula 4-14

Formula 4-15

Formula 4-16

Formula 4-17

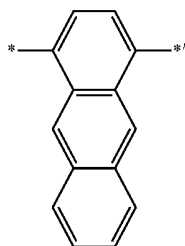
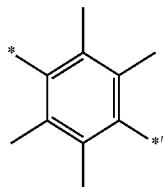
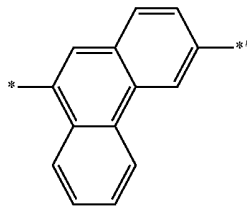
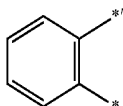
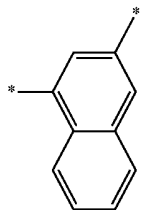
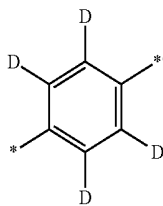
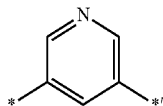
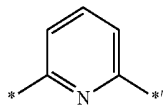
Formula 4-18

Formula 4-19

Formula 4-20

Formula 4-21

-continued



Formula 4-22

Formula 4-23

Formula 4-24

Formula 4-25

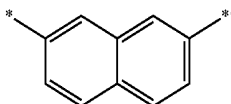
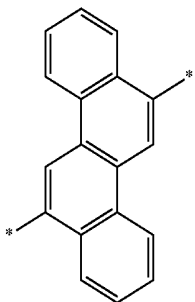
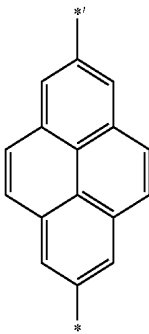
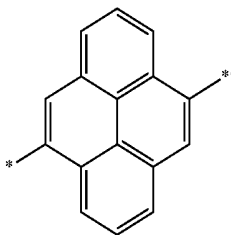
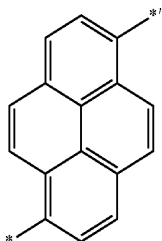
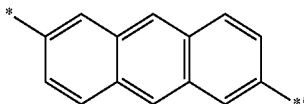
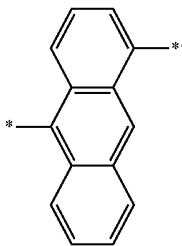
Formula 4-26

Formula 4-27

Formula 4-28

Formula 4-29

-continued



Formula 4-30

Formula 4-31

Formula 4-32

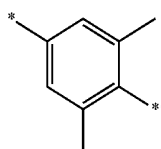
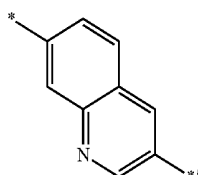
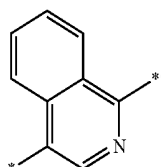
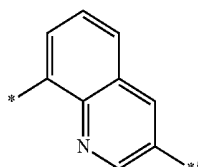
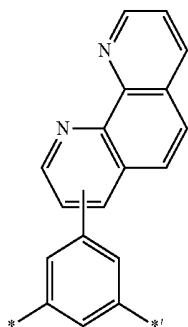
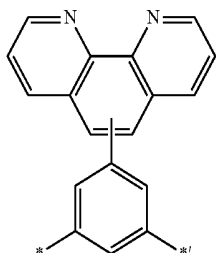
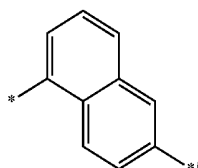
Formula 4-33

Formula 4-34

Formula 4-35

Formula 4-36

-continued



Formula 4-37

Formula 4-38

Formula 4-39

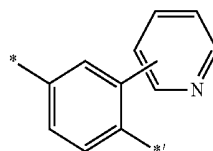
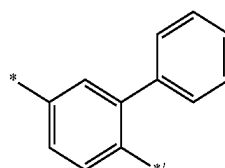
Formula 4-40

Formula 4-41

Formula 4-42

Formula 4-43

-continued



Formula 4-44

Formula 4-45

[0062] * and *' in Formulae 4-1 and 4-45 each indicate a binding site to a neighboring atom.

[0063] In one or more embodiments, L_1 and L_2 in Formula 1 may each independently be selected from groups represented by Formulae 4-1, 4-3, 4-5 to 4-17, 4-20, 4-21, 4-24 to 4-37, 4-43, and 4-44, but embodiments of the present disclosure are not limited thereto.

[0064] a_1 and a_2 in Formula 1 respectively indicate the number of $L_1(s)$ and the number of $L_2(s)$. a_1 and a_2 may each independently be 0, 1, 2, or 3. When a_1 is two or more, two or more $L_1(s)$ may be identical to or different from each other, and when a_2 is two or more, two or more $L_2(s)$ may be identical to or different from each other. When a_1 is zero, $*(L_1)_{a_1}-*$ may be a single bond, and when a_2 is zero, $*(L_2)_{a_2}-*$ may be a single bond.

[0065] In one or more embodiments, a_1 and a_2 in Formula 1 may each independently be 0, 1, or 2, but embodiments of the present disclosure are not limited thereto.

[0066] In one or more embodiments, a_1 and a_2 in Formula 1 may each independently be 0 or 1.

[0067] Ar_1 and Ar_2 in Formula 1 may each independently be selected from a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group.

[0068] For example, Ar_1 and Ar_2 in Formula 2 may each independently be selected from:

[0069] a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl

group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and

[0070] a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl 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 benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —N(Q_{31})(Q_{32}), and —Si(Q_{31})(Q_{32})(Q_{33}).

[0071] wherein Q_{31} to Q_{33} may each independently be selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0072] In one or more embodiments, Ar_1 and Ar_2 in Formula 2 may each independently be selected from:

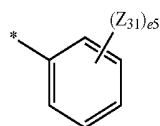
[0073] a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and a dibenzosilolyl group; and

[0074] a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, and a dibenzosilolyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a

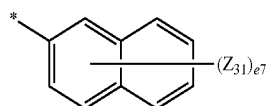
phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzo-carbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, $\text{—N(Q}_{31}\text{)(Q}_{32}\text{)}$, and $\text{—Si(Q}_{31}\text{)(Q}_{32}\text{)(Q}_{33}\text{)}$.

[0075] wherein Q_{31} to Q_{33} may each independently be selected from a $\text{C}_1\text{—C}_{10}$ alkyl group, a $\text{C}_1\text{—C}_{10}$ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

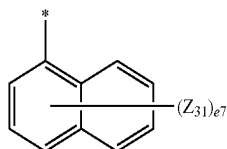
[0076] In one or more embodiments, Ar_1 and Ar_2 in Formula 1 may each independently be selected from Formulae 5-1 to 5-79:



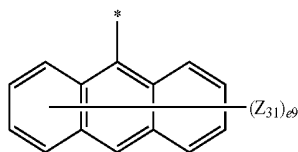
Formula 5-1



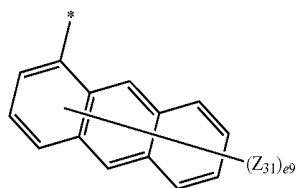
Formula 5-2



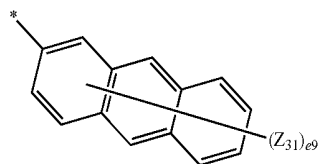
Formula 5-3



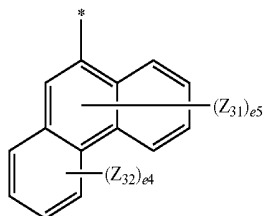
Formula 5-4



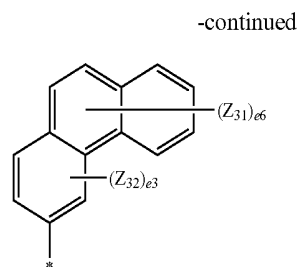
Formula 5-5



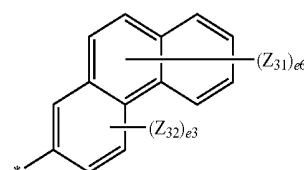
Formula 5-6



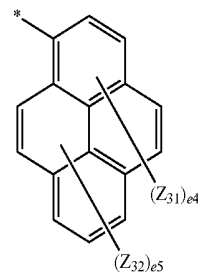
Formula 5-7



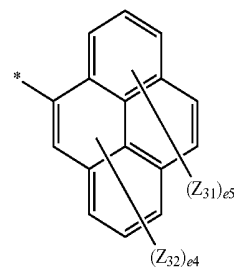
Formula 5-8



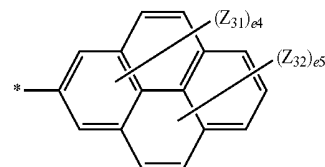
Formula 5-9



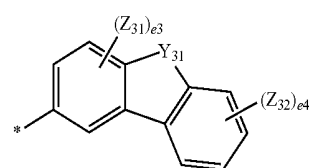
Formula 5-10



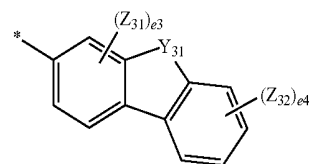
Formula 5-11



Formula 5-12

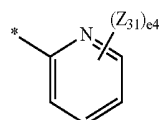
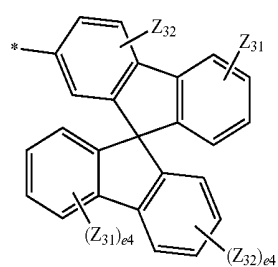
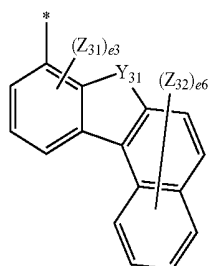
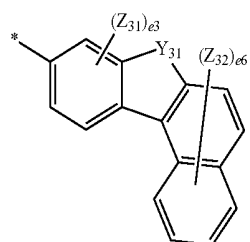
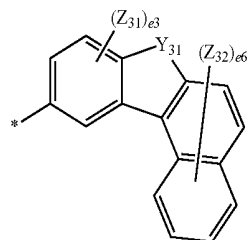
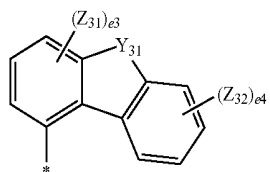
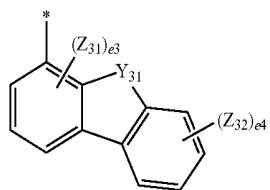


Formula 5-13



Formula 5-14

-continued



Formula 5-15

Formula 5-16

Formula 5-17

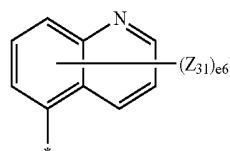
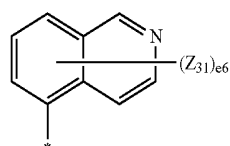
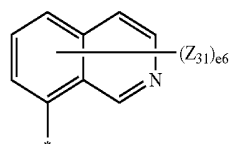
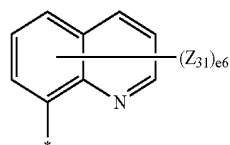
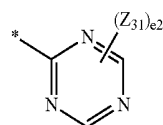
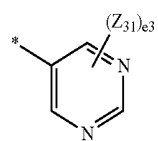
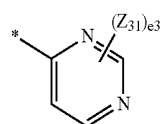
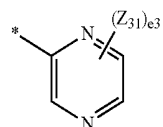
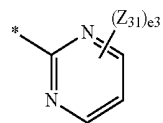
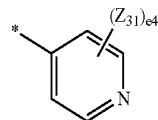
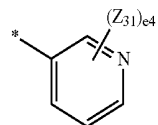
Formula 5-18

Formula 5-19

Formula 5-20

Formula 5-21

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Formula 5-22

Formula 5-23

Formula 5-24

Formula 5-25

Formula 5-26

Formula 5-27

Formula 5-28

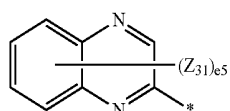
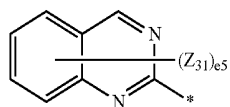
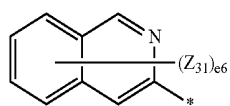
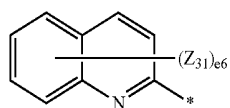
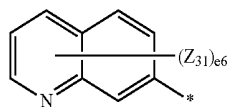
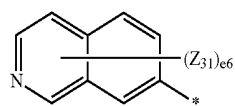
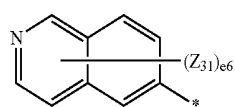
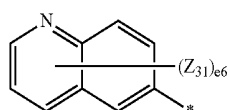
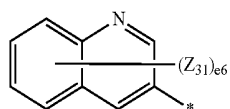
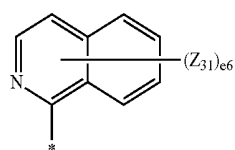
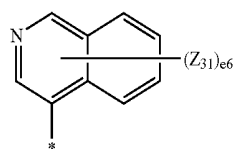
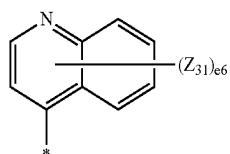
Formula 5-29

Formula 5-30

Formula 5-31

Formula 5-32

-continued



Formula 5-33

Formula 5-34

Formula 5-35

Formula 5-36

Formula 5-37

Formula 5-38

Formula 5-39

Formula 5-40

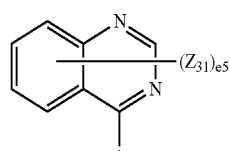
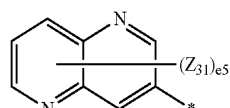
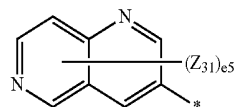
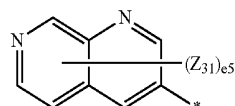
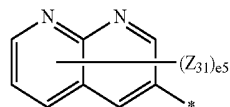
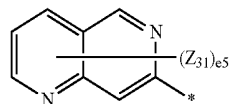
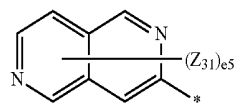
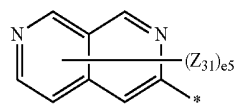
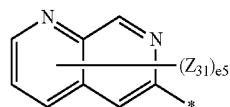
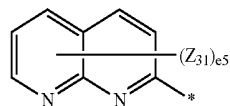
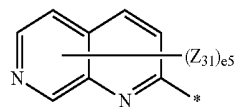
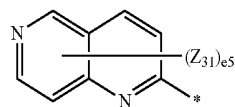
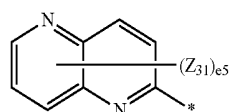
Formula 5-41

Formula 5-42

Formula 5-43

Formula 5-44

-continued



Formula 5-45

Formula 5-46

Formula 5-47

Formula 5-48

Formula 5-49

Formula 5-50

Formula 5-51

Formula 5-52

Formula 5-53

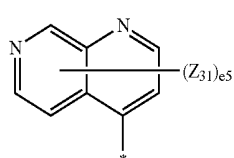
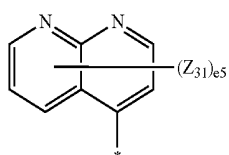
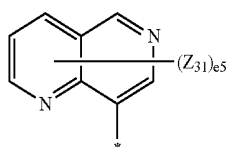
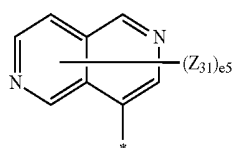
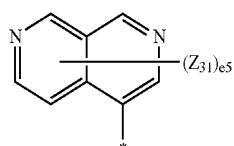
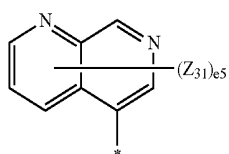
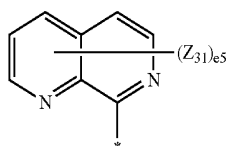
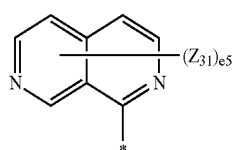
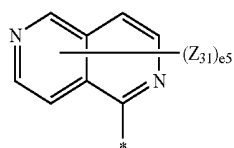
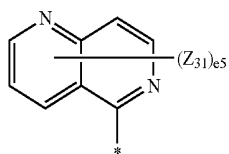
Formula 5-54

Formula 5-55

Formula 5-56

Formula 5-57

-continued



Formula 5-58

Formula 5-59

Formula 5-60

Formula 5-61

Formula 5-62

Formula 5-63

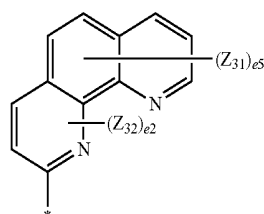
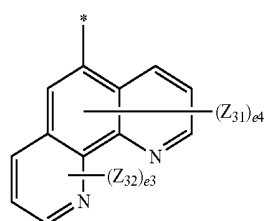
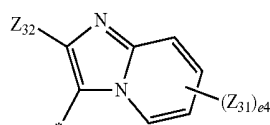
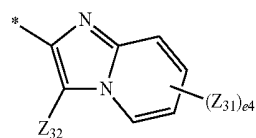
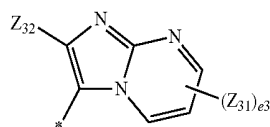
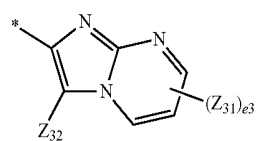
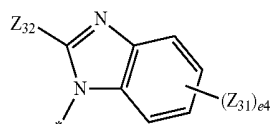
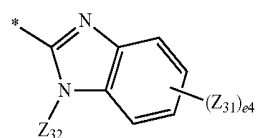
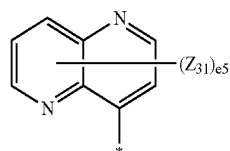
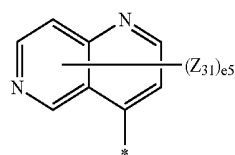
Formula 5-64

Formula 5-65

Formula 5-66

Formula 5-67

-continued



Formula 5-68

Formula 5-69

Formula 5-70

Formula 5-71

Formula 5-72

Formula 5-73

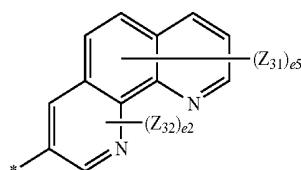
Formula 5-74

Formula 5-75

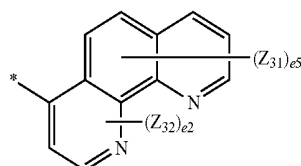
Formula 5-76

Formula 5-77

-continued



Formula 5-78



Formula 5-79

[0077] In Formulae 5-1 to 5-79,

[0078] Y_{31} may be O, S, $C(Z_{33})(Z_{34})$, $N(Z_{35})$, or $Si(Z_{36})(Z_{37})$.

[0079] Z_{31} to Z_{37} may each independently be selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl 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 dibenzofuranyl group, a dibenzothiophenyl group, a benzimidazolyl group, a phenanthrolinyl group, a triazinyl group, $-N(Q_{31})(Q_{32})$, and $-Si(Q_{31})(Q_{32})(Q_{33})$.

[0080] Q_{31} to Q_{33} may each independently be selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

[0081] e2 may be an integer between 0 and 2, inclusive,

[0082] e3 may be an integer between 0 and 3, inclusive,

[0083] e4 may be an integer between 0 and 4, inclusive,

[0084] e5 may be an integer between 0 and 5, inclusive,

[0085] e6 may be an integer between 0 and 6, inclusive,

[0086] e7 may be an integer between 0 and 7, inclusive,

[0087] e9 may be an integer between 0 and 9, inclusive, and

[0088] * indicates a binding site to a neighboring atom.

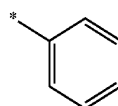
[0089] In one or more embodiments, Ar_1 and Ar_2 in Formula 1 may each independently be selected from groups represented by Formulae 5-1 to 5-20, and

[0090] Z_{31} to Z_{37} in Formulae 5-1 to 5-20 may each independently be selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzo-fluorenyl group, a phenanthrenyl group, an anthracenyl group, a pyrenyl group, a chrysenyl group, a carbazolyl group, a dibenzofuranyl group, a dibenzothiophenyl group, $-N(Q_{31})(Q_{32})$, and $-Si(Q_{31})(Q_{32})(Q_{33})$.

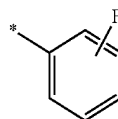
[0091] wherein Q_{31} to Q_{33} may each independently be selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group,

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

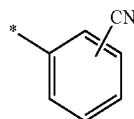
[0092] In one or more embodiments, Ar_1 and Ar_2 in Formula 1 may each independently be selected from groups represented by Formulae 6-1 to 6-100 and groups represented by Formulae 10-1 to 10-121:



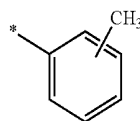
Formula 6-1



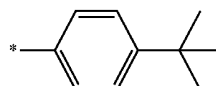
Formula 6-2



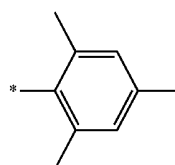
Formula 6-3



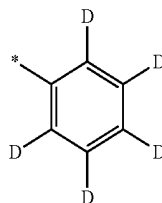
Formula 6-4



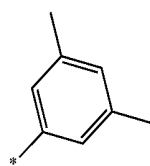
Formula 6-5



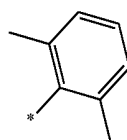
Formula 6-6



Formula 6-7

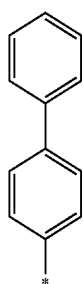
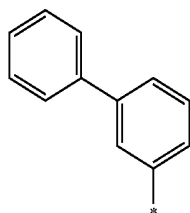
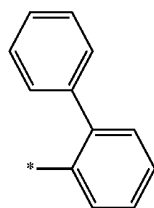
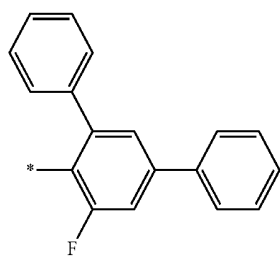
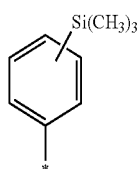
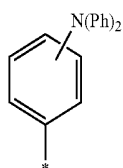
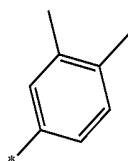


Formula 6-8



Formula 6-9

-continued



Formula 6-10

Formula 6-11

Formula 6-12

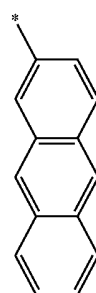
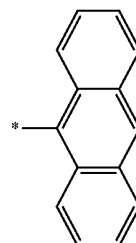
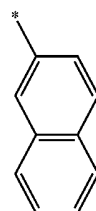
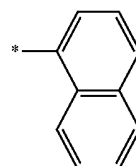
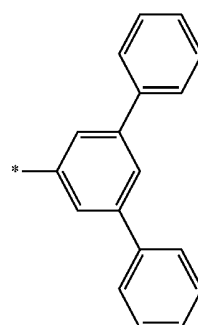
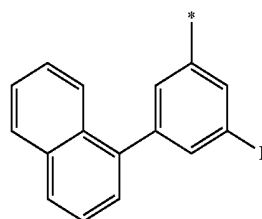
Formula 6-13

Formula 6-14

Formula 6-15

Formula 6-16

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Formula 6-17

Formula 6-18

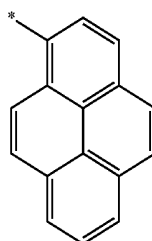
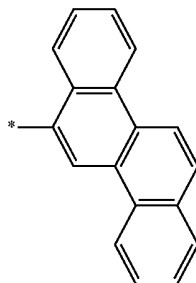
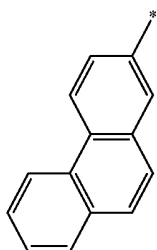
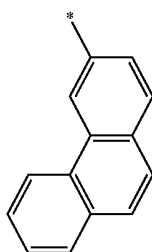
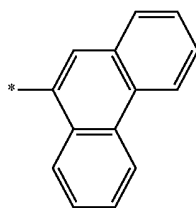
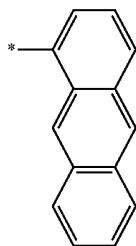
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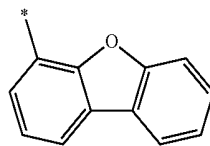
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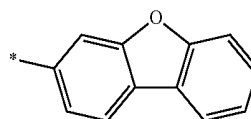
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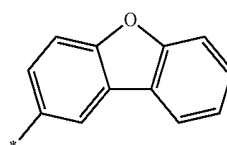
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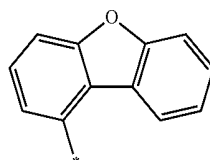
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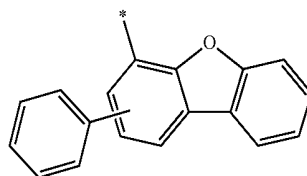
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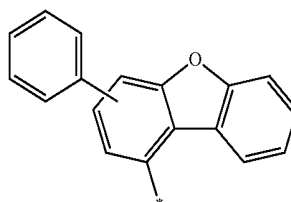
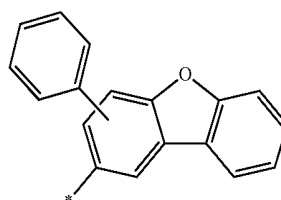
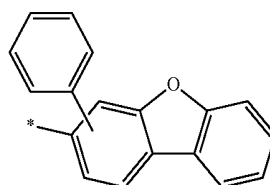
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Formula 6-27



Formula 6-28



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Formula 6-29

Formula 6-30

Formula 6-31

Formula 6-32

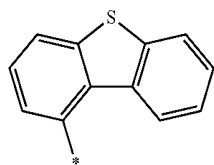
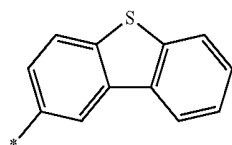
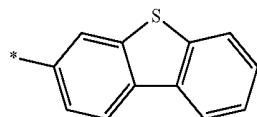
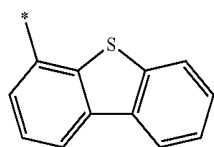
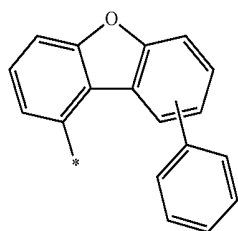
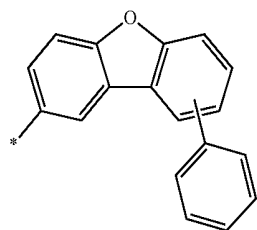
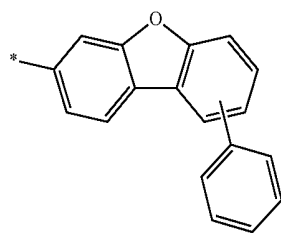
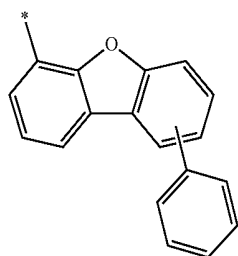
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Formula 6-37

Formula 6-38

Formula 6-39

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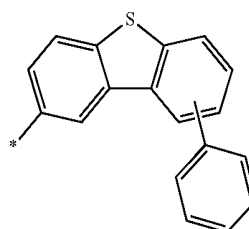
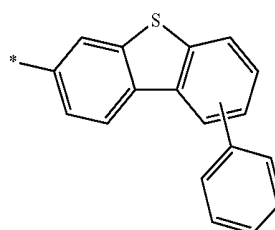
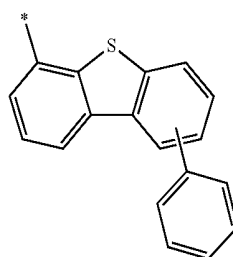
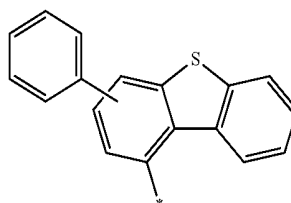
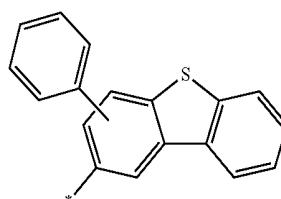
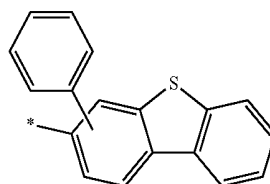
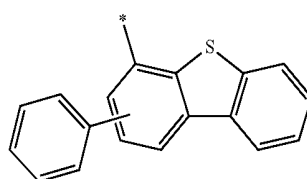
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Formula 6-43

Formula 6-44

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Formula 6-45

Formula 6-46

Formula 6-47

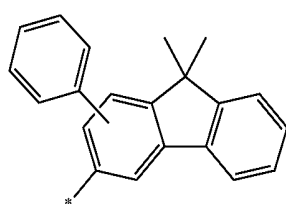
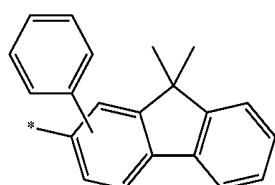
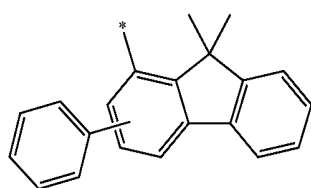
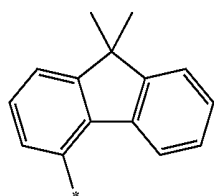
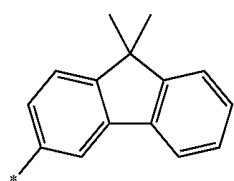
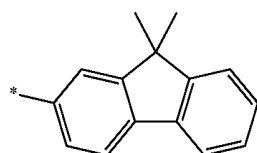
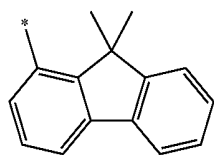
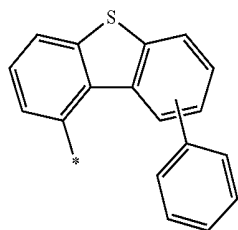
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Formula 6-52

Formula 6-53

Formula 6-54

Formula 6-55

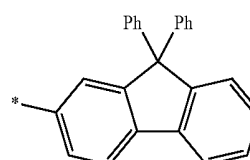
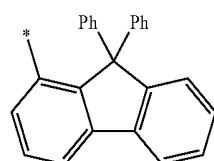
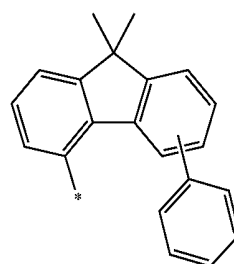
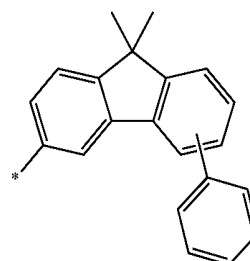
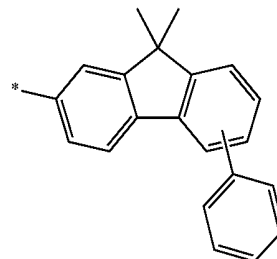
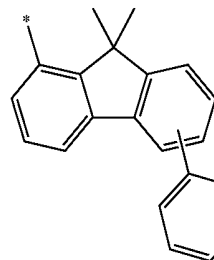
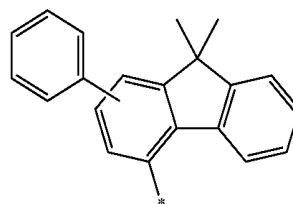
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Formula 6-60

Formula 6-61

Formula 6-62

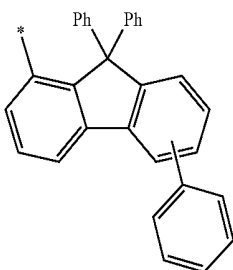
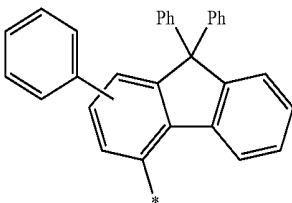
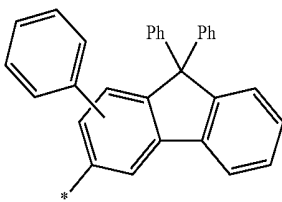
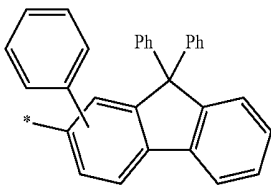
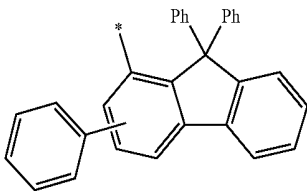
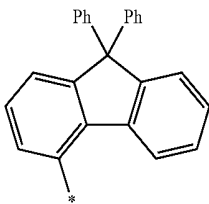
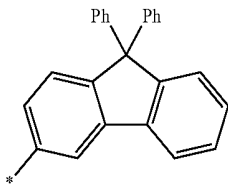
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Formula 6-67

Formula 6-68

Formula 6-69

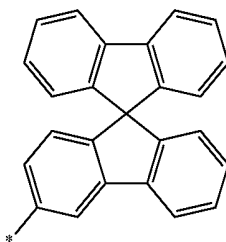
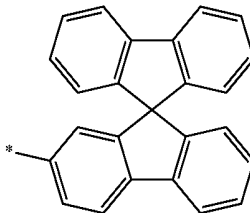
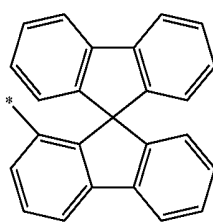
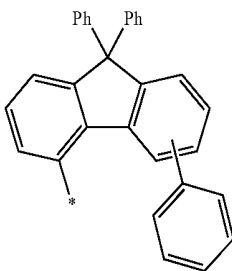
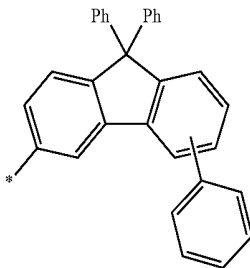
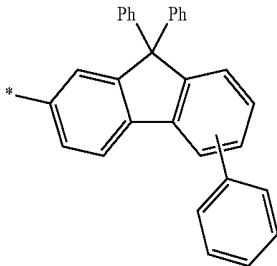
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Formula 6-74

Formula 6-75

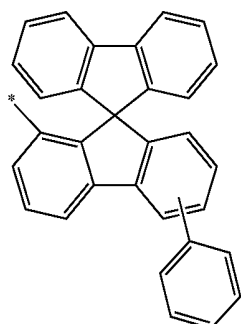
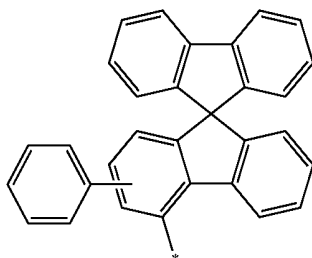
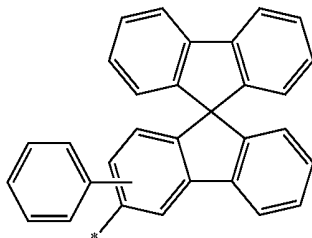
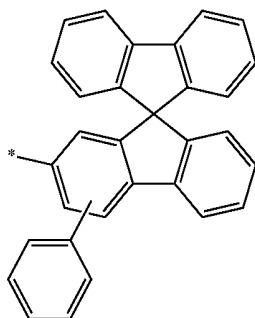
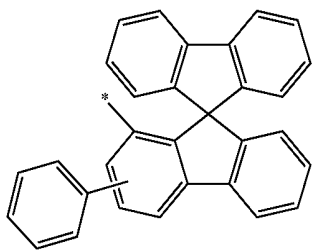
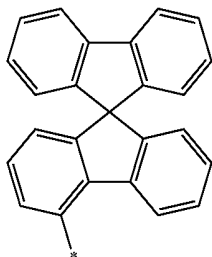
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Formula 6-80

Formula 6-81

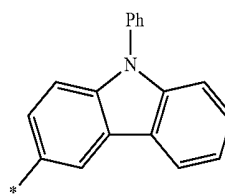
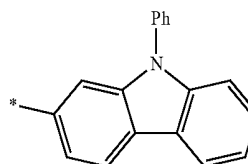
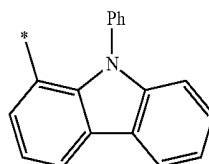
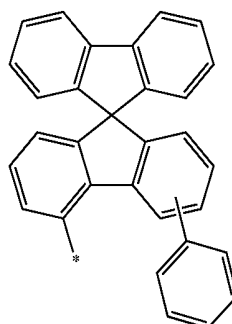
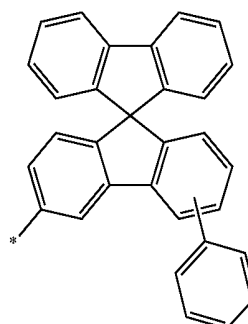
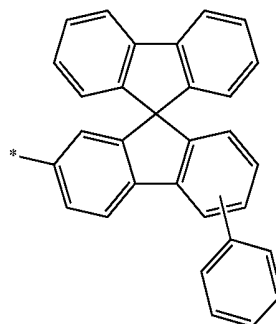
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Formula 6-86

Formula 6-87

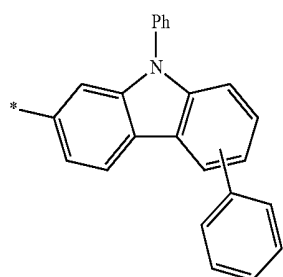
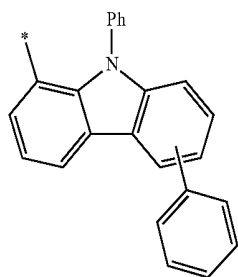
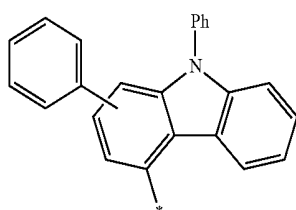
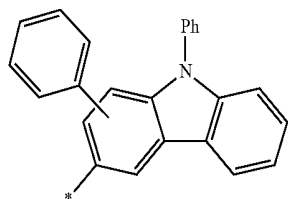
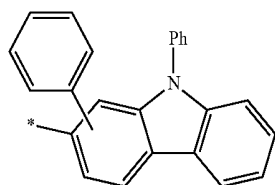
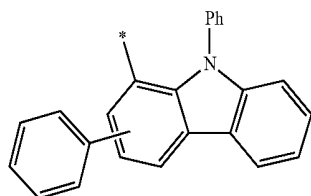
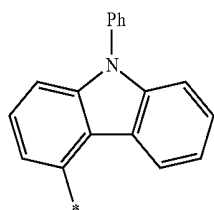
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Formula 6-90

Formula 6-91

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Formula 6-92

Formula 6-93

Formula 6-94

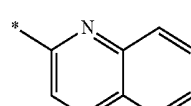
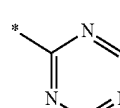
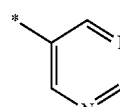
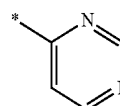
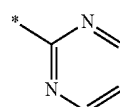
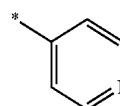
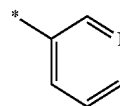
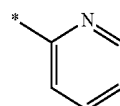
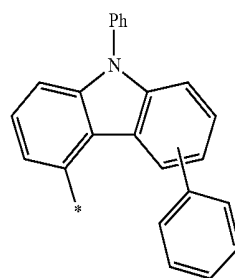
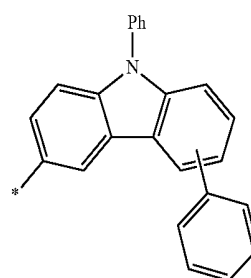
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Formula 6-97

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Formula 6-99

Formula 6-100

Formula 10-1

Formula 10-2

Formula 10-3

Formula 10-4

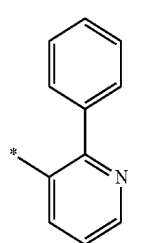
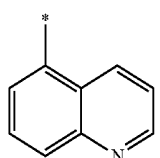
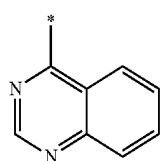
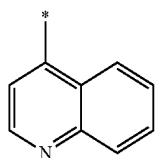
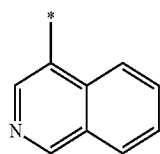
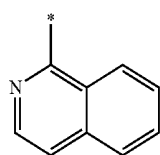
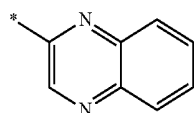
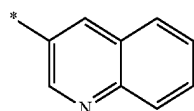
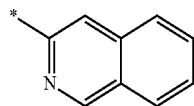
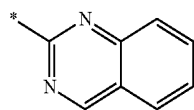
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Formula 10-7

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Formula 10-9

Formula 10-10

Formula 10-11

Formula 10-12

Formula 10-13

Formula 10-14

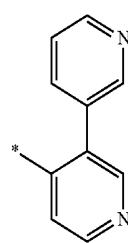
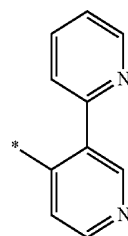
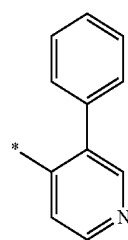
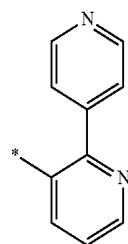
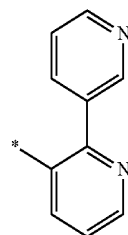
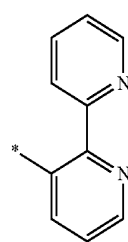
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Formula 10-17

Formula 10-18

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Formula 10-19

Formula 10-20

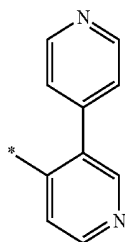
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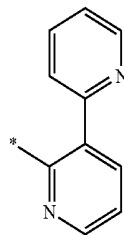
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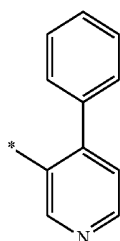
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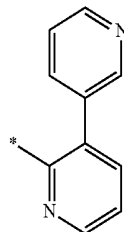
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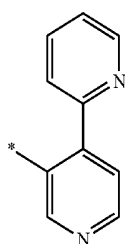
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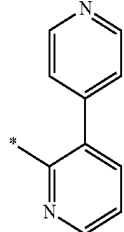
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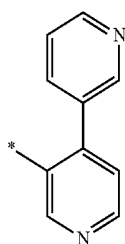
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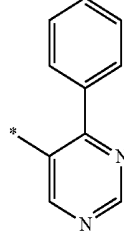
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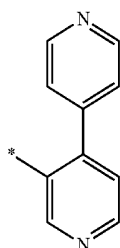
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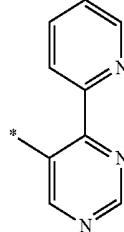
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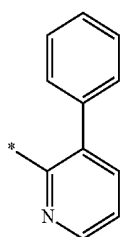
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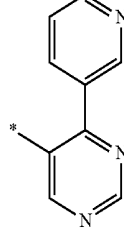
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Formula 10-35

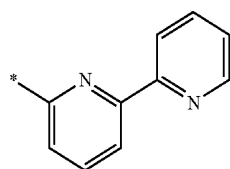
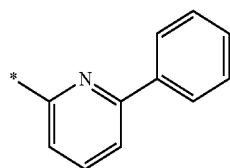
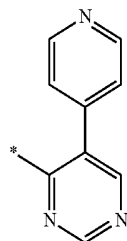
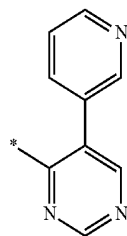
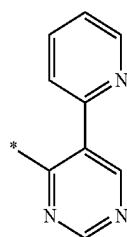
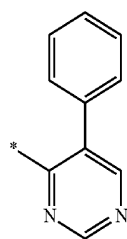
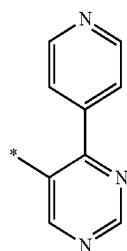


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Formula 10-36

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Formula 10-37

Formula 10-38

Formula 10-39

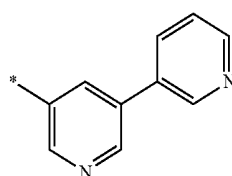
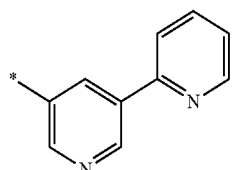
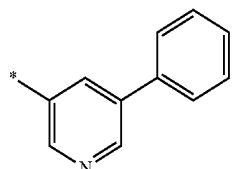
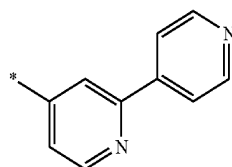
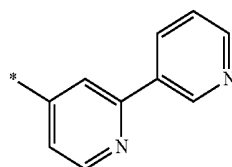
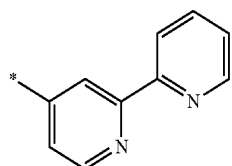
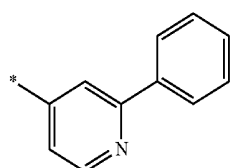
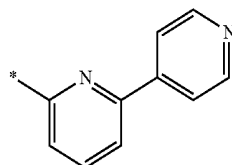
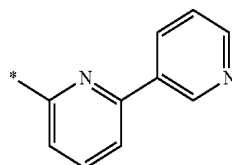
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Formula 10-43

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Formula 10-44

Formula 10-45

Formula 10-46

Formula 10-47

Formula 10-48

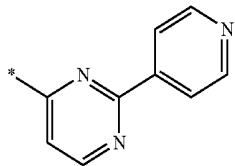
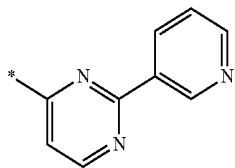
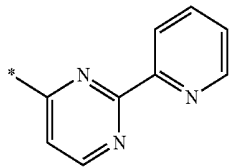
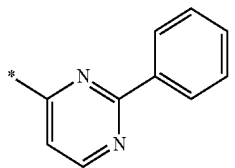
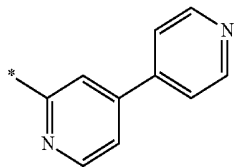
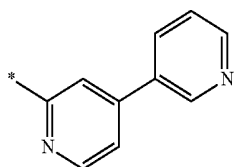
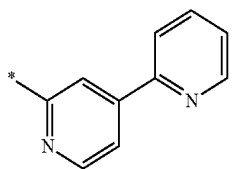
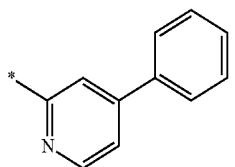
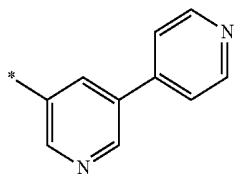
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Formula 10-52

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Formula 10-53

Formula 10-54

Formula 10-55

Formula 10-56

Formula 10-57

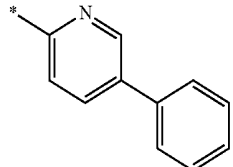
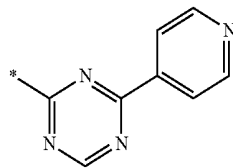
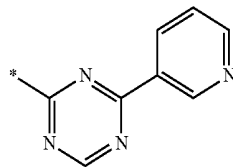
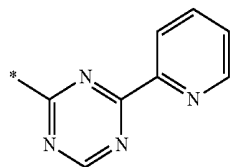
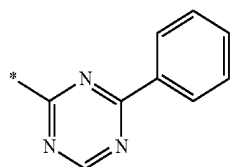
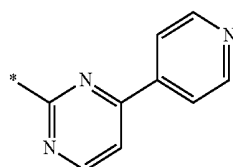
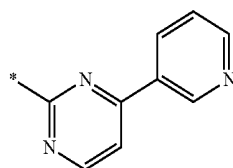
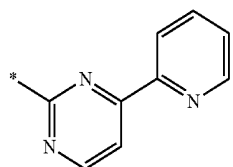
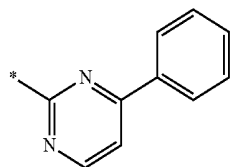
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Formula 10-59

Formula 10-60

Formula 10-61

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Formula 10-62

Formula 10-63

Formula 10-64

Formula 10-65

Formula 10-66

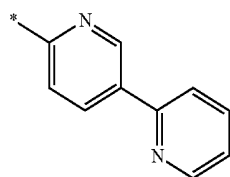
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Formula 10-68

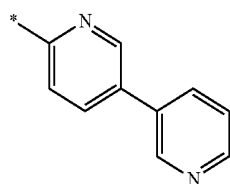
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Formula 10-70

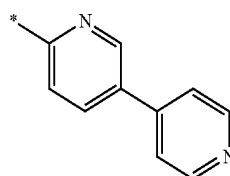
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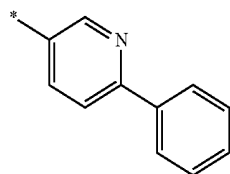
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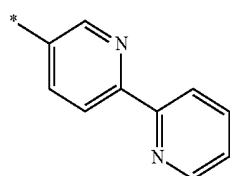
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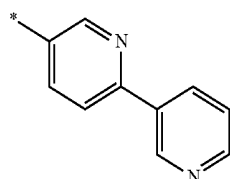
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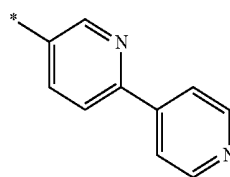
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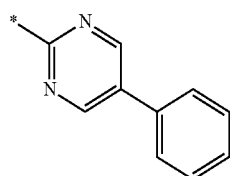
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Formula 10-76

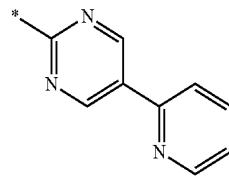


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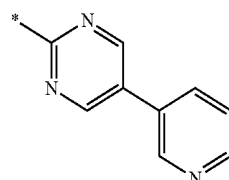


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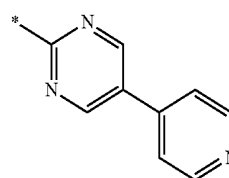
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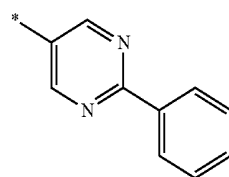
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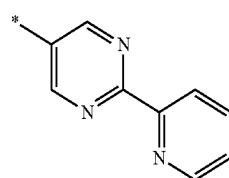
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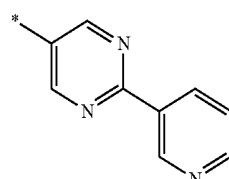
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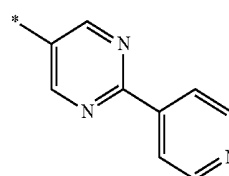
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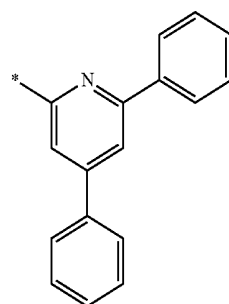
Formula 10-83



Formula 10-84

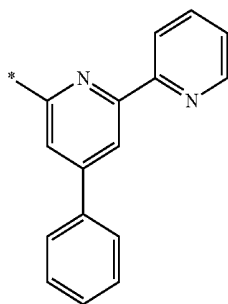


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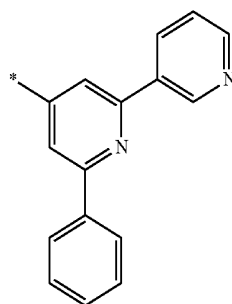
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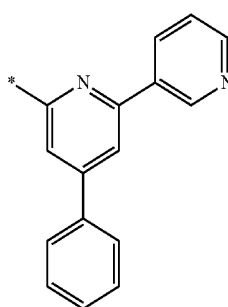


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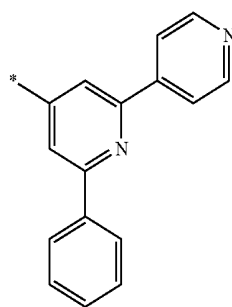
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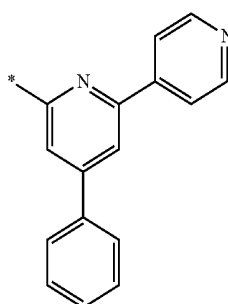
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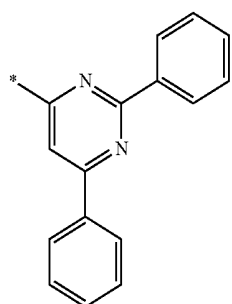
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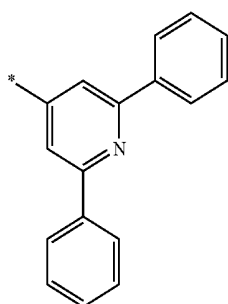
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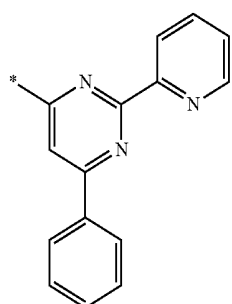
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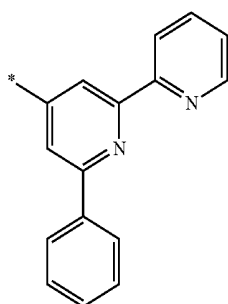
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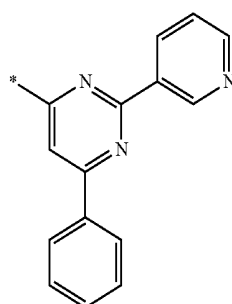
Formula 10-90



Formula 10-95

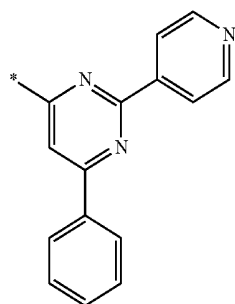


Formula 10-91



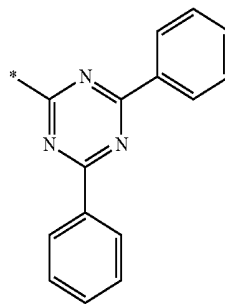
Formula 10-96

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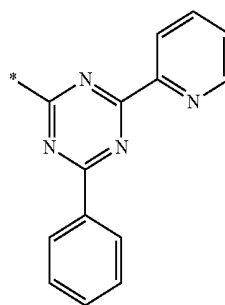
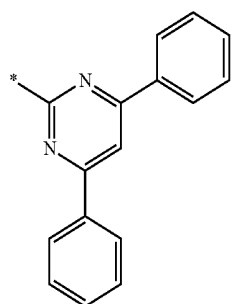
Formula 10-97

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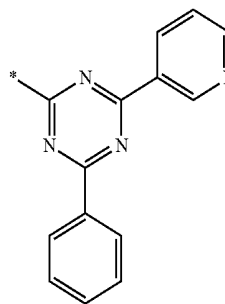
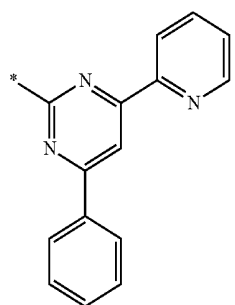
Formula 10-102

Formula 10-98



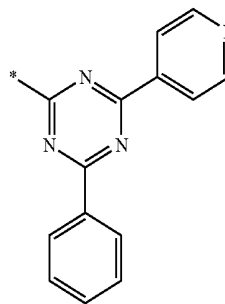
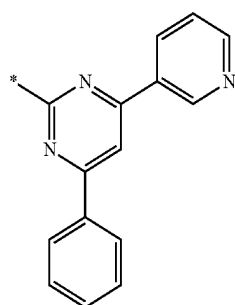
Formula 10-103

Formula 10-99



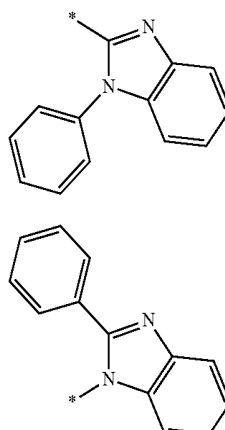
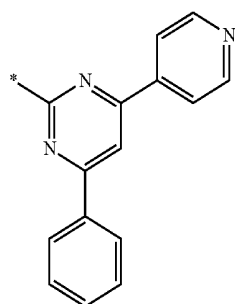
Formula 10-104

Formula 10-100



Formula 10-105

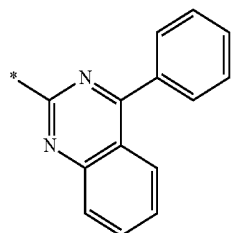
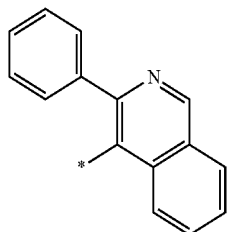
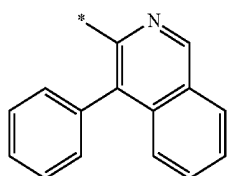
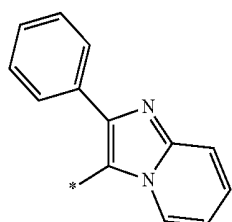
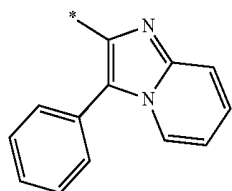
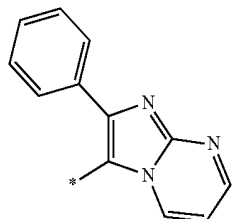
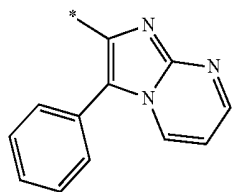
Formula 10-101



Formula 10-106

Formula 10-107

-continued



Formula 10-108

Formula 10-109

Formula 10-110

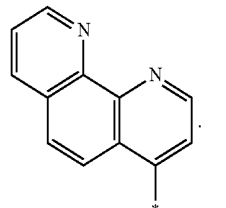
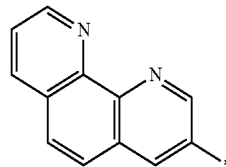
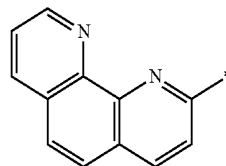
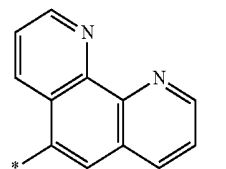
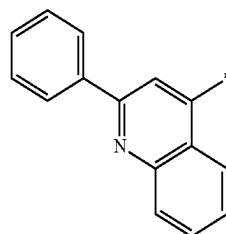
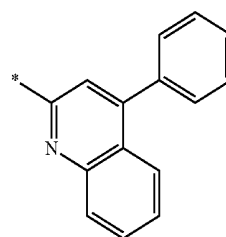
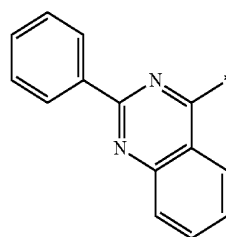
Formula 10-111

Formula 10-112

Formula 10-113

Formula 10-114

-continued



Formula 10-115

Formula 10-116

Formula 10-117

Formula 10-118

Formula 10-119

Formula 10-120

Formula 10-121

[0093] Ph in Formulae 6-1 to 6-100 and 10-1 to 10-121 indicates a phenyl group, and * indicates a binding site to a neighboring atom.

[0094] R₁ to R₆ and R₁₁ in Formula 1 may each independently be selected from hydrogen, deuterium, —F, —Cl,

—Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, —Si(Q_1)(Q_2)(Q_3), —N(Q_1)(Q_2), —B(Q_1)(Q_2), —C(=O)(Q_1), —S(=O)₂(Q_1), and —P(=O)(Q_1)(Q_2).

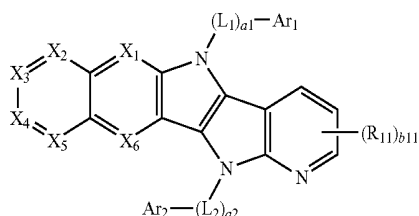
[0095] For example, R_1 to R_6 and R_{11} in Formula 1 may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and —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, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group), but embodiments of the present disclosure are not limited thereto.

[0096] b_{11} in Formula 1 indicates the number of R_{11} (s). b_{11} may be an integer between 0 and 4, inclusive, wherein, when b_{11} is two or more, two or more R_{11} (s) may be identical to or different from each other.

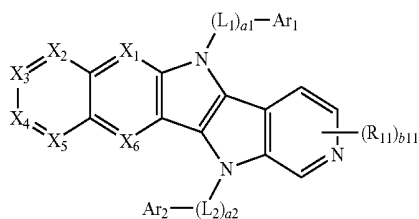
[0097] In one or more embodiments, b_{11} in Formula 1 may be 0 or 1, but embodiments of the present disclosure are not limited thereto.

[0098] For example, the condensed cyclic compound may be represented by one of Formulae 1-1 to 1-7:

Formula 1-1

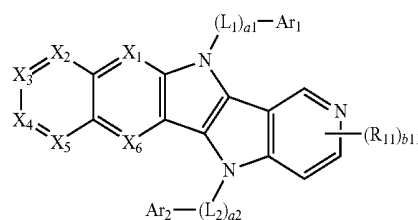


Formula 1-2

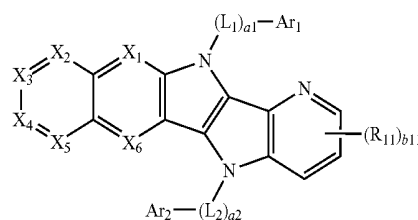


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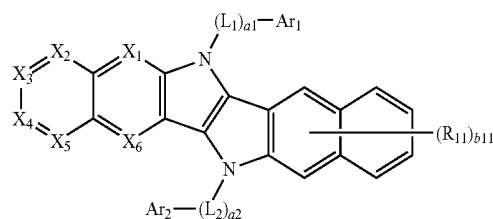
Formula 1-3



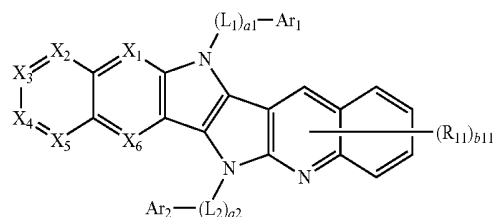
Formula 1-4



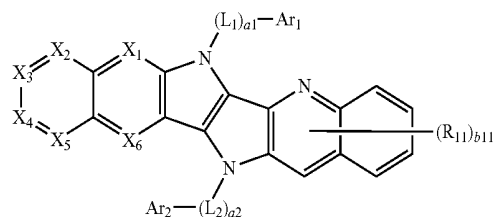
Formula 1-5



Formula 1-6



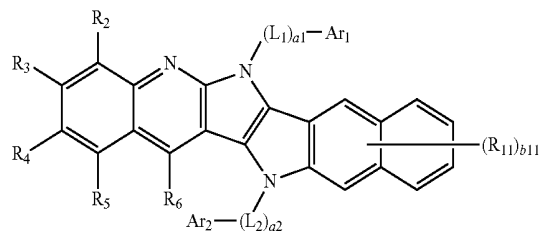
Formula 1-7



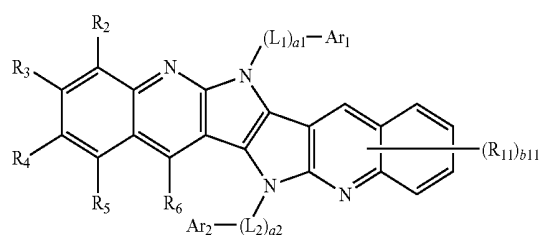
[0099] L_1 , L_2 , a_1 , a_2 , Ar_1 , Ar_2 , X_1 to X_6 , R_{11} , and b_{11} in Formulae 1-1 to 1-7 are the same as described above.

[0100] In one or more embodiments, the condensed cyclic compound may be represented by Formulae 1-5(1) to 1-7(1), but embodiments of the present disclosure are not limited thereto:

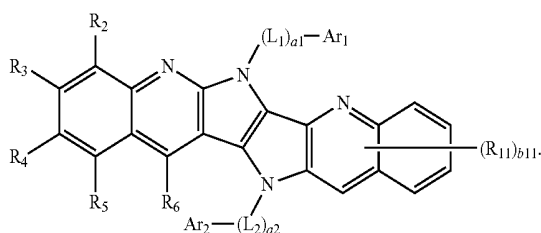
Formula 1-5(1)



Formula 1-6(1)

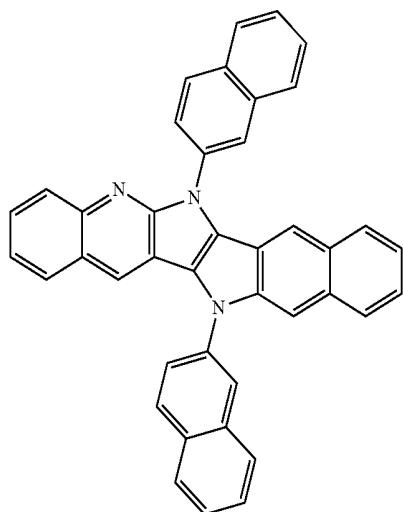


Formula 1-7(1)



[0101] L₁, L₂, a₁, a₂, Ar₁, Ar₂, R₂ to R₆, R₁₁, and b₁₁ in Formulae 1-5(1) to 1-7(1) are the same as described above.

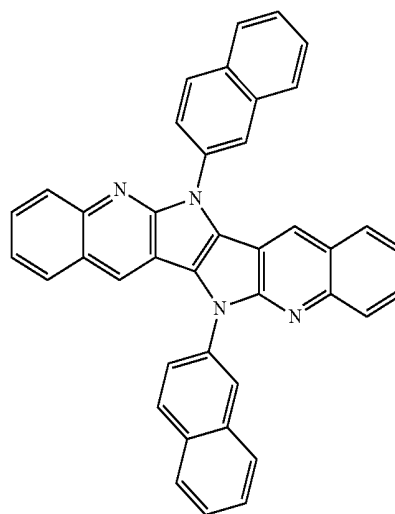
[0102] In one or more embodiments, the condensed cyclic compound may be one of Compounds 1 to 4, but embodiments of the present disclosure are not limited thereto:



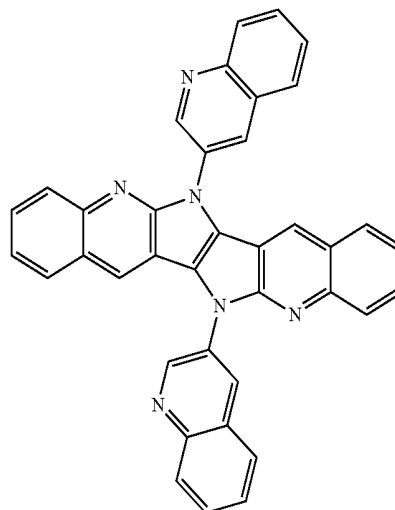
1

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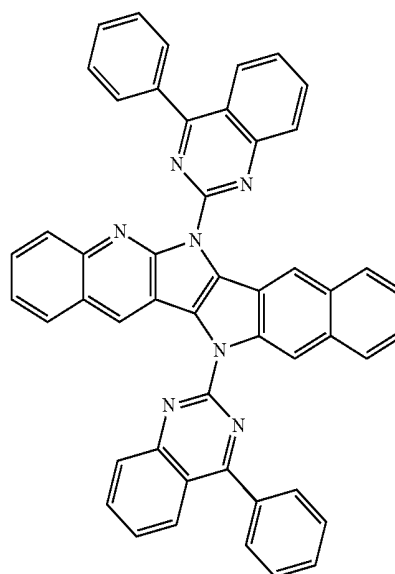
2



3



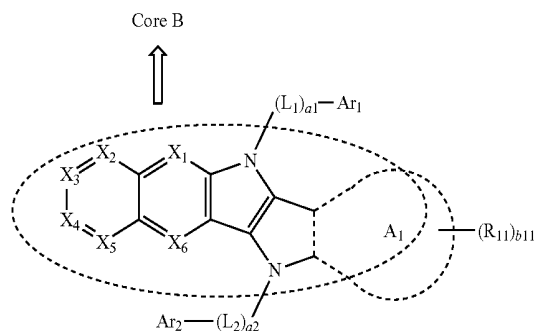
4



[0103] The condensed cyclic compound represented by Formula 1 has a core B (see Formula 1'). The core B may have a long conjugate bond because orbital functions exist

on the same plane in structural terms. Hence, the condensed cyclic compound represented by Formula 1 may have high electrical stability.

<Formula 1'>



[0104] Accordingly, an electronic device (for example, an organic light-emitting device) including the condensed cyclic compound represented by Formula 1 may have a low driving voltage, a high current density, and high efficiency.

[0105] A synthesis method for the condensed cyclic compound represented by Formula 1 would be apparent to those of ordinary skill in the art by referring to the following examples.

[0106] At least one condensed cyclic compound represented by Formula 1 may be used between a pair of electrodes constituting an organic light-emitting device. For example, the condensed cyclic compound may be included in at least one layer selected from an electron transport region and an emission layer. In one or more embodiments, the condensed cyclic compound represented by Formula 1 may be used as a material for forming a capping layer positioned outside the pair of electrodes of the organic light-emitting device.

[0107] Accordingly, provided is an organic light-emitting device including: a first electrode; a second electrode facing the first electrode; and an organic layer between the first electrode and the second electrode, the organic layer including an emission layer, wherein the organic layer includes at least one condensed cyclic compound represented by Formula 1.

[0108] The expression “(an organic layer) includes at least one of the condensed cyclic compounds” used herein may include a case in which “(an organic layer) includes identical condensed cyclic compounds represented by Formula 1” and a case in which “(an organic layer) includes two or more different condensed cyclic compounds represented by Formula 1.”

[0109] For example, the organic layer may include, as the condensed cyclic compound, only Compound 1. In this regard, Compound 1 may exist in an emission layer of the organic light-emitting device. In one or more embodiments, the organic layer may include, as the condensed cyclic compound, Compound 1 and Compound 2. In this regard, Compound 1 and Compound 2 may exist in the same layer (for example, Compound 1 and Compound 2 may be part of an emission layer), or different layers (for example, Compound 1 may exist in an emission layer and Compound 2 may exist in an electron transport layer).

[0110] In one or more embodiments,

[0111] the first electrode of the organic light-emitting device may be an anode,

[0112] the second electrode of the organic light-emitting device may be a cathode,

[0113] the organic layer of the organic light-emitting device may further include a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode,

[0114] the hole transport region may include a hole injection layer, a hole transport layer, an emission auxiliary layer, an electron blocking layer, or any combination thereof, and

[0115] the electron transport region may include a hole blocking layer, a buffer layer, an electron transport layer, an electron injection layer, or any combination thereof. The emission layer may include the condensed cyclic compound represented by Formula 1. The emission layer may further include, in addition to the condensed cyclic compound represented by Formula 1, a dopant. The dopant may include at least one selected from a fluorescent dopant and a phosphorescent dopant. In one or more embodiments, the emission layer of the organic light-emitting device may include a host and a dopant, the host may include the condensed cyclic compound represented by Formula 1, and the dopant may include a phosphorescent dopant. However, embodiments of the present disclosure are not limited thereto.

[0116] The organic light-emitting device may further include at least one selected from a first capping layer disposed in a pathway along which light generated in an emission layer proceeds toward the outside through the first electrode and a second capping layer disposed in a pathway along which light generated in an emission layer proceeds toward the outside through the second electrode, and the at least one selected from the first capping layer and the second capping layer may include at least one of the condensed cyclic compounds.

[0117] For example, the organic light-emitting device may have i) a stack structure including a first electrode, an organic layer, a second electrode, and a second capping layer sequentially stacked in this stated order, ii) a stack structure including a first capping layer, a first electrode, an organic layer, and a second electrode sequentially stacked in this stated order, or iii) a stack structure including a first capping layer, a first electrode, an organic layer, a second electrode, and a second capping layer sequentially stacked in this stated order, wherein at least one of the first capping layer and the second capping layer may include the condensed cyclic compound.

[0118] The term “organic layer” as used herein refers to a single layer and/or a plurality of layers between the first electrode and the second electrode of an organic light-emitting device. A material included in the “organic layer” is not limited to an organic material.

[Description of FIG. 1]

[0119] FIG. 1 is a schematic view of an organic light-emitting device 10 according to an embodiment. The organic light-emitting device 10 includes a first electrode 110, an organic layer 150, and a second electrode 190.

[0120] Hereinafter, the structure of the organic light-emitting device 10 according to an embodiment and a method of manufacturing the organic light-emitting device 10 will be described in connection with FIG. 1.

[First Electrode 110]

[0121] In FIG. 1, a substrate may be additionally disposed under the first electrode 110 or above the second electrode 190. The substrate may be a glass substrate or a plastic substrate, each having excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water resistance.

[0122] The first electrode 110 may be formed by depositing or sputtering a material for forming the first electrode 110 on the substrate. When the first electrode 110 is an anode, the material for forming a first electrode may be selected from materials with a high work function to facilitate hole injection.

[0123] The first electrode 110 may be a reflective electrode, a semi-transmissive electrode, or a transmissive electrode. When the first electrode 110 is a transmissive electrode, a material for forming a first electrode may be selected from indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO₂), zinc oxide (ZnO), and any combinations thereof, but embodiments of the present disclosure are not limited thereto. When the first electrode 110 is a semi-transmissive electrode or a reflective electrode, as a material for forming the first electrode 110, magnesium (Mg), silver (Ag), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), magnesium-silver (Mg—Ag), or any combination thereof may be used. However, the material for forming the first electrode 110 is not limited thereto.

[0124] The first electrode 110 may have a single-layered structure, or a multi-layered structure including two or more layers. For example, the first electrode 110 may have a three-layered structure of ITO/Ag/ITO, but the structure of the first electrode 110 is not limited thereto.

[Organic Layer 150]

[0125] The organic layer 150 is disposed on the first electrode 110. The organic layer 150 may include an emission layer.

[0126] The organic layer 150 may further include a hole transport region between the first electrode 110 and the emission layer, and an electron transport region between the emission layer and the second electrode 190.

[Hole Transport Region in Organic Layer 150]

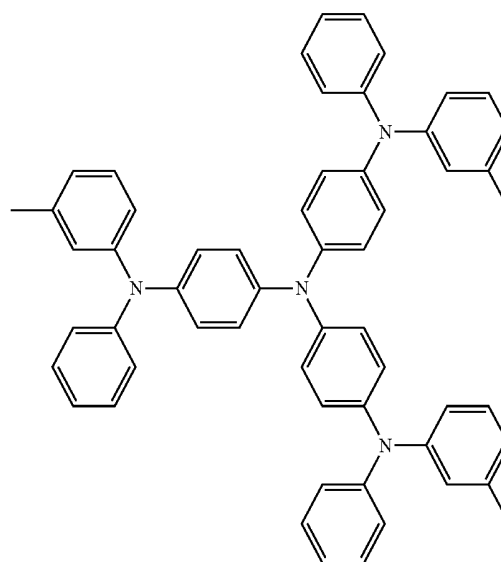
[0127] The hole transport region may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

[0128] The hole transport region may include at least one layer selected from a hole injection layer (HIL), a hole transport layer (HTL), an emission auxiliary layer, and an electron blocking layer (EBL).

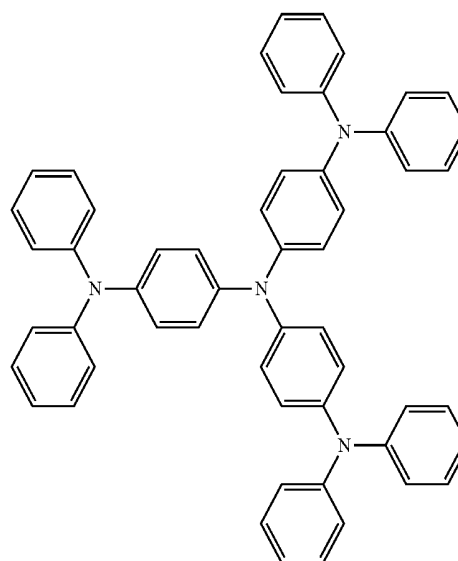
[0129] For example, the hole transport region may have a single-layered structure including a single layer including a plurality of different materials, or a multi-layered structure having a hole injection layer/hole transport layer structure, a hole injection layer/hole transport layer/emission auxiliary layer structure, a hole injection layer/emission auxiliary layer structure, a hole transport layer/emission auxiliary layer structure, or a hole injection layer/hole transport layer/electron blocking layer structure, wherein for each structure,

constituting layers are sequentially stacked from the first electrode 110 in this stated order, but the structure of the hole transport region is not limited thereto.

[0130] The hole transport region may include at least one selected from m-MTDATA, TDATA, 2-TNATA, NPB (NPD), β -NPB, TPD, Spiro-TPD, Spiro-NPB, methylated-NPB, TAPC, HMTPD, 4,4',4''-tris(N-carbazolyl)triphenylamine (TCTA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), PEDOT/PSS (poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate)), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), a compound represented by Formula 201, and a compound represented by Formula 202:

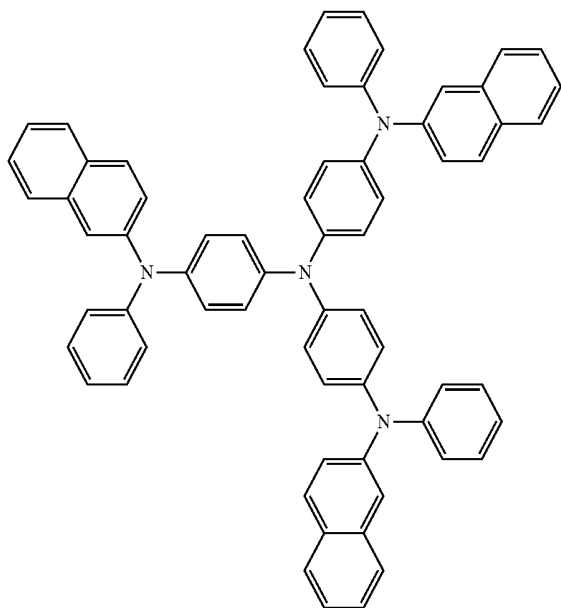


m-MTDATA



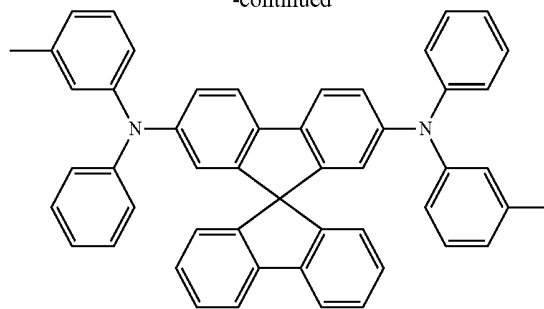
TDATA

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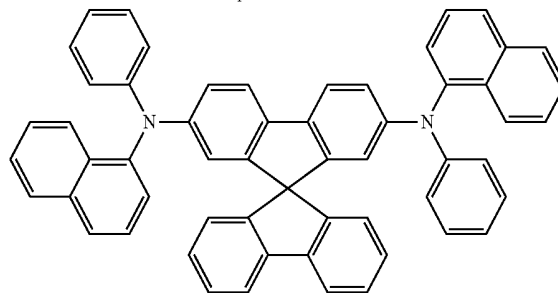


2-TNATA

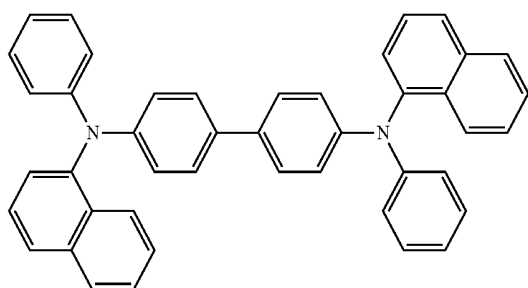
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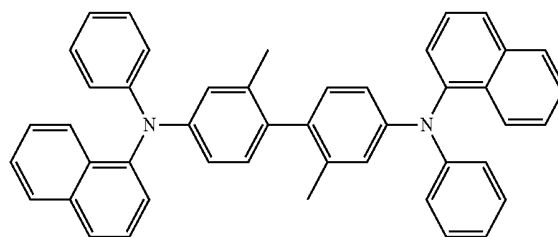
Spiro-TPD



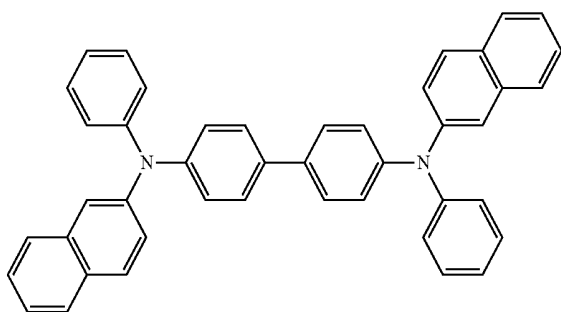
Spiro-NPB



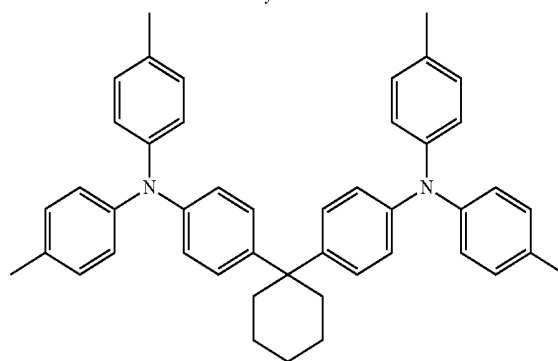
NPB



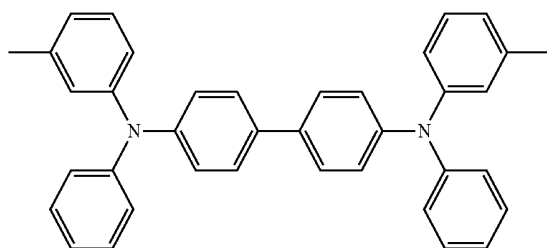
methylated NPB



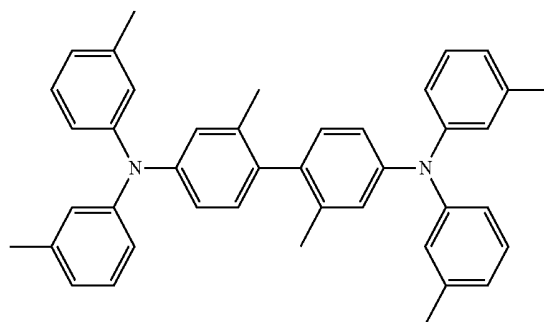
β-NPB



TAPC



TPD



HMTDP

[0132] L₂₀₁ to L₂₀₄ may each independently be selected from a substituted or unsubstituted C₃-C₁₀ cycloalkylene group, a substituted or unsubstituted heterocycloalkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkenylene group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkenylene group, a substituted or unsubstituted C₆-C₆₀ arylene group, a substituted or unsubstituted C₁-C₆₀ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

[0138] In one or more embodiments, in Formulae 201 and 202.

[10141] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a thiophenylene group, a furanylene group, a carbazolylenylene group, an indolylene group, an isoindolylene group, a benzofuranylene group, a benzothiophenylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylene group, and a pyridinylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C₁-C₁₀ alkyl group, a phenyl group substituted with —F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazoyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazoyl group, a dibenzocarbazoyl group, a dibenzosilolyl group, a pyridinyl group, —Si(Q₃₁)(Q₃₂)(Q₃₃), and —N(Q₃₁)(Q₃₂); and

[0142] Q_{31} to Q_{33} may each independently be selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0143] In one or more embodiments, xa1 to xa4 may each independently be 0, 1, or 2.

[0144] In one or more embodiments, xa5 may be 1, 2, 3, or 4.

[0145] In one or more embodiments, R_{201} to R_{204} and Q_{201} may each independently be selected from a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a benzofuranyl group, a benzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group; and

[0146] a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a benzofuranyl group, a benzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1 - C_{10} alkyl group, a phenyl group substituted with —F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group,

an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a benzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, —Si(Q_{31})(Q_{32})(Q_{33}), and —N(Q_{31})(Q_{32}), and

[0147] Q_{31} to Q_{33} are the same as described above.

[0148] In one or more embodiments, at least one from R_{201} to R_{203} in Formula 201 may each independently be selected from:

[0149] a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a benzothiophenyl group; and

[0150] a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a benzothiophenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1 - C_{10} alkyl group, a phenyl group substituted with —F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a benzothiophenyl group;

[0151] but embodiments of the present disclosure are not limited thereto.

[0152] In one or more embodiments, in Formula 202, i) R_{201} and R_{202} may be linked via a single bond, and/or ii) R_{203} and R_{204} may be linked via a single bond.

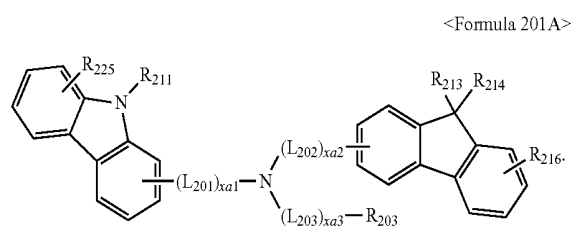
[0153] In one or more embodiments, at least one from R_{201} to R_{204} in Formula 202 may be selected from:

[0154] a carbazolyl group; and

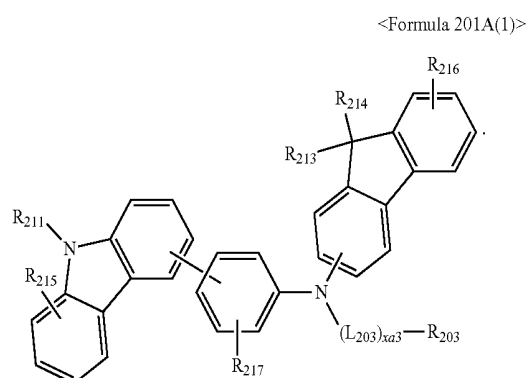
[0155] a carbazolyl group that is substituted with deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1 - C_{10} alkyl group, a phenyl group substituted with —F, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a carbazolyl group, a dibenzofuranyl group, and a benzothiophenyl group;

[0156] but embodiments of the present disclosure are not limited thereto.

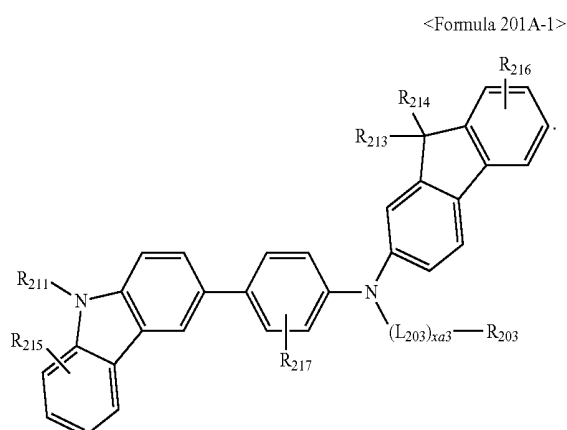
[0157] The compound represented by Formula 201 may be represented by Formula 201A:



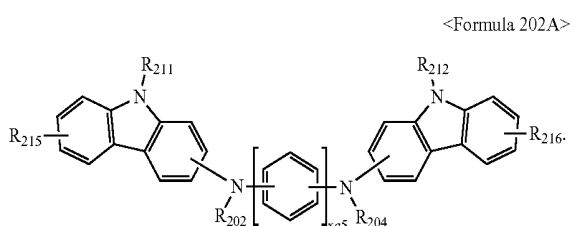
[0158] In one or more embodiments, the compound represented by Formula 201 may be represented by Formula 201A(1), but embodiments of the present disclosure are not limited thereto:



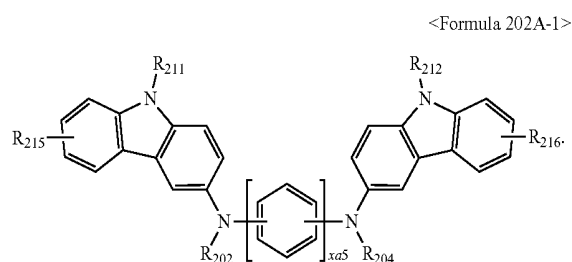
[0159] In one or more embodiments, the compound represented by Formula 201 may be represented by Formula 201A-1 below, but embodiments of the present disclosure are not limited thereto:



[0160] In one or more embodiments, the compound represented by Formula 202 may be represented by Formula 202A:



[0161] In one or more embodiments, the compound represented by Formula 202 may be represented by Formula 202A-1:



[0162] In Formulae 201A, 201A(1), 201A-1, 202A, and 202A-1,

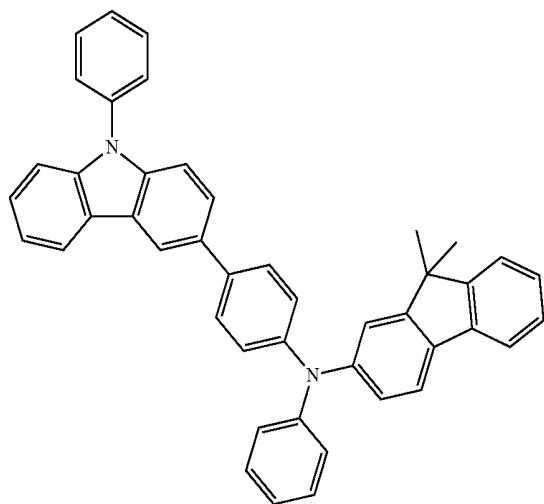
[0163] L_{201} to L_{203} , $xa1$ to $xa3$, $xa5$, and R_{202} to R_{204} are the same as described above, R_{211} and R_{212} may be understood by referring to the description provided herein in connection with R_{203} .

[0164] R_{213} to R_{217} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a phenyl group substituted with a C_1 - C_{10} alkyl group, a phenyl group substituted with —F, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group.

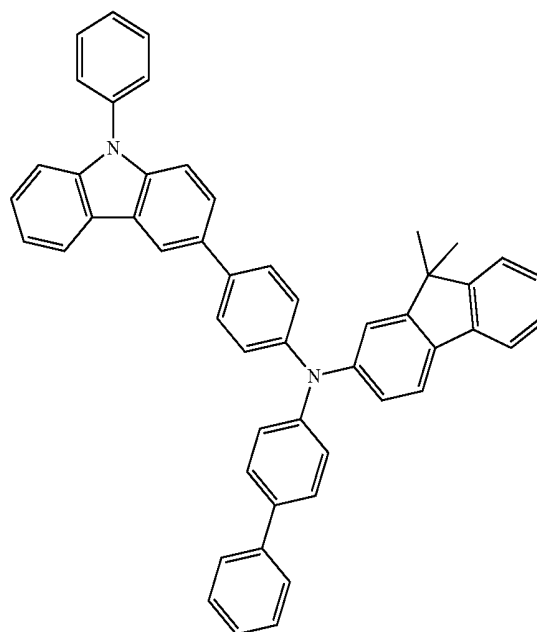
[0165] The hole transport region may include at least one compound selected from Compounds HT1 to HT39, but embodiments of the present disclosure are not limited thereto:

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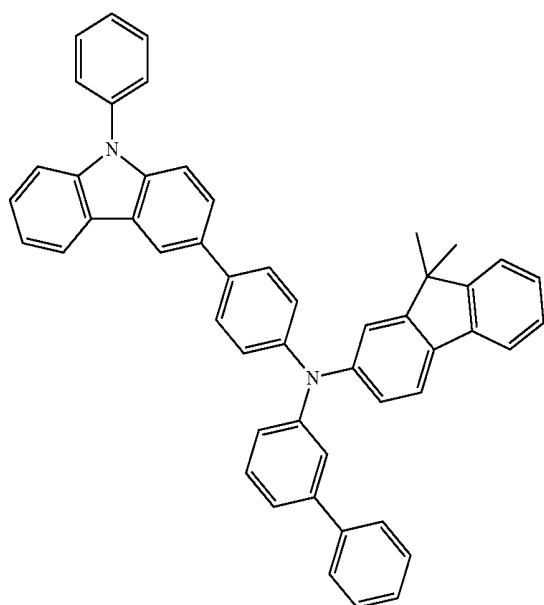
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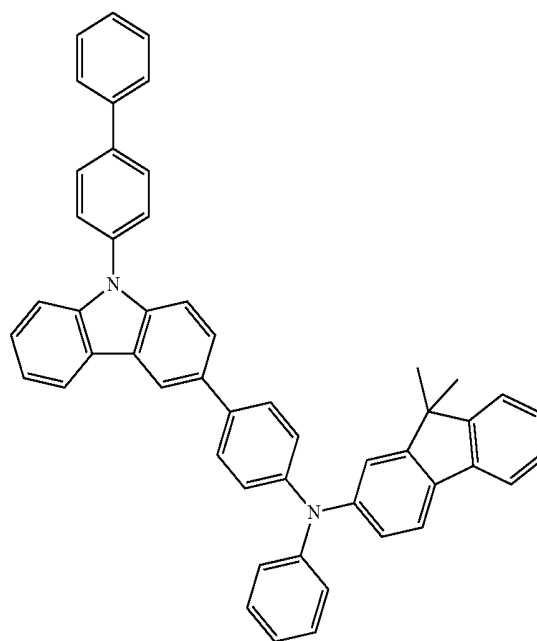
HT3



HT2



HT4

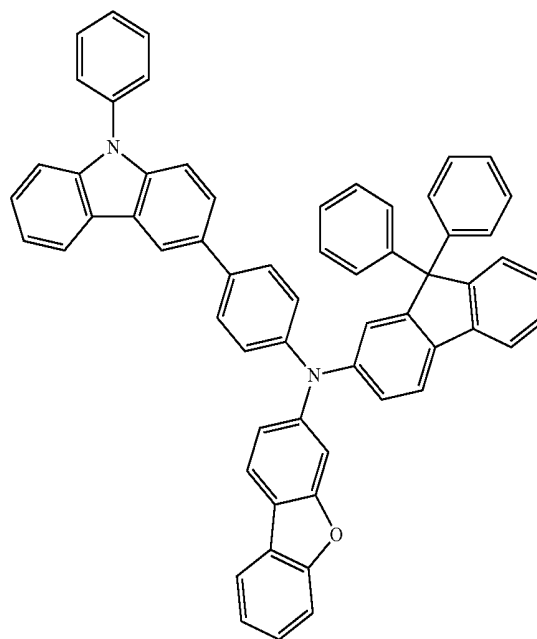
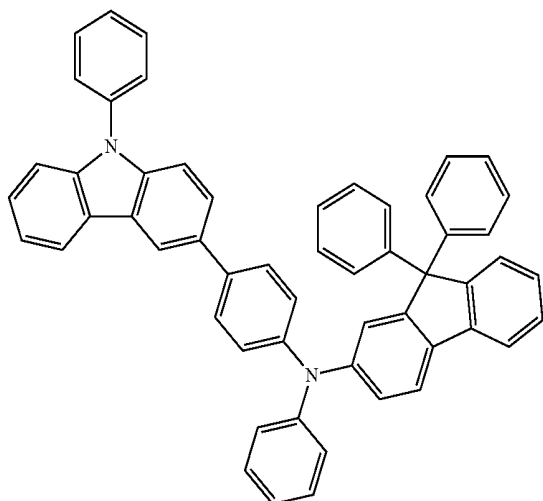


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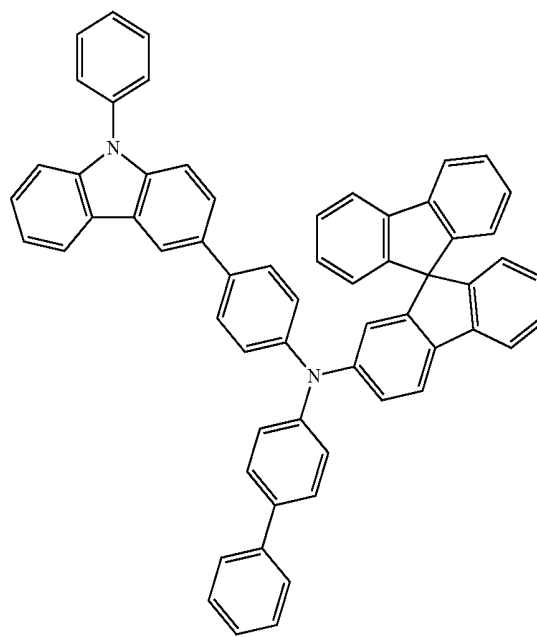
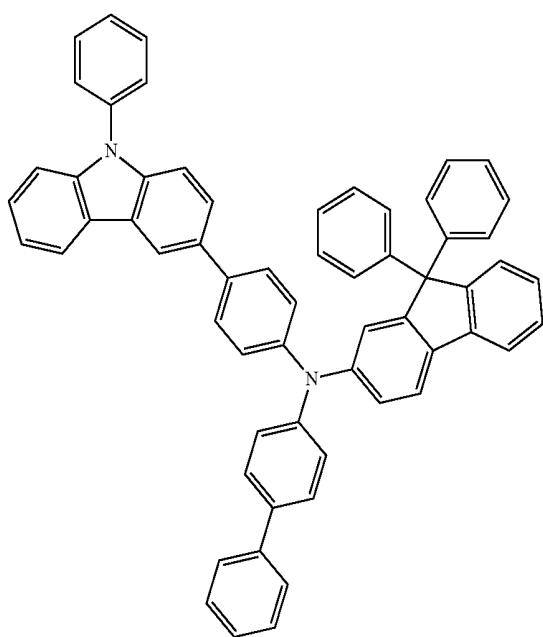
HT5

HT7



HT6

HT8

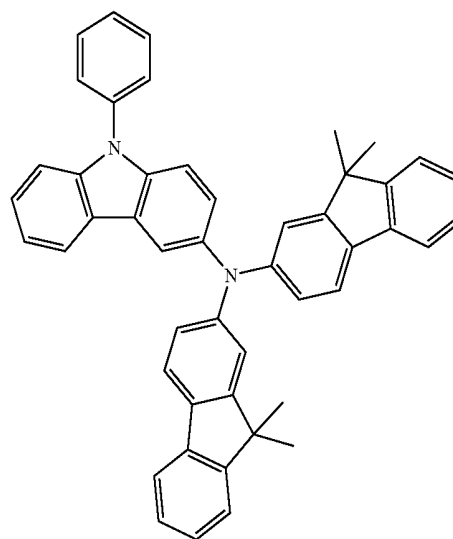
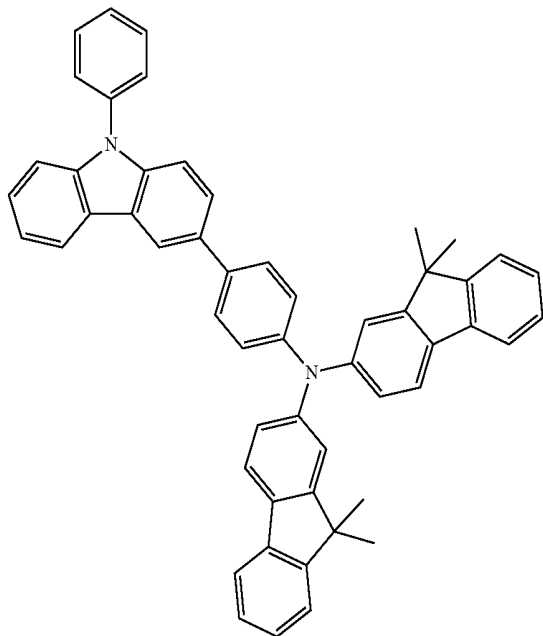


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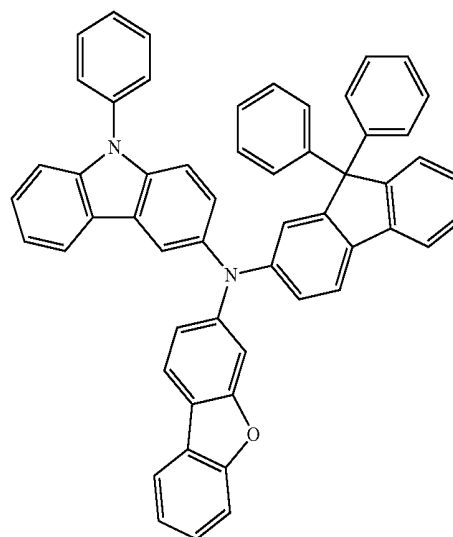
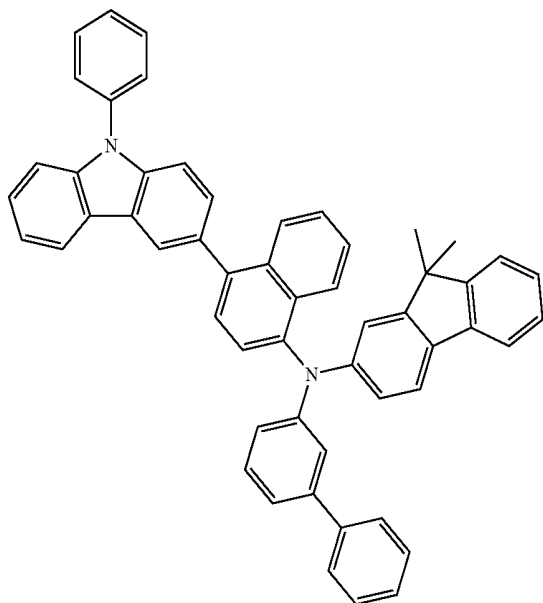
HT11

HT9

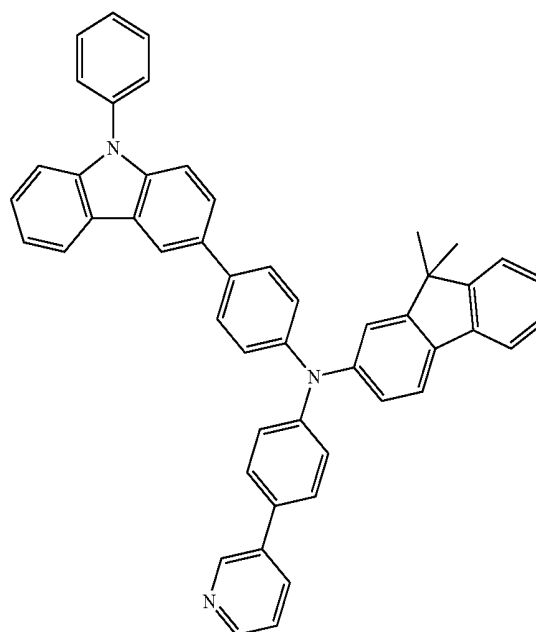


HT12

HT10

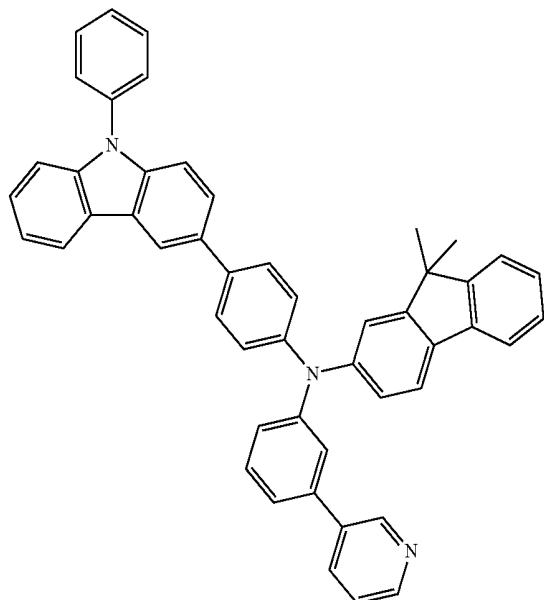


HT13



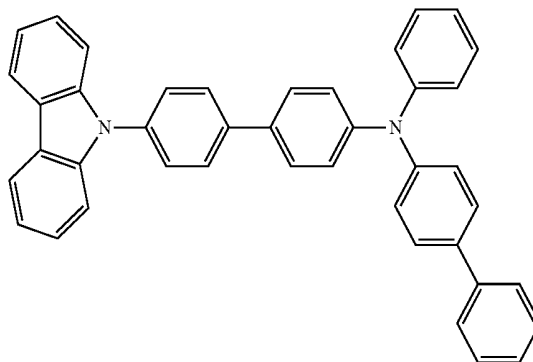
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HT14

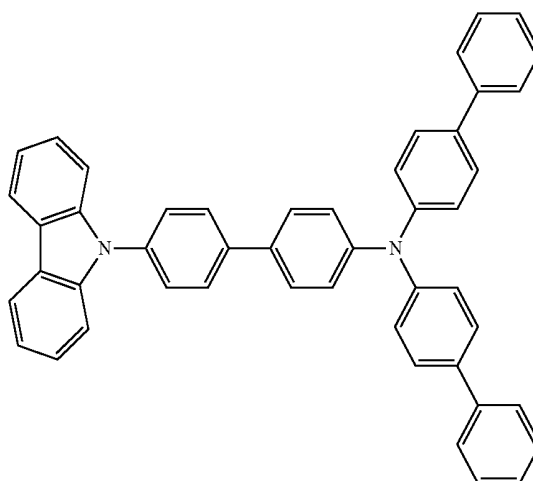


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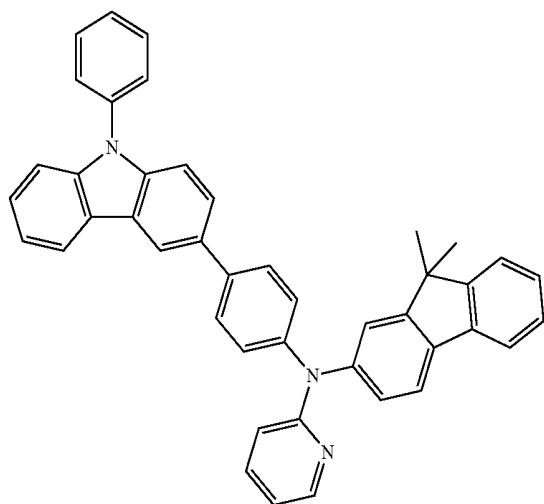
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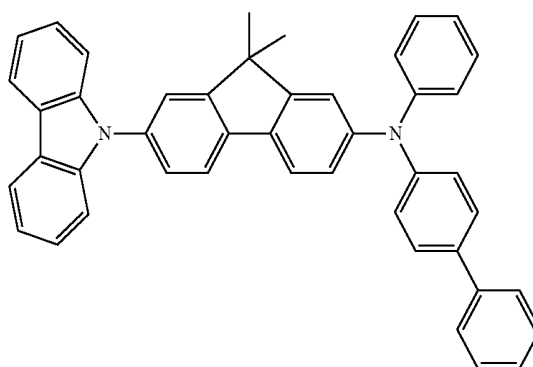
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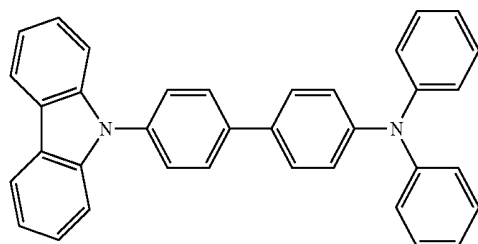
HT15



HT19

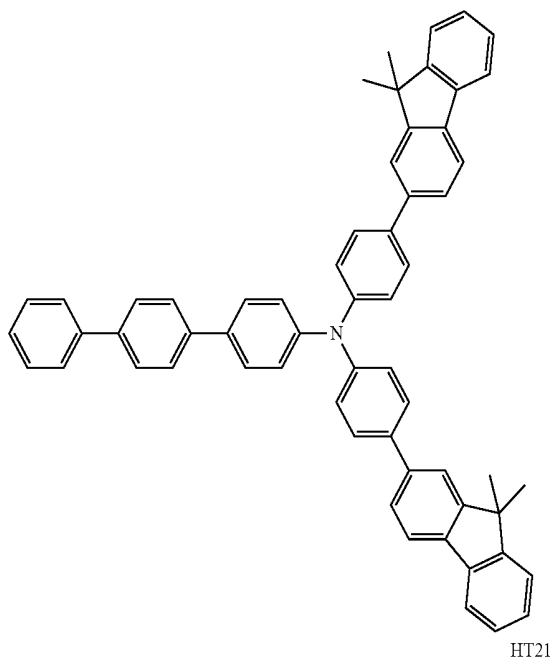


HT16

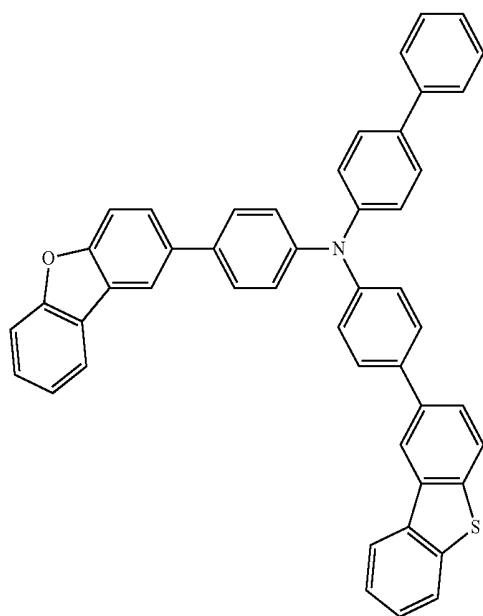


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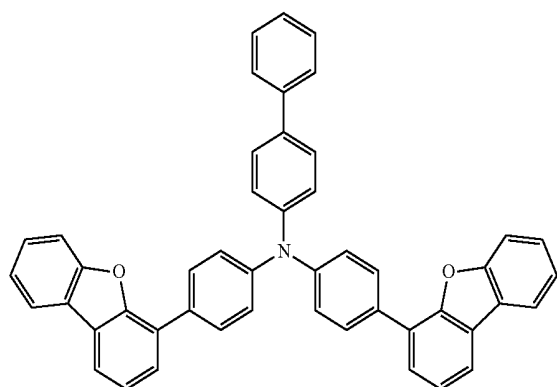
HT20



HT21

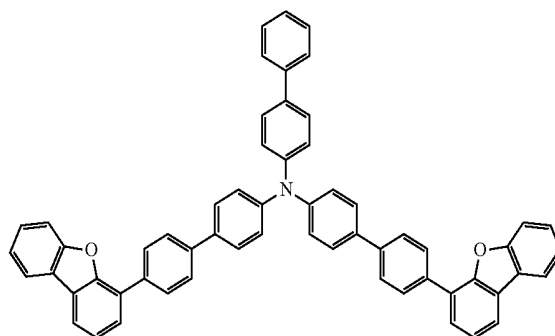


HT22

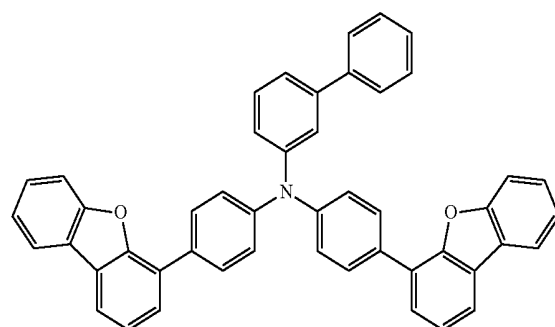


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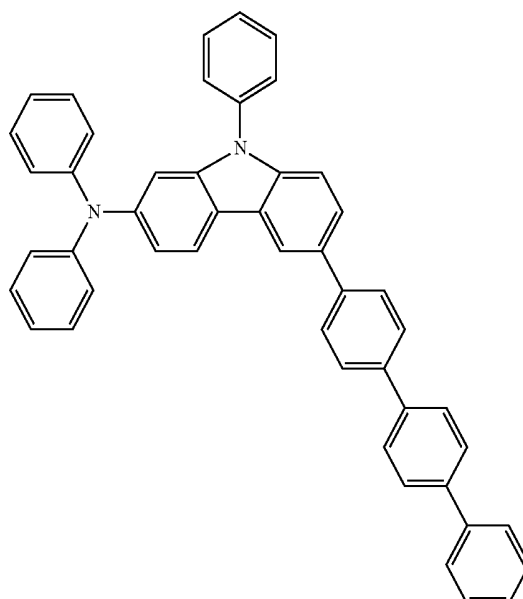
HT23



HT24

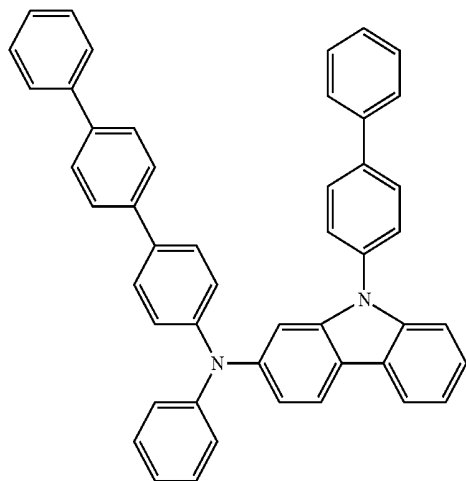


HT25



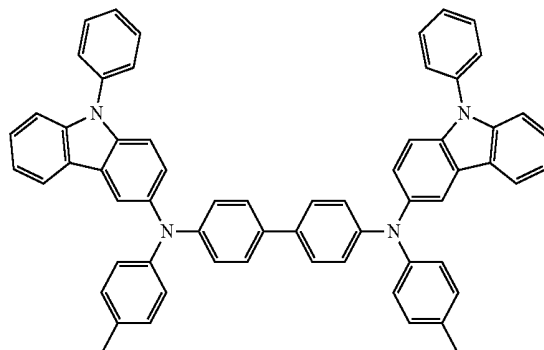
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HT26

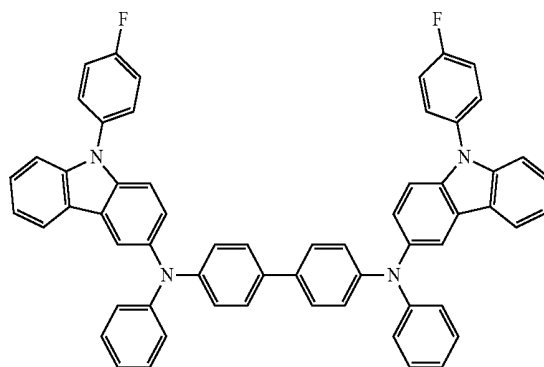


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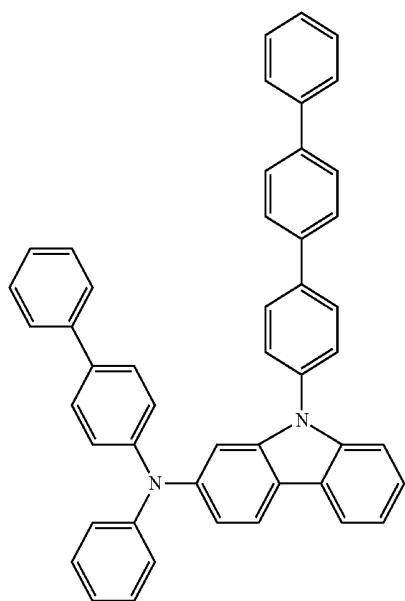
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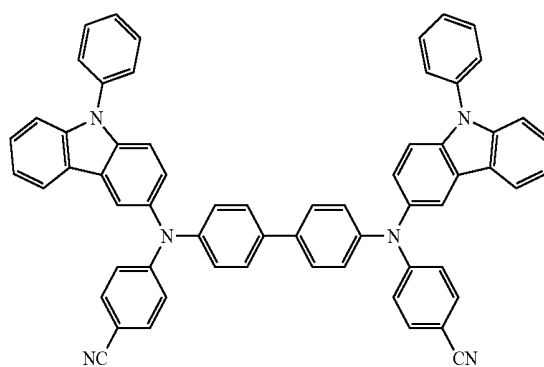
HT30



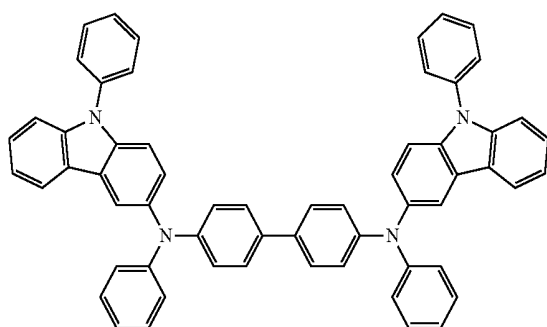
HT27



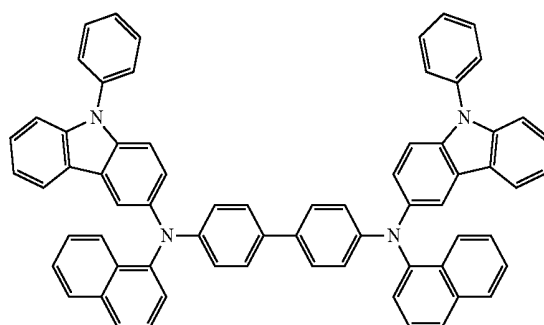
HT31



HT28

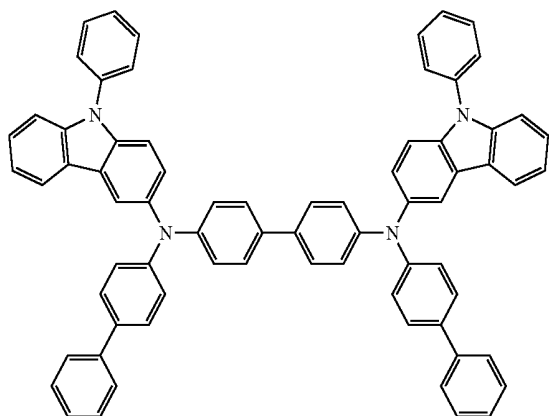


HT32



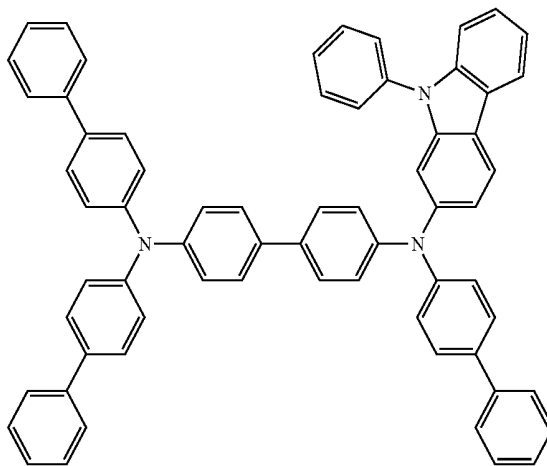
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HT33

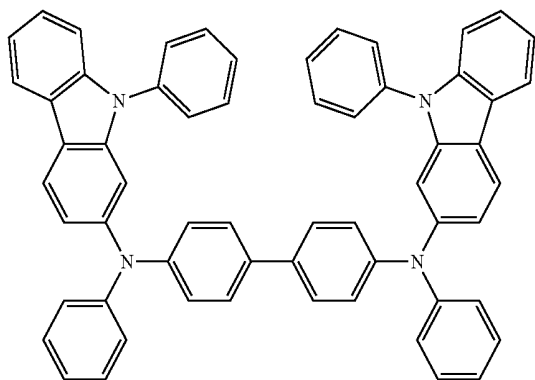


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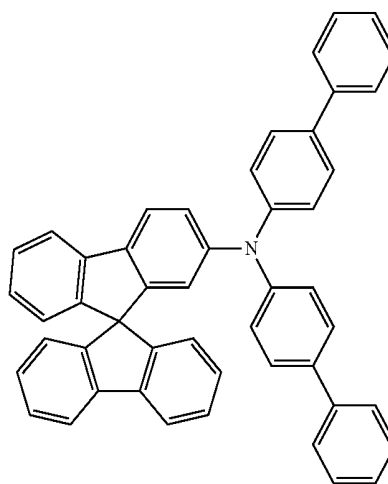
HT36



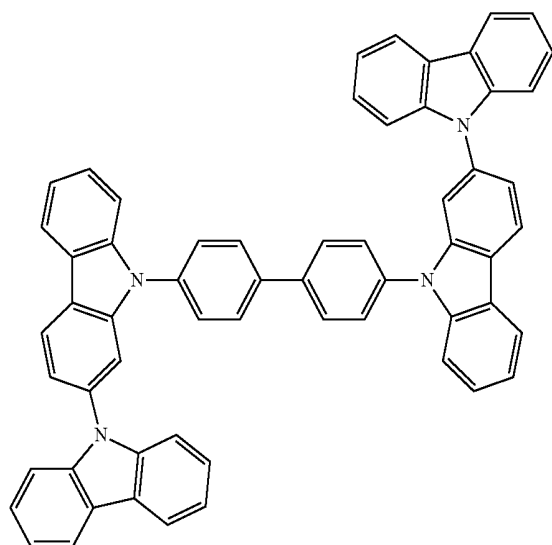
HT34



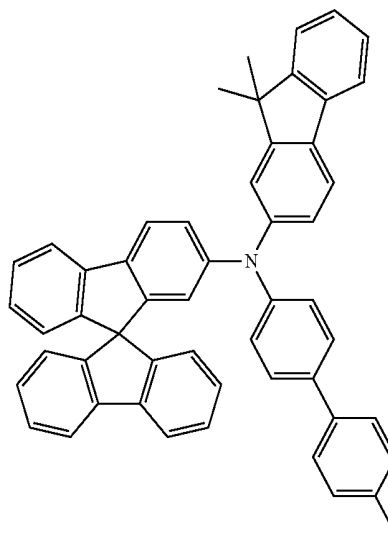
HT37



HT35

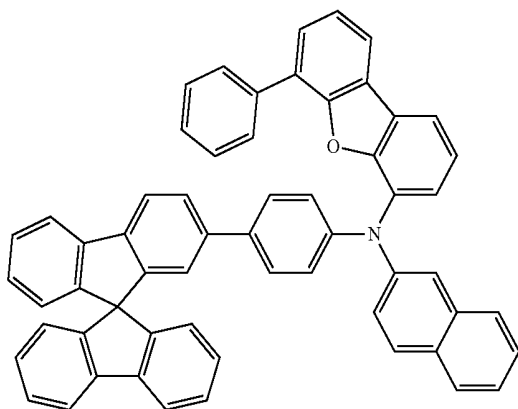


HT38



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HT39



[0166] A thickness of the hole transport region may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å. When the hole transport region includes at least one of a hole injection layer and a hole transport layer, the thickness of the hole injection layer may be in a range of about 100 Å to about 9,000 Å, and for example, about 100 Å to about 1,000 Å, and the thickness of the hole transport layer may be in a range of about 50 Å to about 2,000 Å, and for example, about 100 Å to about 1,500 Å. When the thicknesses of the hole transport region, the hole injection layer and the hole transport layer are within these ranges, satisfactory hole transporting characteristics may be obtained without a substantial increase in driving voltage.

[0167] The emission auxiliary layer may increase light-emission efficiency by compensating for an optical resonance distance according to the wavelength of light emitted by an emission layer, and the electron blocking layer may block the flow of electrons from an electron transport region. The emission auxiliary layer and the electron blocking layer may include the materials as described above.

[p-dopant]

[0168] The hole transport region may further include, in addition to these materials, a charge-generation material for the improvement of conductive properties. The charge-generation material may be homogeneously or non-homogeneously dispersed in the hole transport region.

[0169] The charge-generation material may be, for example, a p-dopant.

[0170] In one or more embodiments, a lowest unoccupied molecular orbital (LUMO) of the p-dopant may be -3.5 eV or less.

[0171] The p-dopant may include at least one selected from a quinone derivative, a metal oxide, and a cyano group-containing compound, but embodiments of the present disclosure are not limited thereto.

[0172] For example, the p-dopant may include at least one selected from:

[0173] a quinone derivative, such as tetracyanoquinodimethane (TCNQ) and 2,3,5,6-tetrafluoro-7,7,8,8-tetracyanoquinodimethane (F4-TCNQ),

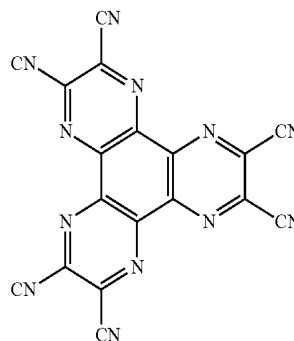
[0174] a metal oxide, such as tungsten oxide or molybdenum oxide;

[0175] 1,4,5,8,9,11-hexaazatriphenylene-hexacarbonitrile (HAT-CN), and

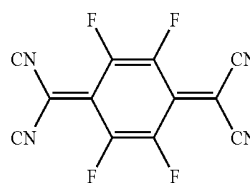
[0176] a compound represented by Formula 221,

[0177] but embodiments of the present disclosure are not limited thereto:

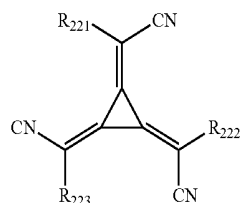
<HAT-CN>



<F4-TCNQ>



<Formula 221>



[0178] In Formula 221,

[0179] R_{221} to R_{223} may each independently be selected from a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, provided that at least one selected from R_{221} to R_{223} has at least one substituent selected from a cyano group, —F, —Cl, —Br, —I, a C_1 - C_{20} alkyl group substituted with —F, a C_1 - C_{20} alkyl group substituted with —Cl, a C_1 - C_{20} alkyl group substituted with —Br, and a C_1 - C_{20} alkyl group substituted with —I.

[Emission Layer in Organic Layer 150]

[0180] When the organic light-emitting device 10 is a full color organic light-emitting device, the emission layer may be patterned into a red emission layer, a green emission layer, or a blue emission layer, according to a sub-pixel. In one or more embodiments, the emission layer may have a stacked structure of two or more layers selected from a red emission layer, a green emission layer, and a blue emission layer, in which the two or more layers contact each other or are separated from each other. In one or more embodiments, the emission layer may include two or more materials selected from a red light-emitting material, a green light-

emitting material, and a blue light-emitting material, in which the two or more materials are mixed with each other in a single layer to emit white light.

[0181] The emission layer may include a host and a dopant. The dopant may include at least one selected from a phosphorescent dopant and a fluorescent dopant.

[0182] An amount of the dopant in the emission layer may be, in general, in a range of about 0.01 parts to about 15 parts by weight based on 100 parts by weight of the host, but embodiments of the present disclosure are not limited thereto.

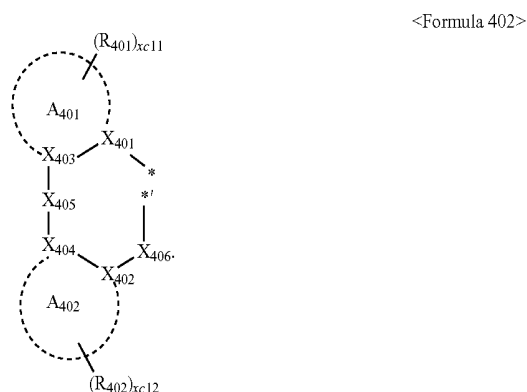
[0183] A thickness of the emission layer may be in a range of about 100 Å to about 1,000 Å, for example, about 200 Å to about 600 Å. When the thickness of the emission layer is within this range, excellent light-emission characteristics may be obtained without a substantial increase in driving voltage.

[Host in Emission Layer]

[0184] The host may include the condensed cyclic compound represented by Formula 1.

[Phosphorescent Dopant included in Emission Layer in Organic Layer 150]

[0185] The phosphorescent dopant may include an organometallic complex represented by Formula 401 below:



[0186] In Formulae 401 and 402,

[0187] M may be selected from iridium (Ir), platinum (Pt), palladium (Pd), osmium (Os), titanium (Ti), zirconium (Zr), hafnium (Hf), europium (Eu), terbium (Tb), rhodium (Rh), and thulium (Tm),

[0188] L_{401} may be selected from ligands represented by Formula 402, and $xc1$ may be 1, 2, or 3, wherein, when $xc1$ is two or more, two or more $L_{401}(s)$ may be identical to or different from each other,

[0189] L_{402} may be an organic ligand, and $xc2$ may be an integer between 0 and 4, inclusive, wherein, when $xc2$ is two or more, two or more $L_{402}(s)$ may be identical to or different from each other,

[0190] X_{401} to X_{404} may each independently be nitrogen or carbon,

[0191] X_{401} and X_{403} may be linked via a single bond or a double bond, and X_{402} and X_{404} may be linked via a single bond or a double bond,

[0192] A_{401} and A_{402} may each independently be selected from a C_5 - C_{60} carbocyclic group or a C_1 - C_{60} heterocyclic group,

[0193] X_{405} may be a single bond, $^*O^*$, $^*S^*$, $^*C(=O)^*$, $^*N(Q_{411})^*$, $^*C(Q_{411})(Q_{412})^*$, $^*C(Q_{411})=C(Q_{412})^*$, $^*C(Q_{411})=^*$, or $^*=C(Q_{411})^*$, wherein Q_{411} and Q_{412} may be hydrogen, deuterium, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group,

[0194] X_{406} may be a single bond, O, or S,

[0195] R_{401} and R_{402} may each independently be selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1 - C_{20} alkyl group, a substituted or unsubstituted C_1 - C_{20} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_1 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group $-Si(Q_{401})(Q_{402})(Q_{403})$, $-N(Q_{401})(Q_{402})$, $-B(Q_{401})(Q_{402})$, $-C(=O)(Q_{401})$, $-S(=O)_2(Q_{401})$, and $-P(=O)(Q_{401})(Q_{402})$, wherein Q_{401} to Q_{403} may each independently be selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a C_6 - C_{20} aryl group, and a C_1 - C_{20} heteroaryl group,

[0196] $xc1$ and $xc2$ may each independently be an integer between 0 and 10, inclusive, and

[0197] $*$ and * in Formula 402 each indicate a binding site to M in Formula 401.

[0198] In one or more embodiments, A_{401} and A_{402} in Formula 402 may each independently be selected from a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, an indene group, a pyrrole group, a thiophene group, a furan group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a quinoxaline group, a quinazoline group, a carbazole group, a benzimidazole group, a benzofuran group, a benzothienophene group, an isobenzothienophene group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, a dibenzofuran group, and a dibenzothienophene group.

[0199] In one or more embodiments, in Formula 402, i) X_{401} may be nitrogen, and X_{402} may be carbon, or ii) X_{401} and X_{402} may each be nitrogen at the same time.

[0200] In one or more embodiments, R_{401} and R_{402} in Formula 402 may each independently be selected from:

[0201] hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, and a C_1 - C_{20} alkoxy group;

[0202] a C_1 - C_{20} alkyl group and a C_1 - C_{20} alkoxy group, each substituted with at least one selected from deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydra-

zono group, a phenyl group, a naphthyl group, a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, and a norbornenyl group;

[0203] a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

[0204] a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, an adamantanyl group, a norbornanyl group, a norbornenyl group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a quinoxalinyl group, a quinazolinyl group, a carbazolyl group, a dibenzofuranyl group, and a dibenzothiophenyl group;

[0205] $-S(Q_{401})(Q_{402})(Q_{403})$, $-N(Q_{401})(Q_{402})$, $-B(Q_{401})(Q_{402})$, $-C(=O)(Q_{401})$, $-S(=O)_2(Q_{401})$, and $-P(=O)(Q_{401})(Q_{402})$, and

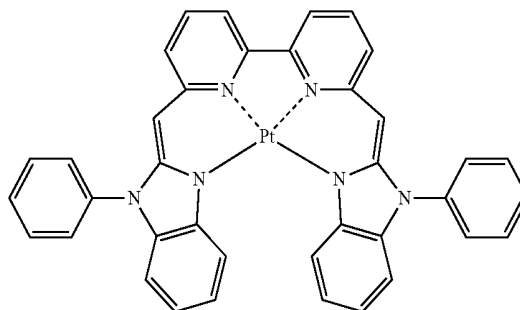
[0206] Q_{401} to Q_{403} may each independently be selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, and a naphthyl group, but are not limited thereto.

[0207] In one or more embodiments, when xc1 in Formula 401 is two or more, two $A_{401}(s)$ in two or more $L_{401}(s)$ may optionally be linked to each other via X_{407} , which is a linking group, or two $A_{402}(s)$ in two or more $L_{401}(s)$ may optionally be linked to each other via X_{408} , which is a linking group (see Compounds PD1 to PD4 and PD7). X_{407} and X_{408} may each independently be a single bond, $*-O-$, $*-S-$, $*-C(=O)-$, $*-N(Q_{413})-$, $*-C(Q_{413})(Q_{414})-$, or $*-C(Q_{413})=C(Q_{414})-$ (wherein Q_{413} and Q_{414} may each independently be hydrogen, deuterium, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group), but are not limited thereto.

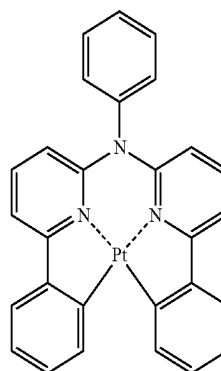
[0208] L_{402} in Formula 401 may be a monovalent, divalent, or trivalent organic ligand. For example, L_{402} may be selected from halogen, diketone (for example, acetylacetonate), carboxylic acid (for example, picolinate), $-C(=O)$, isonitrile, $-CN$, and phosphorus (for example, phosphine, or phosphite), but embodiments of the present disclosure are not limited thereto.

[0209] In one or more embodiments, the phosphorescent dopant may be selected from, for example, Compounds PD1 to PD25, but embodiments of the present disclosure are not limited thereto:

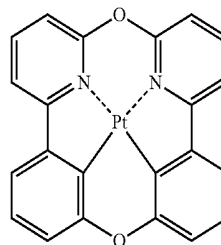
PD1



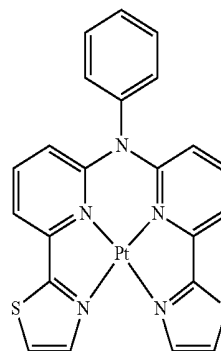
PD2



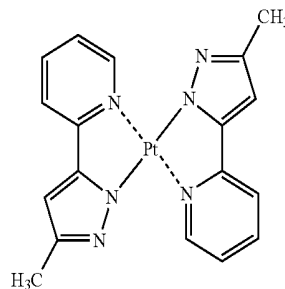
PD3



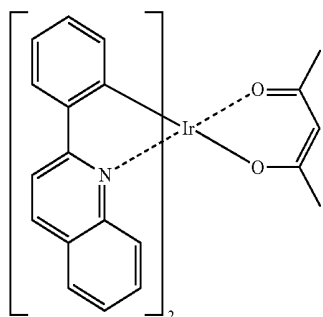
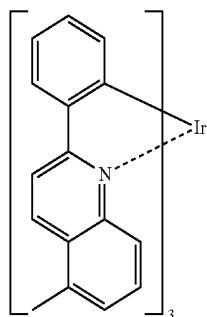
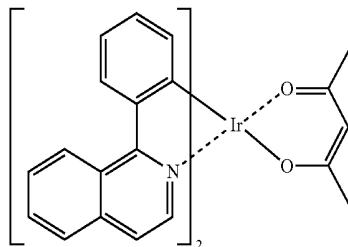
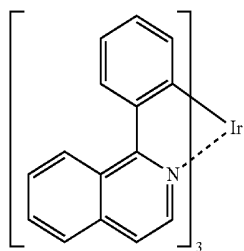
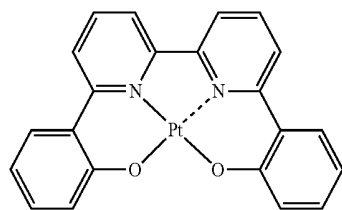
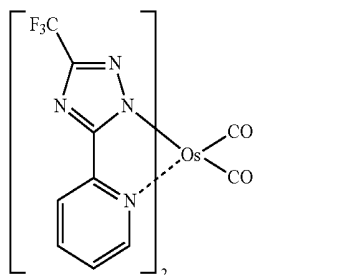
PD4



PD5

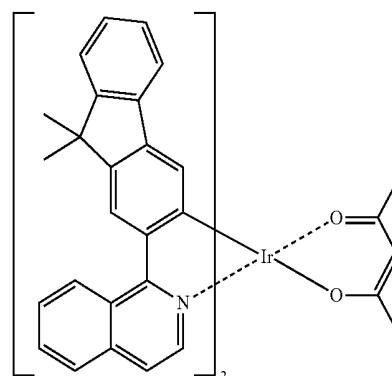


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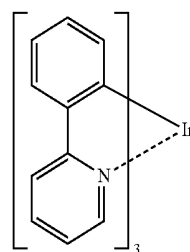
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PD6



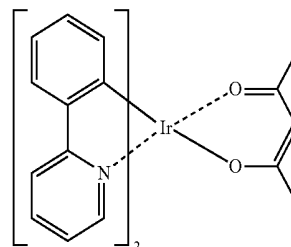
PD12

PD7



PD13

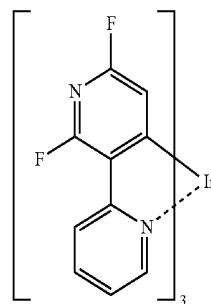
PD8



PD14

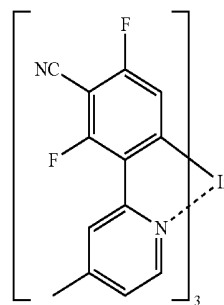
PD9

PD10



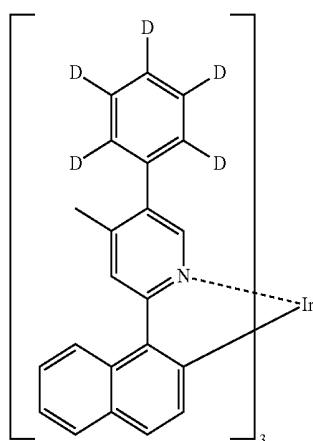
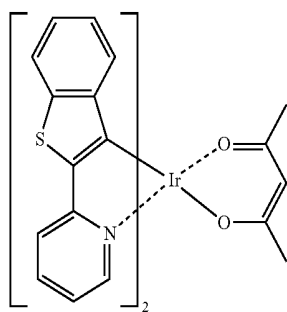
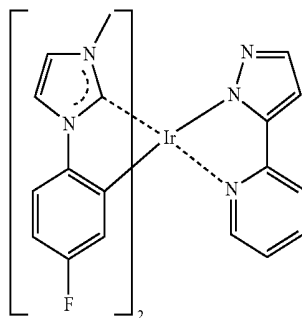
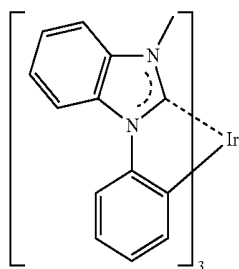
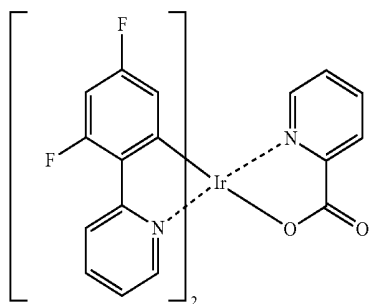
PD15

PD11



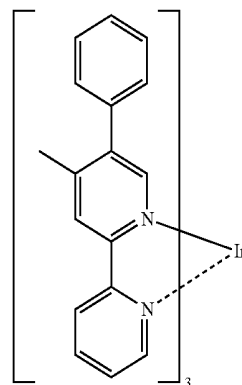
PD16

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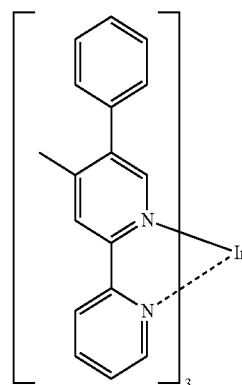
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PD17



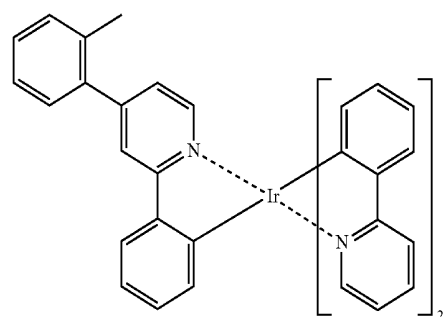
PD22

PD18



PD23

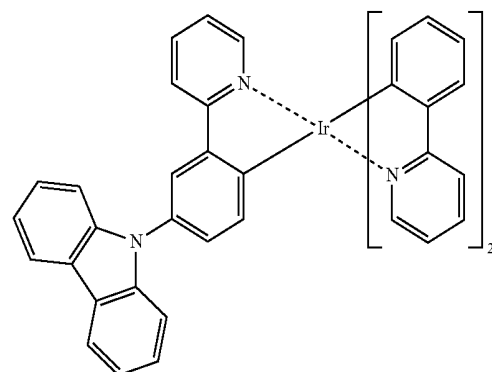
PD19



PD24

PD20

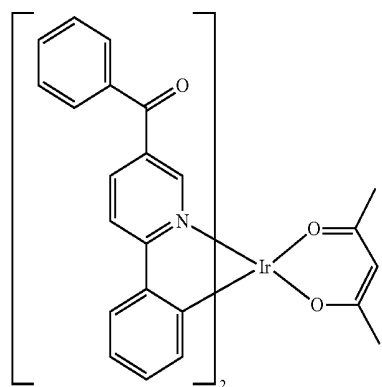
PD21



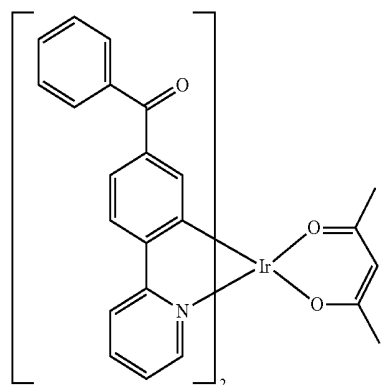
PD25

[0210] In one or more embodiments, the phosphorescent dopant may include one of Compounds 2-1 to 2-28, but embodiments of the present disclosure are not limited thereto (Compound 2-4 is identical to Compound PD9,

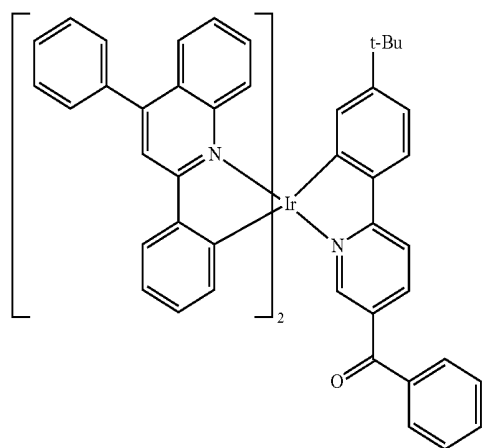
Compounds 2-10 and 2-15 are each identical to Compound PD20, and Compound 2-17 is identical to Compound PD11):



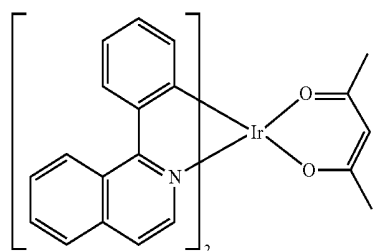
2-1



2-2

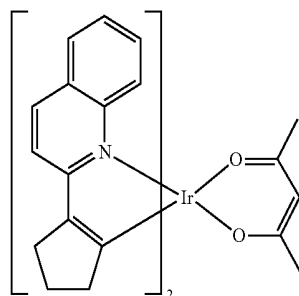


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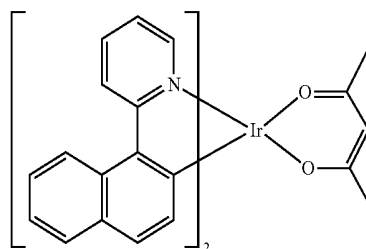


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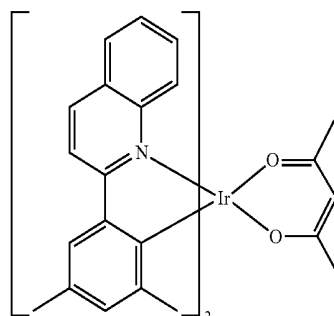
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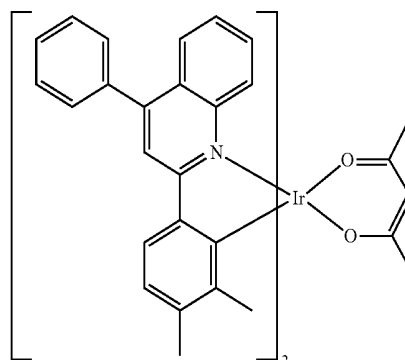
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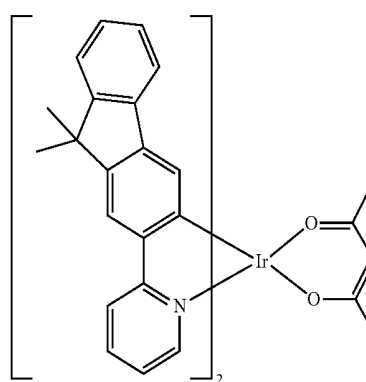
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2-7

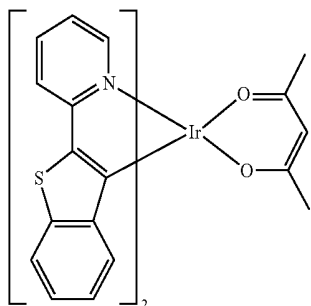


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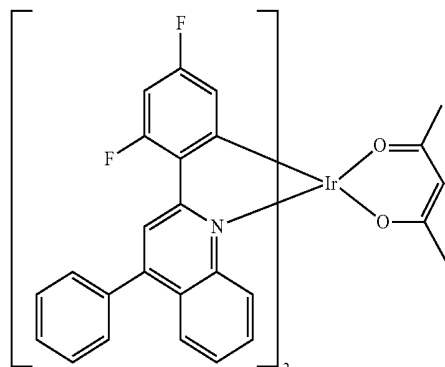
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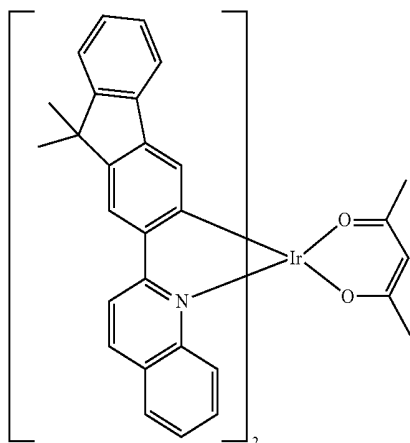


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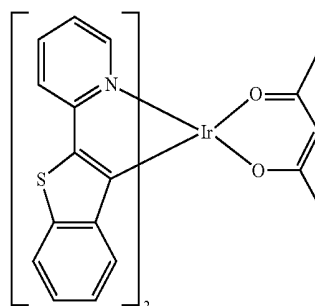
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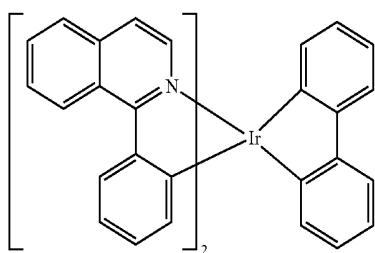
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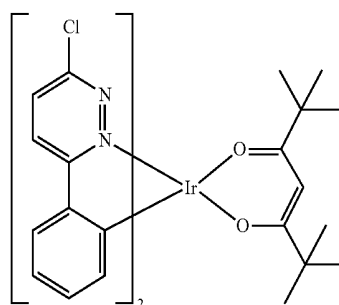
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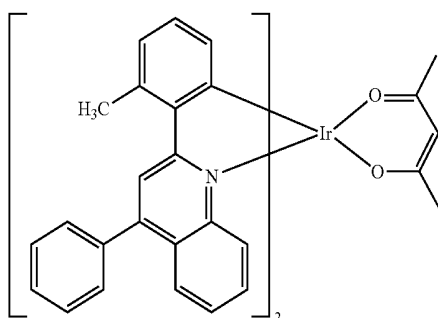
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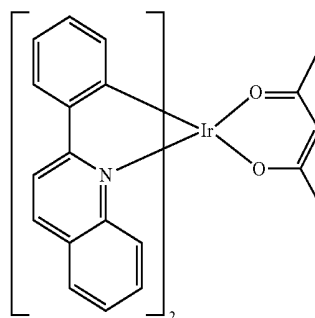
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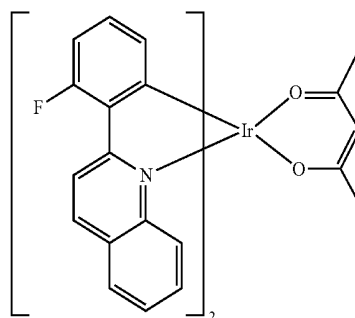
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2-13

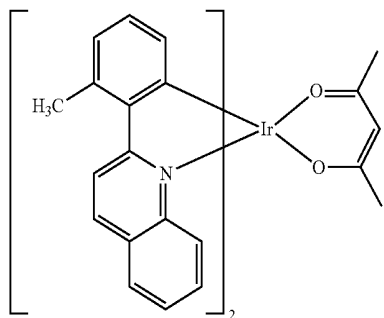


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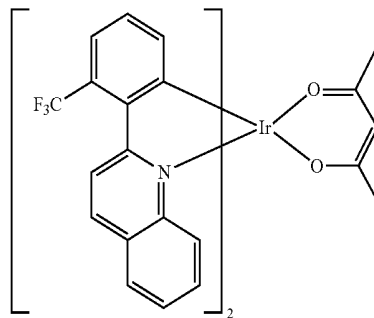
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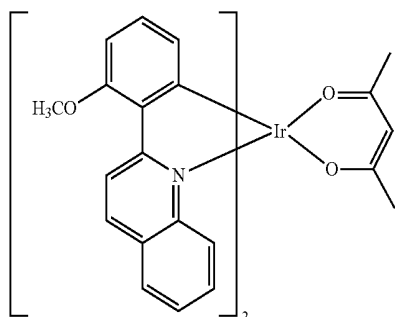


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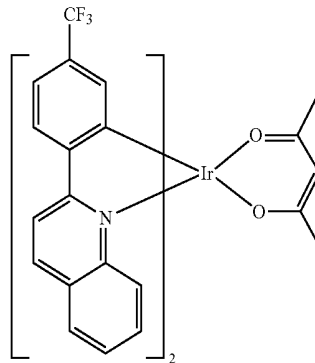
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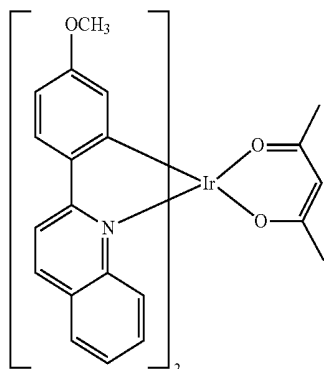
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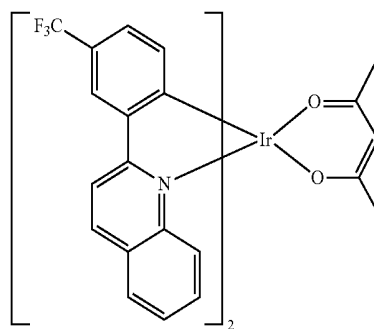
2-20



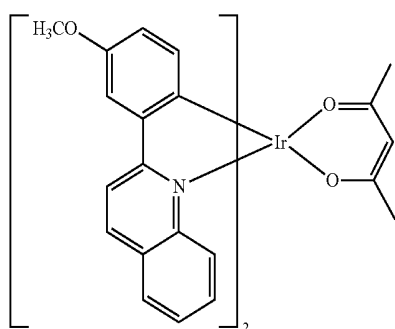
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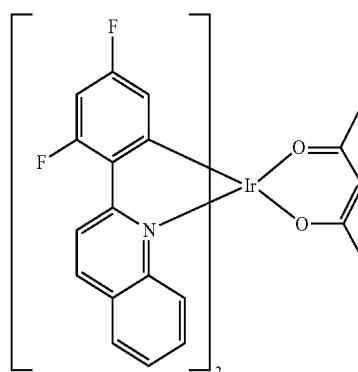
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2-25

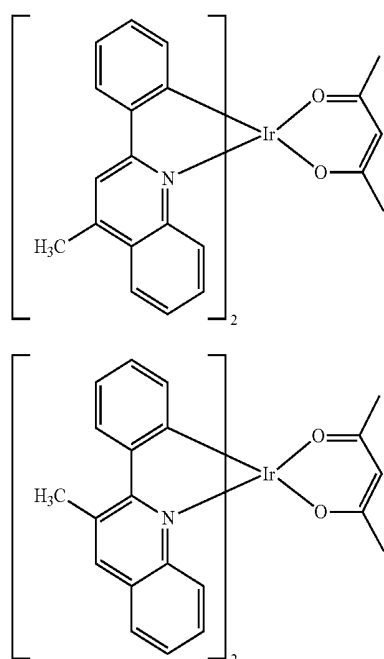


2-22



2-26

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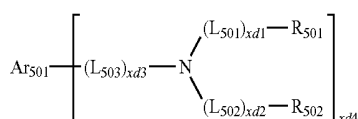
2-27

2-28

[Fluorescent Dopant in Emission Layer]

[0211] The fluorescent dopant may include an arylamine compound or a styrylamine compound.

[0212] The fluorescent dopant may include a compound represented by Formula 501 below.



<Formula 501>

[0213] In Formula 501,

[0214] Ar₅₀₁ may be a substituted or unsubstituted C₅-C₆₀ carbocyclic group or a substituted or unsubstituted C₁-C₆₀ heterocyclic group,

[0215] L₅₀₁ to L₅₀₃ may each independently be selected from a substituted or unsubstituted C₃-C₁₀ cycloalkylene group, a substituted or unsubstituted heterocycloalkylene group, a substituted or unsubstituted C₃-C₁₀ cycloalkenylene group, a substituted or unsubstituted heterocycloalkenylene group, a substituted or unsubstituted C₆-C₆₀ arylene group, a substituted or unsubstituted C₁-C₆₀ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group,

[0216] xd1 to xd3 may each independently be an integer between 0 and 3, inclusive;

[0217] R₅₀₁ and R₅₀₂ may each independently be selected from a substituted or unsubstituted C₃-C₁₀ cycloalkyl group, a substituted or unsubstituted C₁-C₁₀ heterocycloalkyl group, a substituted or unsubstituted C₃-C₁₀ cycloalkenyl group, a substituted or unsubstituted heterocycloalkenyl

group, a substituted or unsubstituted C₆-C₆₀ aryl group, a substituted or unsubstituted C₆-C₆₀ aryloxy group, a substituted or unsubstituted C₆-C₆₀ arylthio group, a substituted or unsubstituted C₁-C₆₀ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, and

[0218] xd4 may be an integer of 1 to 6.

[0219] In one or more embodiments, Ar₅₀₁ in Formula 501 may be selected from:

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

[0221] a naphthalene group, a heptalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, a naphthacene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, and an indenophenanthrene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0222] In one or more embodiments, L₅₀₁ to L₅₀₃ in Formula 501 may each independently be selected from:

[0223] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, dibenzosilolylenylene group, and a pyridinylenylene group; and

[0224] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylenylene group, a pentacenylenylene group, a thiophenylenylene group, a furanylenylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, dibenzosilolylenylene group, and a pyridinylenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naph-

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

[0225] In one or more embodiments, R_{501} and R_{501} in Formula 502 may each independently be selected from:

[0226] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group;

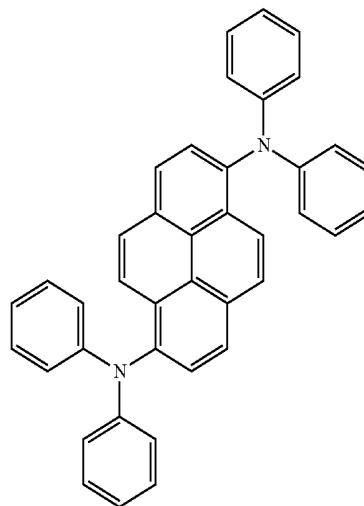
[0227] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, and a pyridinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a pyridinyl group, and —Si(Q_{31})(Q_{32})(Q_{33}), and

[0228] Q_{31} to Q_{33} may each be selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

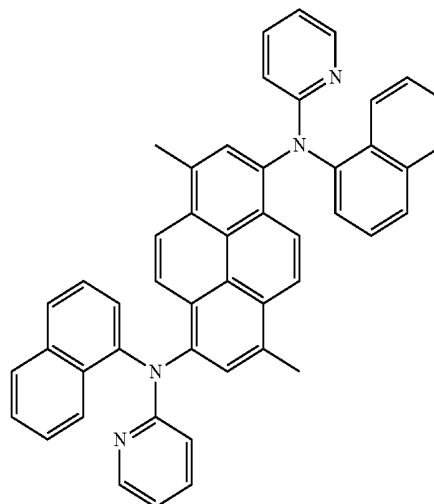
[0229] In one or more embodiments, $xd4$ in Formula 501 may be 2, but embodiments of the present disclosure are not limited thereto.

[0230] For example, the fluorescent dopant may be selected from Compounds FD1 to FD22:

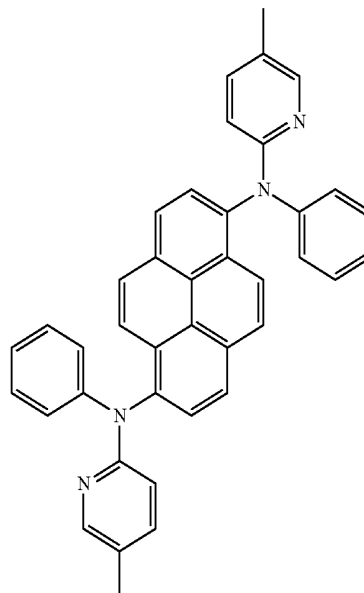
FD1



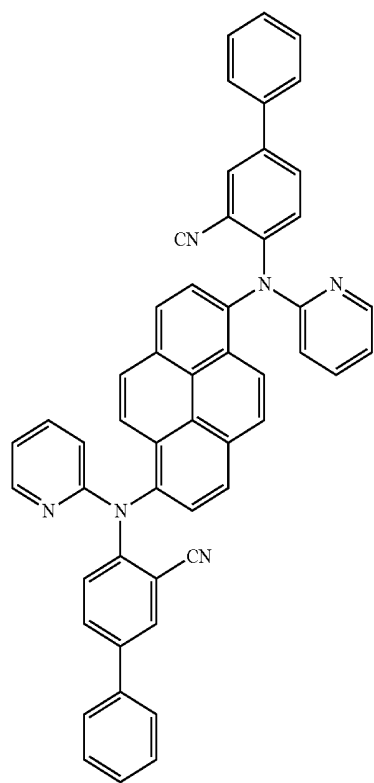
FD2



FD3

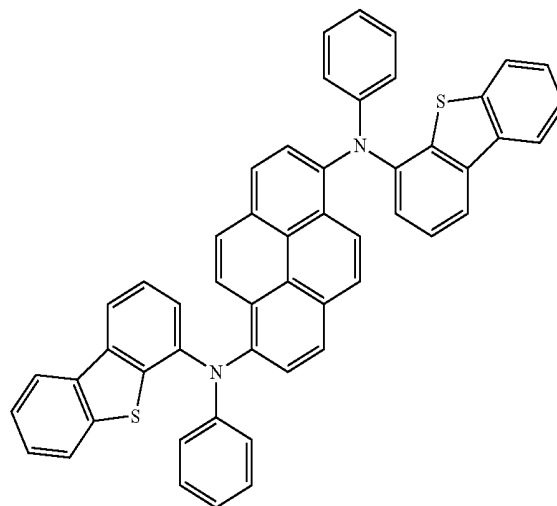


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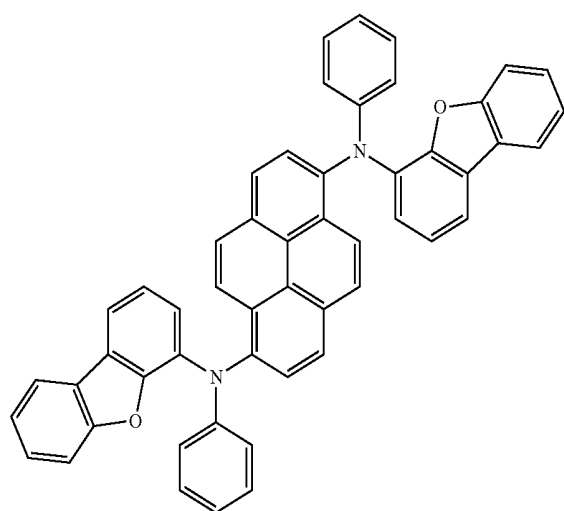


FD4

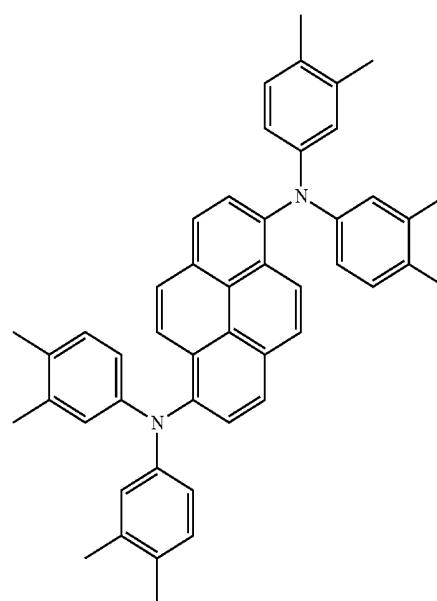
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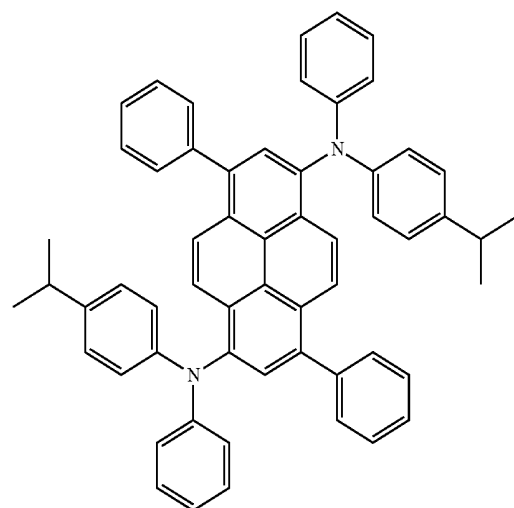
FD6



FD5



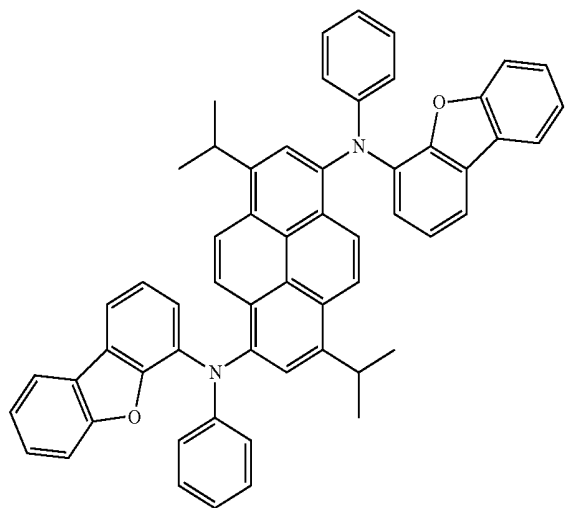
FD7



FD8

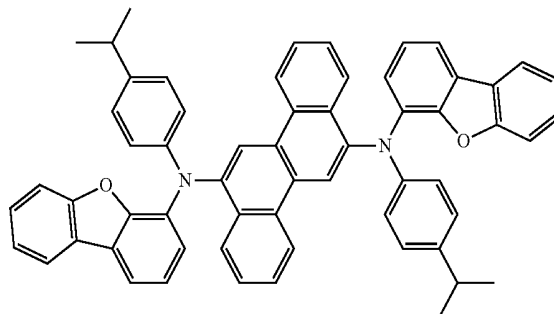
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FD9

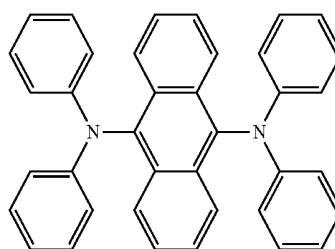


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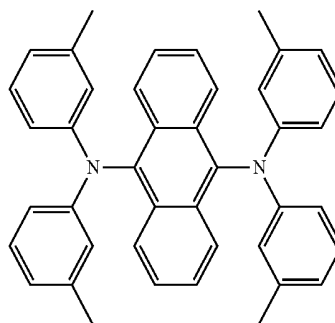
FD13



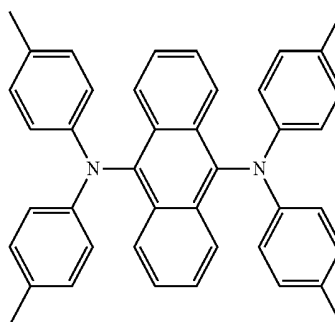
FD14



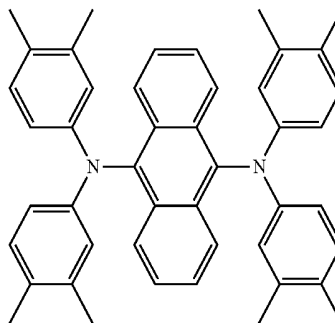
FD15



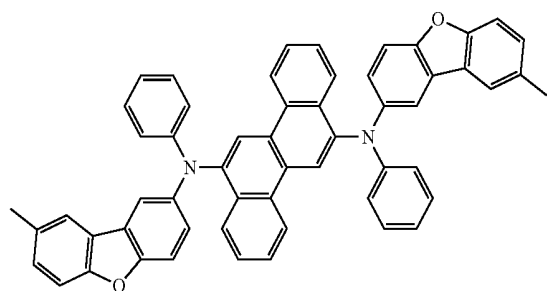
FD16



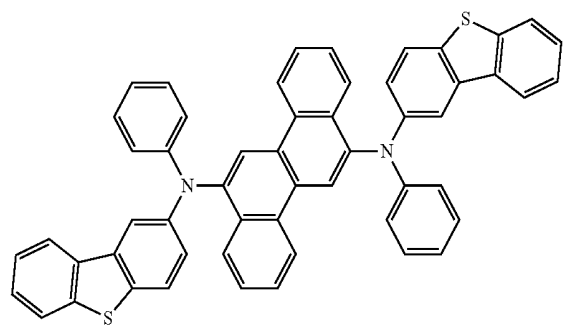
FD17



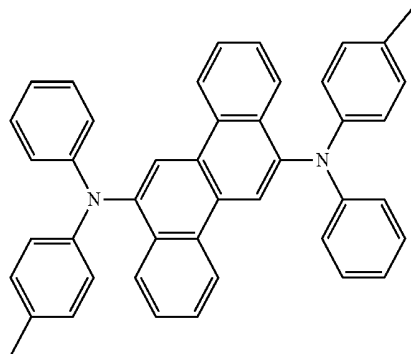
FD10



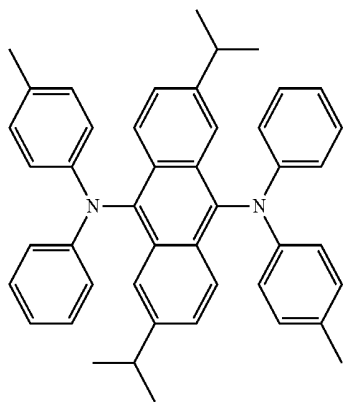
FD11



FD12

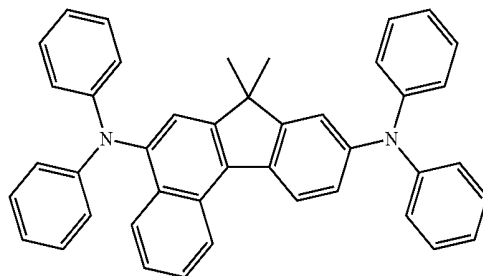


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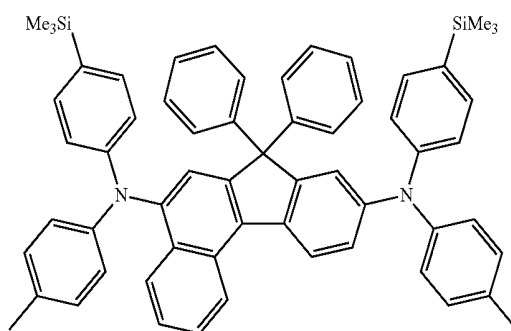
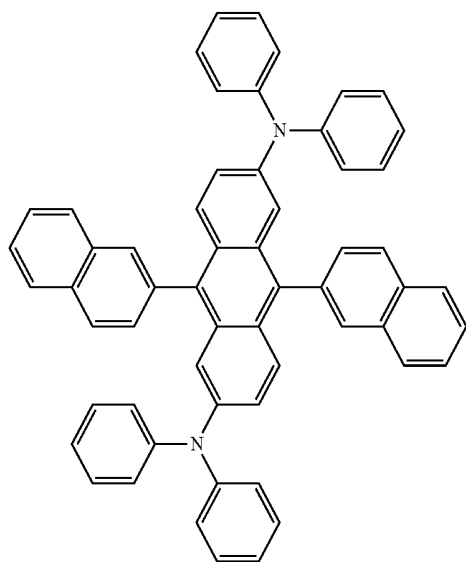
FD18

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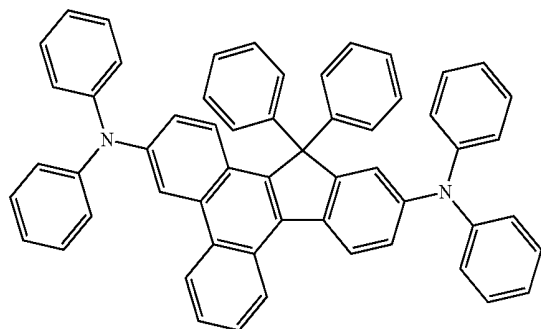
FD20

FD19

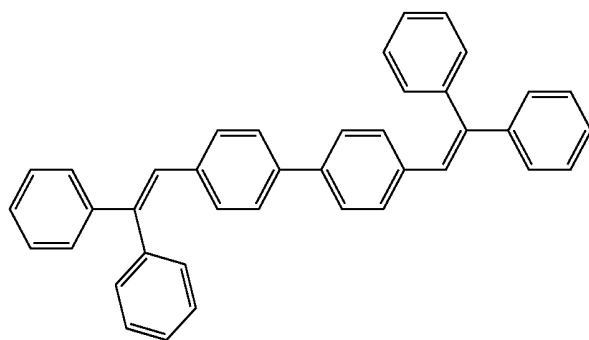


FD21

FD22

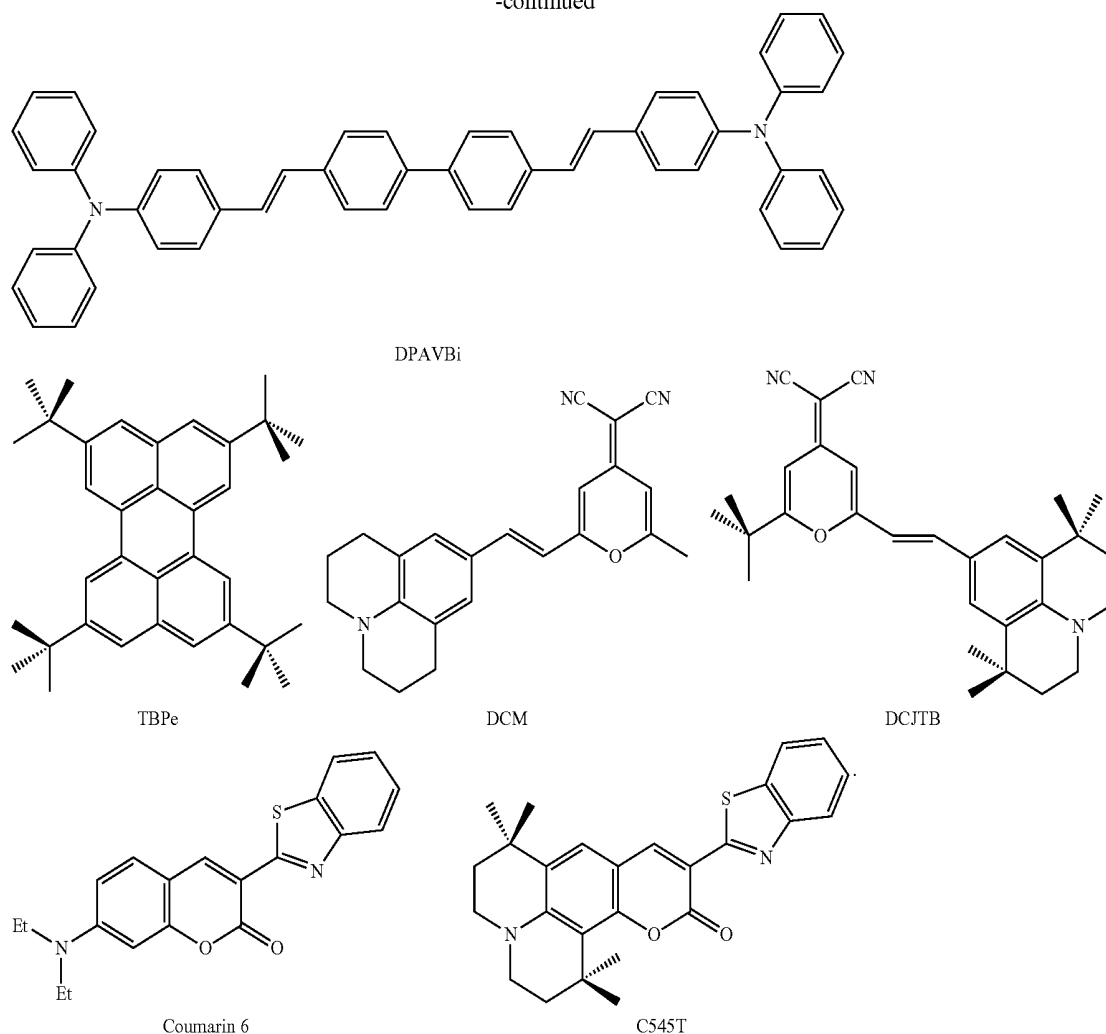


[0231] In one or more embodiments, the fluorescent dopant may be selected from the following compounds, but embodiments of the present disclosure are not limited thereto.



DPVBi

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[Electron Transport Region in Organic Layer 150]

[0232] The electron transport region may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

[0233] The electron transport region may include at least one selected from a buffer layer, a hole blocking layer, an electron control layer, an electron transport layer, and an electron injection layer, but embodiments of the present disclosure are not limited thereto.

[0234] For example, the electron transport region may have an electron transport layer/electron injection layer structure, a hole blocking layer/electron transport layer/electron injection layer structure, an electron control layer/electron transport layer/electron injection layer structure, or a buffer layer/electron transport layer/electron injection layer structure, wherein for each structure, constituting layers are sequentially stacked on an emission layer. However, embodiments of the structure of the electron transport region are not limited thereto.

[0235] The electron transport region (for example, a buffer layer, a hole blocking layer, an electron control layer, or an

electron transport layer in the electron transport region) may include a metal-free compound containing at least one π electron-depleted nitrogen-containing ring.

[0236] The “ π electron-depleted nitrogen-containing ring” indicates a C_1 - C_{60} heterocyclic group having at least one $*-N=*$ moiety as a ring-forming moiety.

[0237] For example, the “ π electron-depleted nitrogen-containing ring” may be i) a 5-membered to 7-membered heteromonocyclic group having at least one $*-N=*$ moiety, ii) a heteropolycyclic group in which two or more 5-membered to 7-membered heteromonocyclic groups each having at least one $*-N=*$ moiety are condensed with each other, or iii) a heteropolycyclic group in which at least one of 5-membered to 7-membered heteromonocyclic groups, each having at least one $*-N=*$ moiety, is condensed with at least one C_5 - C_{60} carbocyclic group.

[0238] Examples of the π electron-depleted nitrogen-containing ring include an imidazole, a pyrazole, a thiazole, an isothiazole, an oxazole, an isoxazole, a pyridine, a pyrazine, a pyrimidine, a pyridazine, an indazole, a purine, a quinoline, an isoquinoline, a benzoquinoline, a phthalazine, a naphthyridine, a quinoxaline, a quinazoline, a cinnoline, a phenanthridine, an acridine, a phenanthroline, a phenazine, a benzimidazole, an isobenzothiazole, a benzoxazole, an

isobenzoxazole, a triazole, a tetrazole, an oxadiazole, a triazine, thiadiazol, an imidazopyridine, an imidazopyrimidine, and an azacarbazole, but are not limited thereto.

[0239] For example, the electron transport region may include a compound represented by Formula 601:



[0240] In Formula 601,

[0241] Ar_{601} may be a substituted or unsubstituted $\text{C}_5\text{-C}_{60}$ carbocyclic group or a substituted or unsubstituted $\text{C}_1\text{-C}_{60}$ heterocyclic group,

[0242] xe11 may be 1, 2, or 3,

[0243] L_{601} may be selected from a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkylene group, a substituted or unsubstituted $\text{C}_1\text{-C}_{10}$ heterocycloalkylene group, a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkenylene group, a substituted or unsubstituted $\text{C}_1\text{-C}_{10}$ heterocycloalkenylene group, a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ arylene group, a substituted or unsubstituted $\text{C}_1\text{-C}_{60}$ heteroarylene group, a substituted or unsubstituted divalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted divalent non-aromatic condensed heteropolycyclic group;

[0244] xe1 may be an integer between 0 and 5, inclusive,

[0245] R_{601} may be selected from a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkyl group, a substituted or unsubstituted $\text{C}_1\text{-C}_{10}$ heterocycloalkyl group, a substituted or unsubstituted $\text{C}_3\text{-C}_{10}$ cycloalkenyl group, a substituted or unsubstituted heterocycloalkenyl group, a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ aryl group, a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ aryloxy group, a substituted or unsubstituted $\text{C}_6\text{-C}_{60}$ arylthio group, a substituted or unsubstituted $\text{C}_1\text{-C}_{60}$ heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-\text{Si}(\text{Q}_{601})(\text{Q}_{602})(\text{Q}_{603})$, $-\text{C}(=\text{O})(\text{Q}_{601})$, $-\text{S}(=\text{O})_2(\text{Q}_{601})$, and $-\text{P}(=\text{O})(\text{Q}_{601})(\text{Q}_{602})$,

[0246] Q_{601} to Q_{603} may each independently be a $\text{C}_1\text{-C}_{10}$ alkyl group, a $\text{C}_1\text{-C}_{10}$ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group, and

[0247] xe21 may be an integer between 1 and 5. Inclusive,

[0248] In one or more embodiments, at least one of $\text{Ar}_{601}(\text{s})$ in the number of xe11 and/or at least one of $\text{R}_{601}(\text{s})$ in the number of xe21 may include the π electron-depleted nitrogen-containing ring.

[0249] In one or more embodiments, ring Ar_{601} in Formula 601 may be selected from:

[0250] a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, naphthalene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, an iso-benzothiazole group, a benzoxazole group, an isobenzoxazole group,

a triazole group, a tetrazole group, an oxadiazole group, a triazine group, thiadiazol group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group; and

[0251] a benzene group, a naphthalene group, a fluorene group, a spiro-bifluorene group, a benzofluorene group, a dibenzofluorene group, a phenalene group, a phenanthrene group, an anthracene group, a fluoranthene group, a triphenylene group, a pyrene group, a chrysene group, naphthalene group, a picene group, a perylene group, a pentaphene group, an indenoanthracene group, a dibenzofuran group, a dibenzothiophene group, a carbazole group, an imidazole group, a pyrazole group, a thiazole group, an isothiazole group, an oxazole group, an isoxazole group, a pyridine group, a pyrazine group, a pyrimidine group, a pyridazine group, an indazole group, a purine group, a quinoline group, an isoquinoline group, a benzoquinoline group, a phthalazine group, naphthyridine group, a quinoxaline group, a quinazoline group, a cinnoline group, a phenanthridine group, an acridine group, a phenanthroline group, a phenazine group, a benzimidazole group, an iso-benzothiazole group, a benzoxazole group, an isobenzoxazole group, a triazole group, a tetrazole group, an oxadiazole group, a triazine group, thiadiazol group, an imidazopyridine group, an imidazopyrimidine group, and an azacarbazole group, each substituted with at least one selected from deuterium, $-\text{F}$, $-\text{Cl}$, $-\text{Br}$, $-\text{I}$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a $\text{C}_1\text{-C}_{20}$ alkyl group, a $\text{C}_1\text{-C}_{20}$ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$, $-\text{S}(=\text{O})_2(\text{Q}_{31})$, and $-\text{P}(=\text{O})(\text{Q}_{31})(\text{Q}_{32})$,

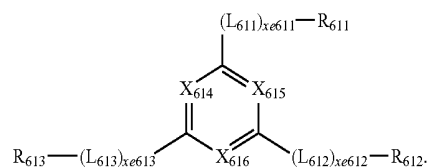
[0252] wherein Q_{31} to Q_{33} may each independently be selected from a $\text{C}_1\text{-C}_{10}$ alkyl group, a $\text{C}_1\text{-C}_{10}$ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0253] When xe11 in Formula 601 is two or more, two or more $\text{Ar}_{601}(\text{s})$ may be linked to each other via a single bond.

[0254] In one or more embodiments, Ar_{601} in Formula 601 may be an anthracene group.

[0255] In one or more embodiments, a compound represented by Formula 601 may be represented by Formula 601-1:

<Formula 601-1>



[0256] In Formula 601-1,

[0257] X_{614} may be N or C(R_{614}), X_{615} may be N or C(R_{615}), X_{616} may be N or C(R_{616}), and at least one selected from X_{614} to X_{616} may be N,

[0258] L_{611} to L_{613} may each independently be the same as described in connection with L_{601} ,

[0259] xe611 to xe613 may each independently be the same as described in connection with xe1 ,

[0260] R_{611} to R_{613} may each independently be the same as described in connection with R_{601} ,

[0261] R_{614} to R_{616} may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

[0262] In one or more embodiments, L_{601} and L_{611} to L_{613} in Formulae 601 and 601-1 may each independently be selected from:

[0263] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a thiophenylenylene group, a furanylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, a pyridinylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a thiadiazolylenylene group, an oxadiazolylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a triazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzimidazolylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an imidazopyridinylenylene group, an imidazopyrimidinylenylene group, and an azacarbazolylenylene group;

[0264] a phenylene group, a naphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenanthrenylene group, an anthracenylenylene group, a fluoranthenylenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a perylenylene group, a pentaphenylenylene group, a hexacenylene group, a pentacenylene group, a thiophenylenylene group, a furanylene group, a carbazolylenylene group, an indolylenylene group, an isoindolylenylene group, a benzofuranylenylene group, a benzothiophenylenylene group, a dibenzofuranylenylene group, a dibenzothiophenylenylene group, a benzocarbazolylenylene group, a dibenzocarbazolylenylene group, a dibenzosilolylenylene group, a pyridinylenylene group, an imidazolylenylene group, a pyrazolylenylene group, a thiazolylenylene group, an isothiazolylenylene group, an oxazolylenylene group, an isoxazolylenylene group, a thiadiazolylenylene group, an oxadiazolylenylene group, a pyrazinylenylene group, a pyrimidinylenylene group, a pyridazinylenylene group, a triazinylenylene group, a quinolinylenylene group, an isoquinolinylenylene group, a benzoquinolinylenylene group, a phthalazinylenylene group, a naphthyridinylenylene group, a quinoxalinylenylene group, a quinazolinylenylene group, a cinnolinylenylene group, a phenanthridinylenylene group, an acridinylenylene group, a phenanthrolinylenylene group, a phenazinylenylene group, a benzimidazolylenylene group, an isobenzothiazolylenylene group, a benzoxazolylenylene group, an isobenzoxazolylenylene group, a triazolylenylene group, a tetrazolylenylene group, an imidazopyridinylenylene group, an imidazopyrimidinylenylene group, and an

azacarbazolylenylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a phthalazinyl group, a naphthyridinyl group, a quinoxaliny group, a quinazoliny group, a cinnoliny group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, but are not limited thereto,

[0265] but embodiments of the present disclosure are not limited thereto.

[0266] In one or more embodiments, $xe1$ and $xe611$ to $xe613$ in Formulae 601 and 601-1 may each independently be 0, 1, or 2.

[0267] In one or more embodiments, R_{601} and R_{611} to R_{613} in Formula 601 and 601-1 may each independently be selected from:

[0268] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinoliny group, an isoquinoliny group, a benzoquinoliny group, a phthalazinyl group, a naphthyridinyl group, a quinoxaliny group, a quinazoliny group, a cinnoliny group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetra-

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

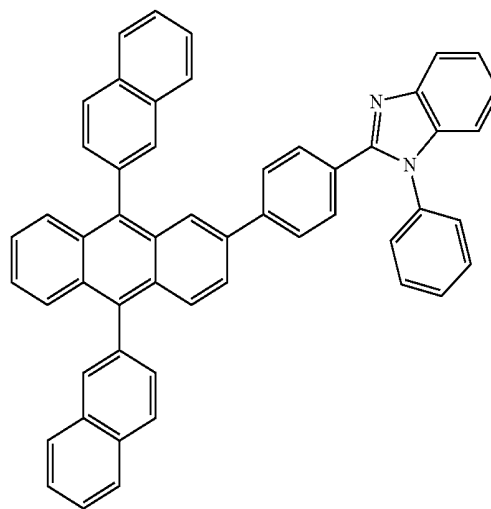
[0269] a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthrenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a thiophenyl group, a furanyl group, a carbazolyl group, an indolyl group, an isoindolyl group, a benzofuranyl group, a benzothiophenyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a pyridinyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a thiadiazolyl group, an oxadiazolyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, and an azacarbazolyl group;

[0270] —S(=O)₂(Q₆₀₁), and —P(=O)(Q₆₀₁)(Q₆₀₂); and

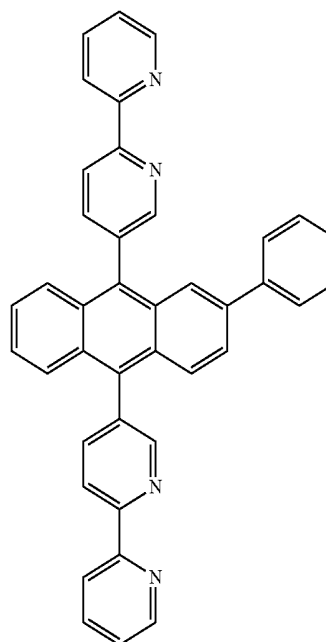
[0271] Q₆₀₁ and Q₆₀₂ may be the same as described above

[0272] The electron transport region may include at least one compound selected from Compounds ET1 to ET36, but embodiments of the present disclosure are not limited thereto:

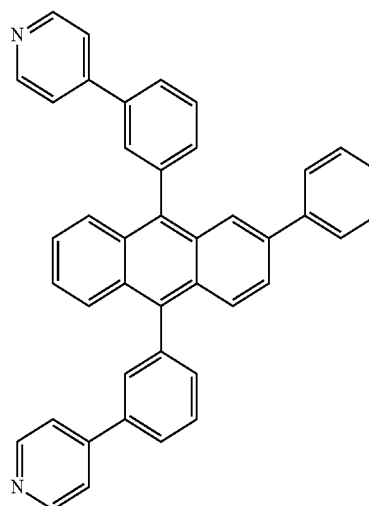
ET1



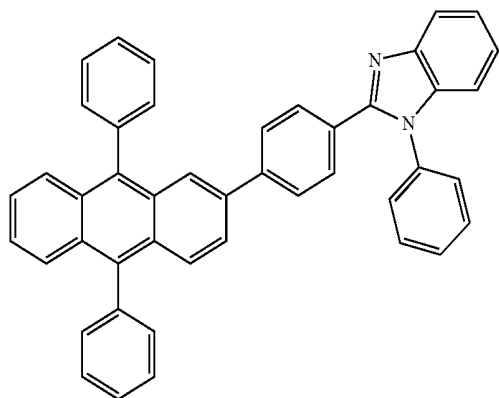
ET2



ET3

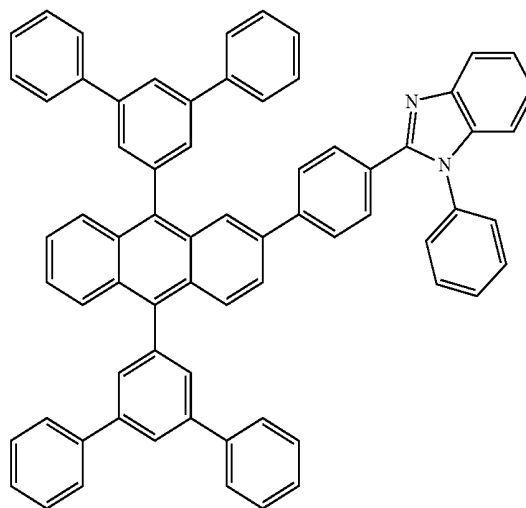


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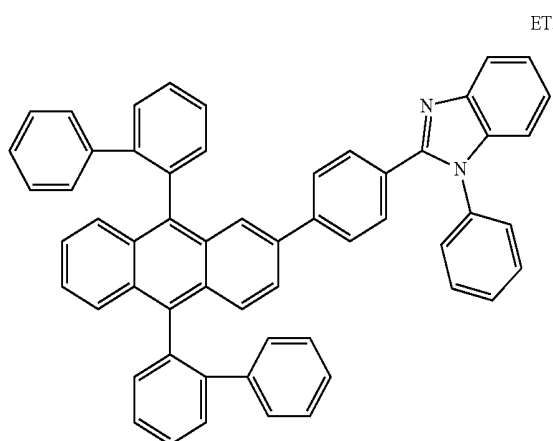


ET4

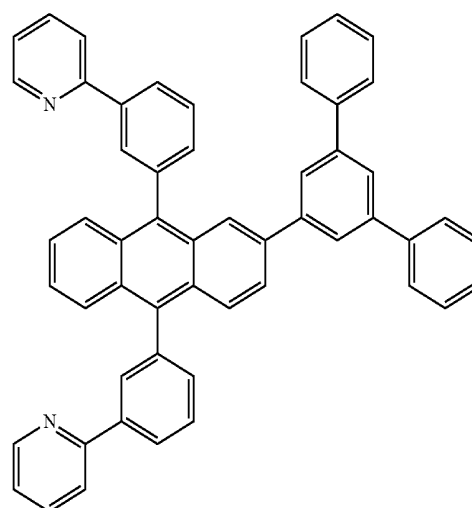
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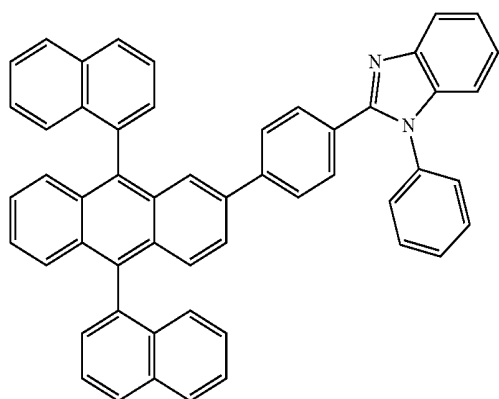
ET7



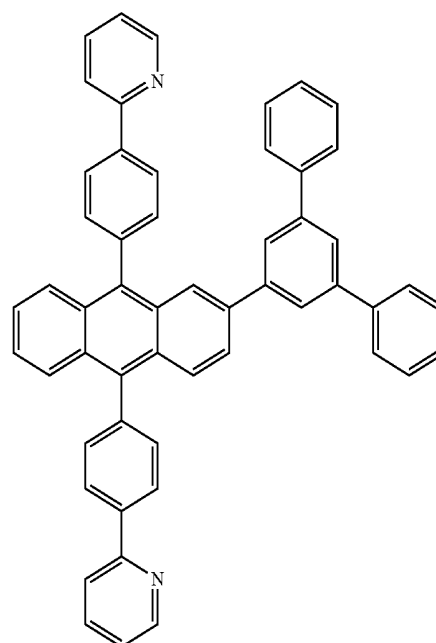
ET5



ET8



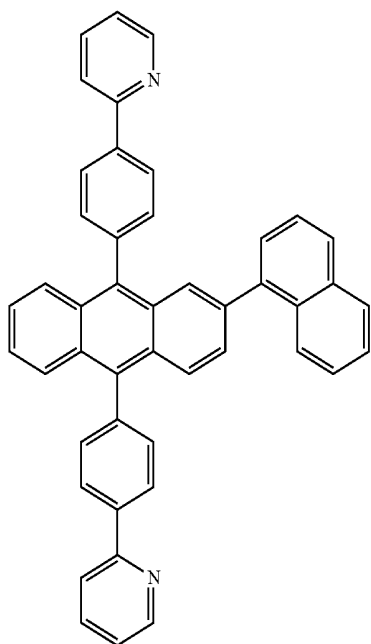
ET6



ET9

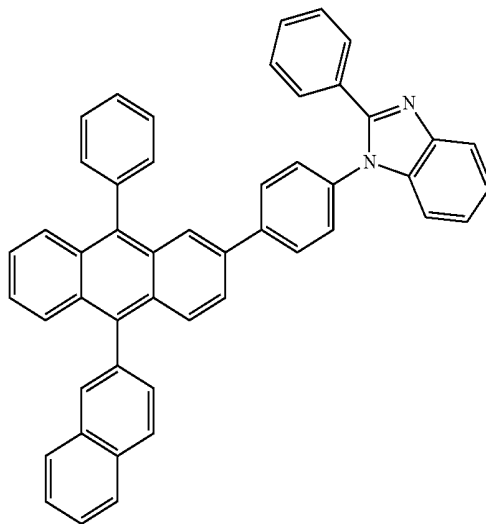
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ET10

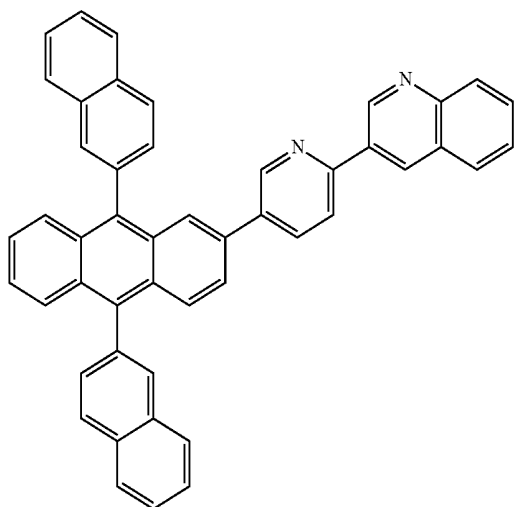


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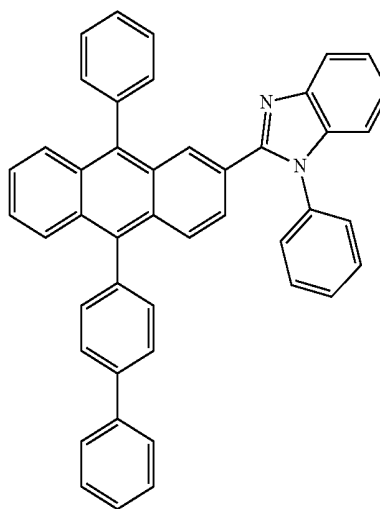
ET13



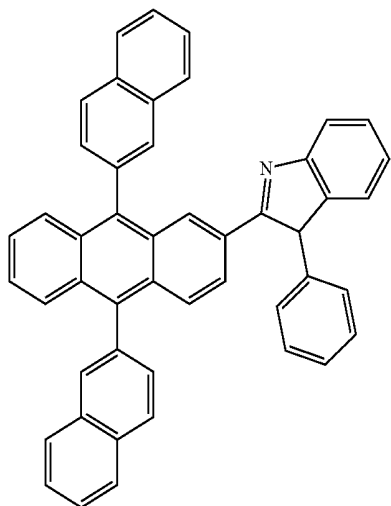
ET11



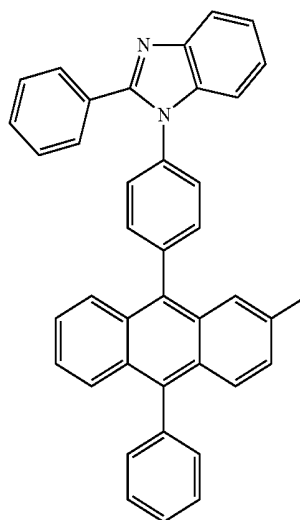
ET14



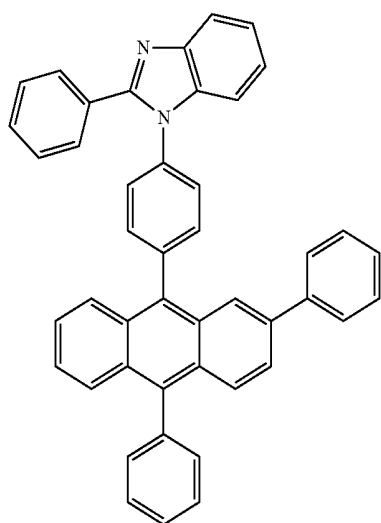
ET12



ET15

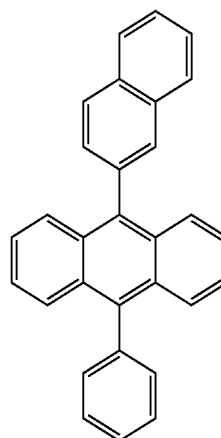


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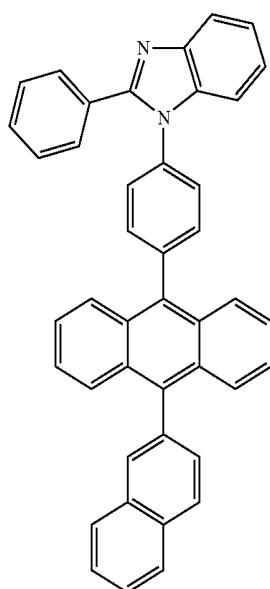
ET16

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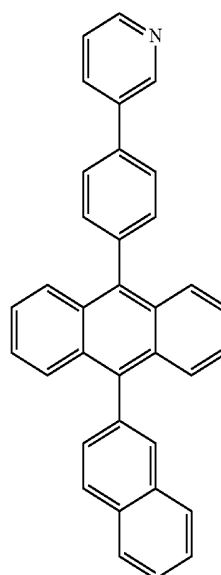


ET19

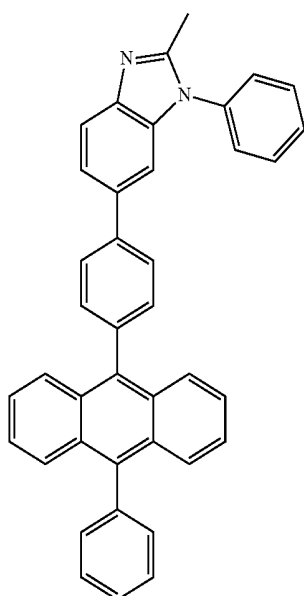
ET17



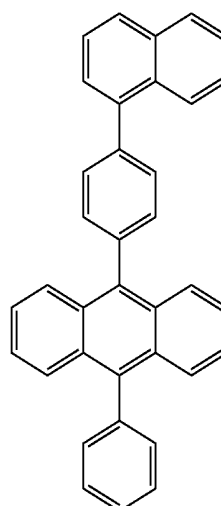
ET20



ET18

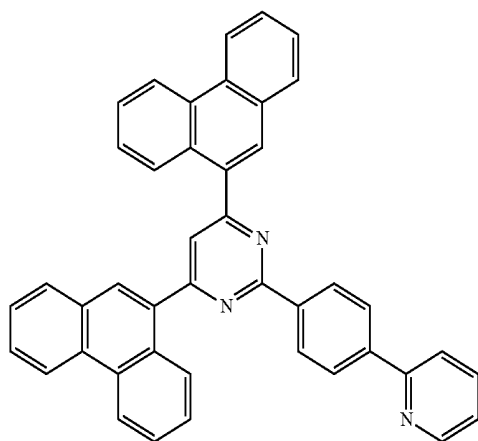


ET21



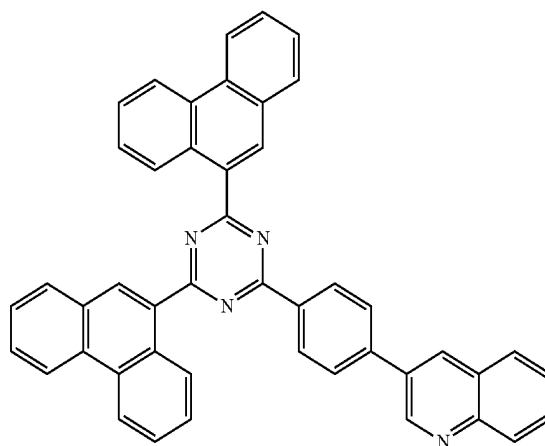
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ET22

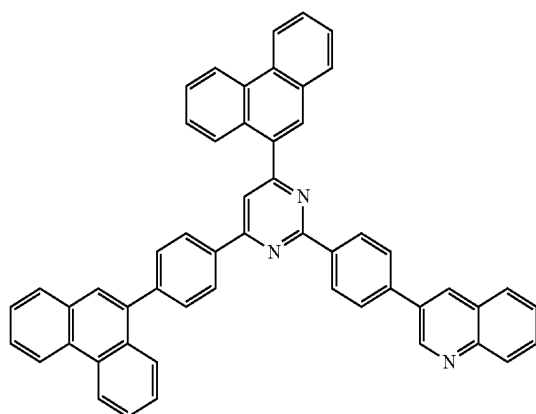


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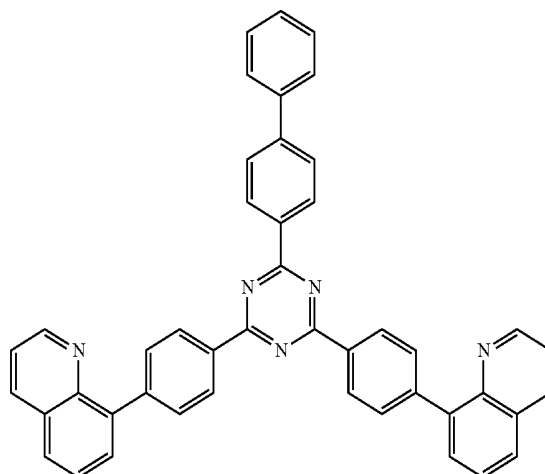
ET25



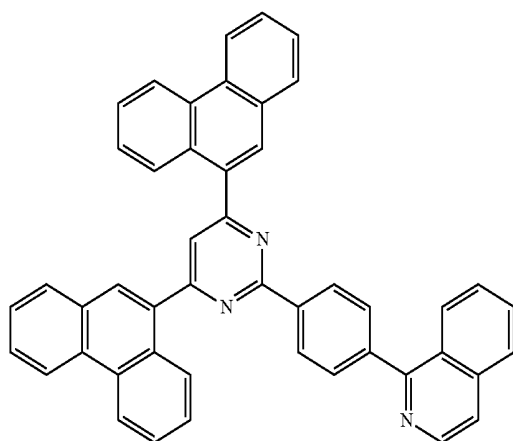
ET23



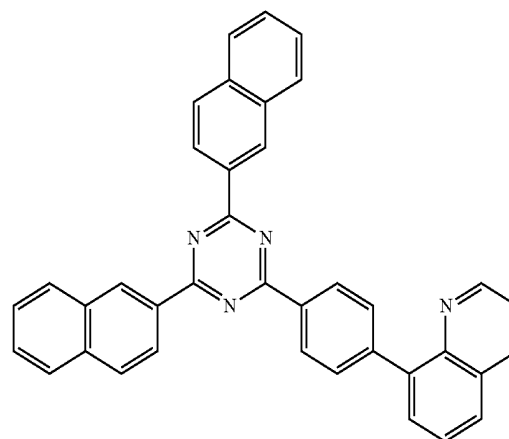
ET26



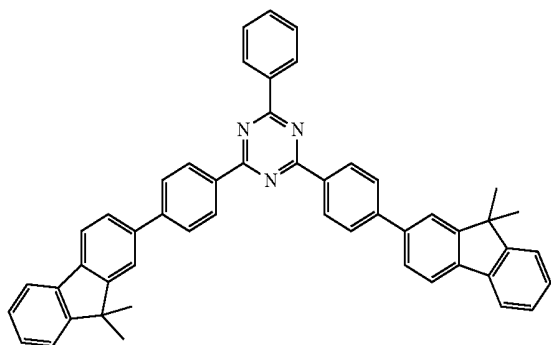
ET24



ET27

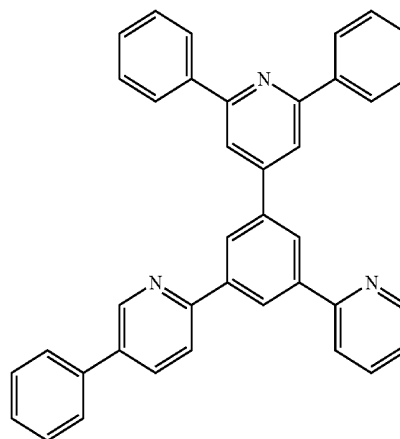


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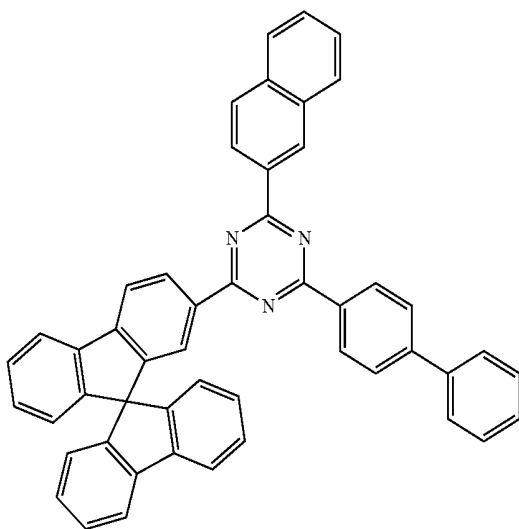
ET28

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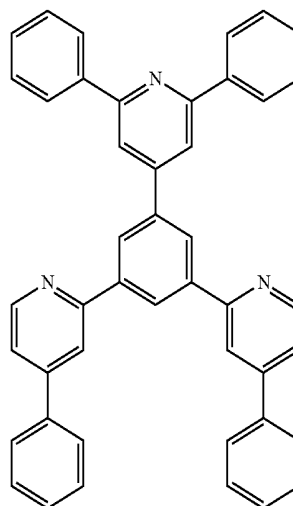


ET31

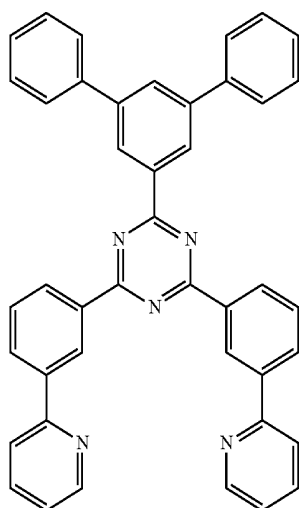
ET29



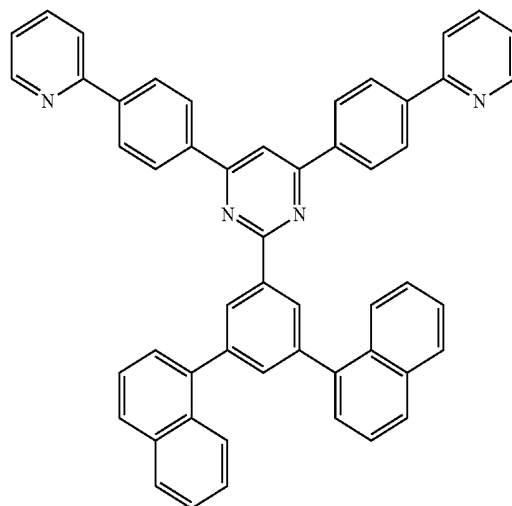
ET32



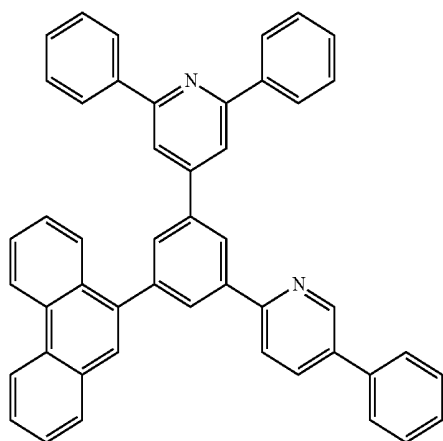
ET30



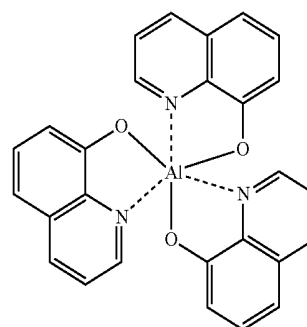
ET33



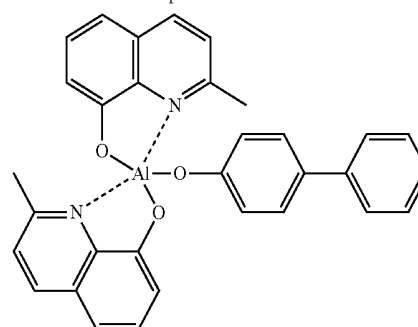
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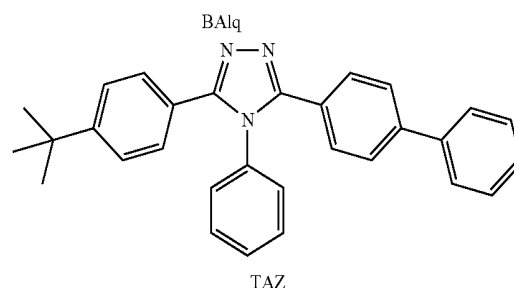
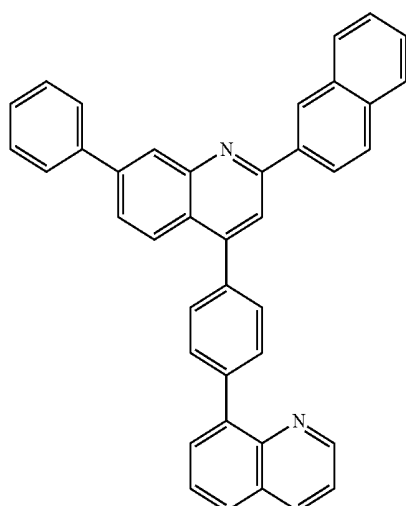
ET34



Alq3

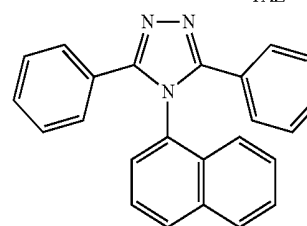


ET35



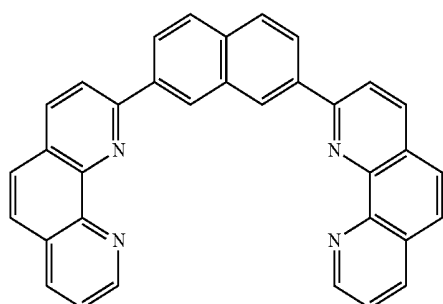
BAlq

TAZ



NTAZ

ET36



[0273] In one or more embodiments, the electron transport region may include at least one selected from 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), Alq₃, BAlq, 3-(biphenyl-4-yl)-5-(4-tert-butylphenyl)-4-phenyl-4H-1,2,4-triazole (TAZ), and NTAZ.

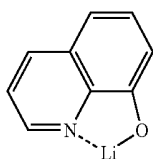
[0274] The thickness of the buffer layer, the hole blocking layer, or the electron controlling layer may each independently be in a range of about 20 Å to about 1,000 Å, for example, about 30 Å to about 300 Å. When the thicknesses of the buffer layer, the hole blocking layer, and the electron control layer are within these ranges, the electron blocking layer may have excellent electron blocking characteristics or electron control characteristics without a substantial increase in driving voltage.

[0275] A thickness of the electron transport layer may be in a range of about 100 Å to about 1,000 Å, for example, about 150 Å to about 500 Å. When the thickness of the electron transport layer is within the range described above, the electron transport layer may have satisfactory electron transport characteristics without a substantial increase in driving voltage.

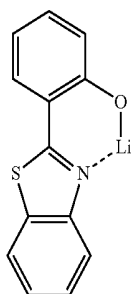
[0276] The electron transport region (for example, the electron transport layer in the electron transport region) may further include, in addition to the materials described above, a metal-containing material.

[0277] The metal-containing material may include at least one selected from an alkali metal complex and an alkaline earth-metal complex. The alkali metal complex may include a metal ion selected from a Li ion, a Na ion, a K ion, a Rb ion, and a Cs ion, and the alkaline earth-metal complex may include a metal ion selected from a Be ion, a Mg ion, a Ca ion, a Sr ion, and a Ba ion. A ligand coordinated with the metal ion of the alkali metal complex or the alkaline earth-metal complex may be selected from a hydroxy quinoline, a hydroxy isoquinoline, a hydroxy benzoquinoline, a hydroxy acridine, a hydroxy phenanthridine, a hydroxy phenylan oxazole, a hydroxy phenylthiazole, a hydroxy diphenylan oxadiazole, a hydroxy diphenylthiadiazol, a hydroxy phenylpyridine, a hydroxy phenylbenzimidazole, a hydroxy phenylbenzothiazole, a bipyridine, a phenanthroline, and a cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

[0278] For example, the metal-containing material may include a Li complex. The Li complex may include, for example, Compound ET-D1 (lithium quinolate, LiQ) or ET-D2.



ET-D1



ET-D2

[0279] The electron transport region may include an electron injection layer that facilitates injection of electrons from the second electrode 190. The electron injection layer may directly contact the second electrode 190.

[0280] The electron injection layer may have i) a single-layered structure including a single layer including a single material, ii) a single-layered structure including a single layer including a plurality of different materials, or iii) a multi-layered structure having a plurality of layers including a plurality of different materials.

[0281] The electron injection layer may include an alkali metal, an alkaline earth metal, a rare-earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare-earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare-earth metal complex, or any combinations thereof.

[0282] The alkali metal may be selected from Li, Na, K, Rb, and Cs. In one or more embodiments, the alkali metal

may be Li, Na, or Cs. In one or more embodiments, the alkali metal may be Li or Cs, but embodiments of the present disclosure are not limited thereto.

[0283] The alkaline earth metal may be selected from Mg, Ca, Sr, and Ba.

[0284] The rare-earth metal may be selected from Sc, Y, Ce, Tb, Yb, and Gd.

[0285] The alkali metal compound, the alkaline earth-metal compound, and the rare-earth metal compound may be selected from oxides and halides (for example, fluorides, chlorides, bromides, or iodides) of the alkali metal, the alkaline earth-metal, and the rare-earth metal.

[0286] The alkali metal compound may be selected from alkali metal oxides, such as Li_2O , Cs_2O , or K_2O , and alkali metal halides, such as LiF, NaF, CsF, KF, LiI, NaI, CsI, or KI. In one or more embodiments, the alkali metal compound may be selected from LiF, Li_2O , NaF, LiI, NaI, CsI, and KI, but embodiments of the present disclosure are not limited thereto.

[0287] The alkaline earth-metal compound may be selected from alkaline earth-metal oxides, such as BaO, SrO, CaO, $\text{Ba}_x\text{Sr}_{1-x}\text{O}$ ($0 < x < 1$), or $\text{Ba}_x\text{Ca}_{1-x}\text{O}$ ($0 < x < 1$). In one or more embodiments, the alkaline earth-metal compound may be selected from BaO, SrO, and CaO, but embodiments of the present disclosure are not limited thereto.

[0288] The rare-earth metal compound may be selected from YbF_3 , ScF_3 , ScO_3 , Y_2O_3 , Ce_2O_3 , GdF_3 , and TbF_3 . In one or more embodiments, the rare-earth metal compound may be selected from YbF_3 , ScF_3 , TbF_3 , YbI_3 , ScI_3 , and TbI_3 , but embodiments of the present disclosure are not limited thereto.

[0289] The alkali metal complex, the alkaline earth-metal complex, and the rare-earth metal complex may include an ion of alkali metal, alkaline earth-metal, and rare-earth metal as described above, and a ligand coordinated with a metal ion of the alkali metal complex, the alkaline earth-metal complex, or the rare-earth metal complex may be selected from hydroxy quinoline, hydroxy isoquinoline, hydroxy benzoquinoline, hydroxy acridine, hydroxy phenanthridine, hydroxy phenylan oxazole, hydroxy phenylthiazole, hydroxy diphenylan oxadiazole, hydroxy diphenylthiadiazol, hydroxy phenylpyridine, hydroxy phenylbenzimidazole, hydroxy phenylbenzothiazole, bipyridine, phenanthroline, and cyclopentadiene, but embodiments of the present disclosure are not limited thereto.

[0290] The electron injection layer may consist of an alkali metal, an alkaline earth metal, a rare-earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare-earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare-earth metal complex, or any combinations thereof, as described above. In one or more embodiments, the electron injection layer may further include an organic material. When the electron injection layer further includes an organic material, an alkali metal, an alkaline earth metal, a rare-earth metal, an alkali metal compound, an alkaline earth-metal compound, a rare-earth metal compound, an alkali metal complex, an alkaline earth-metal complex, a rare-earth metal complex, or any combinations thereof may be homogeneously or non-homogeneously dispersed in a matrix including the organic material.

[0291] A thickness of the electron injection layer may be in a range of about 1 Å to about 100 Å, for example, about 3 Å to about 90 Å. When the thickness of the electron

injection layer is within the range described above, the electron injection layer may have satisfactory electron injection characteristics without a substantial increase in driving voltage.

[Second Electrode 190]

[0292] The second electrode 190 may be disposed on the organic layer 150 having such a structure. The second electrode 190 may be a cathode that is an electron injection electrode, and in this regard, a material for forming the second electrode 190 may be a material having a low work function, and such a material may be metal, alloy, an electrically conductive compound, or a combination thereof.

[0293] The second electrode 190 may include at least one selected from lithium (Li), silver (Si), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), magnesium-silver (Mg—Ag), ITO, and IZO, but embodiments of the present disclosure are not limited thereto. The second electrode 190 may be a transmissive electrode, a semi-transmissive electrode, or a reflective electrode.

[0294] The second electrode 190 may have a single-layered structure, or a multi-layered structure including two or more layers.

[Description of FIGS. 2 to 4]

[0295] An organic light-emitting device 20 of FIG. 2 includes a first capping layer 210, a first electrode 110, an organic layer 150, and a second electrode 190 which are sequentially stacked in this stated order, an organic light-emitting device 30 of FIG. 3 includes a first electrode 110, an organic layer 150, a second electrode 190, and a second capping layer 220 which are sequentially stacked in this stated order, and an organic light-emitting device 40 of FIG. 4 includes a first capping layer 210, a first electrode 110, an organic layer 150, a second electrode 190, and a second capping layer 220.

[0296] Regarding FIGS. 2 to 4, the first electrode 110, the organic layer 150, and the second electrode 190 may be understood by referring to the description presented in connection with FIG. 1.

[0297] In the organic layer 150 of each of the organic light-emitting devices 20 and 40, light generated in an emission layer may pass through the first electrode 110, which is a semi-transmissive electrode or a transmissive electrode, and the first capping layer 210 toward the outside, and in the organic layer 150 of each of the organic light-emitting devices 30 and 40, light generated in an emission layer may pass through the second electrode 190, which is a semi-transmissive electrode or a transmissive electrode, and the second capping layer 220 toward the outside.

[0298] The first capping layer 210 and the second capping layer 220 may increase external luminescent efficiency according to the principle of constructive interference.

[0299] The first capping layer 210 and the second capping layer 220 may each independently be an organic capping layer including an organic material, an inorganic capping layer including an inorganic material, or a composite capping layer including an organic material and an inorganic material.

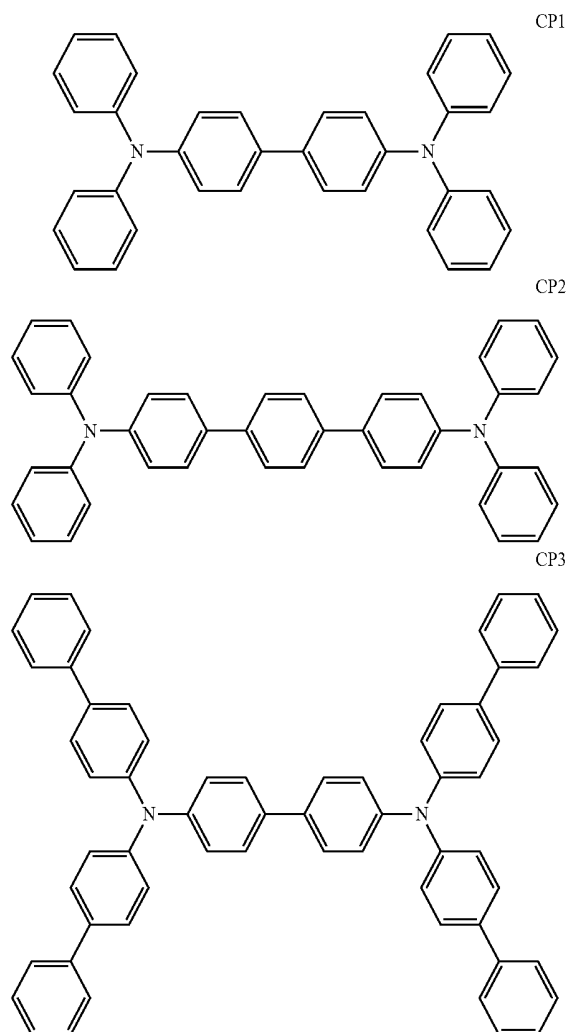
[0300] At least one selected from the first capping layer 210 and the second capping layer 220 may each independently include at least one material selected from carbocyclic compounds, heterocyclic compounds, amine-based

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

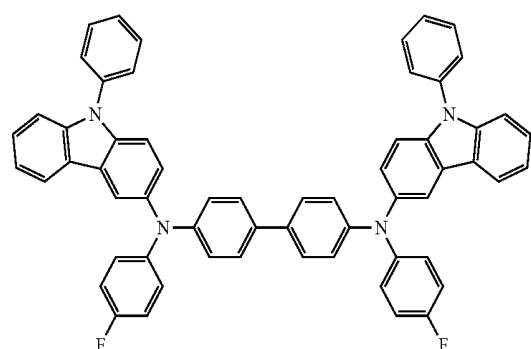
[0301] In one or more embodiments, at least one selected from the first capping layer 210 and the second capping layer 220 illustrated in FIG. 4 may include the condensed cyclic compound represented by Formula 1.

[0302] In one or more embodiments, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently include the compound represented by Formula 201 or the compound represented by Formula 202.

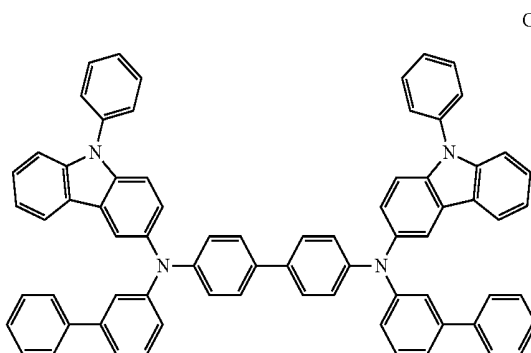
[0303] In one or more embodiments, at least one selected from the first capping layer 210 and the second capping layer 220 may each independently include a compound selected from Compounds HT28 to HT33 and Compounds CP1 to CP5, but embodiments of the present disclosure are not limited thereto.



-continued



CP4



CP5

[0304] Hereinbefore, the organic light-emitting device according to an embodiment has been described in connection with FIGS. 1-4. However, embodiments of the present disclosure are not limited thereto.

[0305] Layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region may be formed in a certain region by using one or more suitable methods selected from vacuum deposition, spin coating, casting, Langmuir-Blodgett (LB) deposition, ink-jet printing, laser-printing, and laser-induced thermal imaging.

[0306] When the respective layers of the hole transport region, the emission layer, and the respective layers of the electron transport region are formed by deposition, the deposition may be performed at a deposition temperature of about 100° C. to about 500° C., at a vacuum degree of about 10⁻⁸ torr to about 10⁻³ torr, and at a deposition rate of about 0.01 Å/sec to about 100 Å/sec by taking into account a material for forming a layer to be deposited, and the structure of a layer to be formed.

[0307] When layers constituting the hole transport region, an emission layer, and layers constituting the electron transport region are formed by spin coating, the spin coating may be performed at a coating speed of about 2,000 rpm to about 5,000 rpm and at a heat treatment temperature of about 80° C. to about 200° C., depending on a material to be included in a layer and the structure of each layer to be formed.

[General Definition of Substituents]

[0308] The term “C₁-C₆₀ alkyl group” as used herein refers to a linear or branched saturated aliphatic hydrocarbon monovalent group having 1 to 60 carbon atoms, and non-limiting examples thereof include a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, an iso-amyl group, and a

hexyl group. The term “C₁-C₆₀ alkylene group” as used herein refers to a divalent group having the same structure as the C₁-C₆₀ alkyl group.

[0309] The term “C₂-C₆₀ alkenyl group” as used herein refers to a hydrocarbon group formed by substituting at least one carbon-carbon double bond in the middle or at the terminus of the C₂-C₆₀ alkyl group, and non-limiting examples thereof include an ethenyl group, a propenyl group, and a butenyl group. The term “C₂-C₆₀ alkenylene group” as used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkenyl group.

[0310] The term “C₂-C₆₀ alkynyl group” as used herein refers to a hydrocarbon group formed by substituting at least one carbon-carbon triple bond in the middle or at the terminus of the C₂-C₆₀ alkyl group, and non-limiting examples thereof include an ethynyl group, and a propynyl group. The term “C₂-C₆₀ alkynylene group” as used herein refers to a divalent group having the same structure as the C₂-C₆₀ alkynyl group.

[0311] The term “C₁-C₆₀ alkoxy group” as used herein refers to a monovalent group represented by -OA₁₀₁ (wherein A₁₀₁ is the C₁-C₆₀ alkyl group), and non-limiting examples thereof include a methoxy group, an ethoxy group, and an isopropoxy group.

[0312] The term “C₃-C₁₀ cycloalkyl group” as used herein refers to a monovalent saturated hydrocarbon monocyclic group having 3 to 10 carbon atoms, and non-limiting examples thereof include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group. The term “C₃-C₁₀ cycloalkylene group” as used herein refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkyl group.

[0313] The term “C₁₀-C₁₀ heterocycloalkyl group” as used herein refers to a monovalent saturated monocyclic group having at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom and 1 to 10 carbon atoms, and non-limiting examples thereof include a 1,2,3,4-oxatriazolidinyl group, a tetrahydrofuran group, and a tetrahydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkylene group” as used herein refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkyl group.

[0314] The term “C₃-C₁₀ cycloalkenyl group” as used herein refers to a monovalent monocyclic group that has 3 to 10 carbon atoms and at least one carbon-carbon double bond in the ring thereof and no aromaticity, and non-limiting examples thereof include a cyclopentenyl group, a cyclohexenyl group, and a cycloheptenyl group. The term “C₃-C₁₀ cycloalkenylene group” as used herein refers to a divalent group having the same structure as the C₃-C₁₀ cycloalkenyl group.

[0315] The term “C₁-C₁₀ heterocycloalkenyl group” as used herein refers to a monovalent monocyclic group that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, 1 to 10 carbon atoms, and at least one carbon-carbon double bond in its ring. Non-limiting examples of the C₁-C₁₀ heterocycloalkenyl group include a 4,5-dihydro-1,2,3,4-oxatriazolyl group, a 2,3-dihydrofuran group, and a 2,3-dihydrothiophenyl group. The term “C₁-C₁₀ heterocycloalkenylene group” as used herein refers to a divalent group having the same structure as the C₁-C₁₀ heterocycloalkenyl group.

[0316] The term “C₆-C₆₀ aryl group” as used herein refers to a monovalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms, and the term “C₆-C₆₀ arylene

group” as used herein refers to a divalent group having a carbocyclic aromatic system having 6 to 60 carbon atoms. Non-limiting examples of the C_6 - C_{60} aryl group include a phenyl group, a naphthyl group, an anthracenyl group, a phenanthrenyl group, a pyrenyl group, and a chrysenyl group. When the C_6 - C_{60} aryl group and the C_6 - C_{60} arylene group each include two or more rings, the rings may be fused to each other.

[0317] The term “ C_1 - C_{60} heteroaryl group” as used herein refers to a monovalent group having a heterocyclic aromatic system that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 60 carbon atoms. The term “ C_1 - C_{60} heteroarylene group” as used herein refers to a divalent group having a heterocyclic aromatic system that has at least one heteroatom selected from N, O, Si, P, and S as a ring-forming atom, in addition to 1 to 60 carbon atoms. Non-limiting examples of the C_1 - C_{60} heteroaryl group include a pyridinyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a quinolinyl group, and an isoquinolinyl group. When the C_1 - C_{60} heteroaryl group and the C_1 - C_{60} heteroarylene group each include two or more rings, the rings may be fused to each other.

[0318] The term “ C_6 - C_{60} aryloxy group” as used herein refers to $-OA_{102}$ (wherein A_{102} is the C_6 - C_{60} aryl group), and a C_6 - C_{60} arylthio group used herein indicates $-SA_{103}$ (wherein A_{103} is the C_6 - C_{60} aryl group).

[0319] The term “monovalent non-aromatic condensed polycyclic group” as used herein refers to a monovalent group (for example, having 8 to 60 carbon atoms) having two or more rings condensed with each other, only carbon atoms as ring-forming atoms, and no aromaticity in the entire molecular structure. A detailed example of the monovalent non-aromatic condensed polycyclic group is a fluorenyl group. The term “divalent non-aromatic condensed polycyclic group,” used herein, refers to a divalent group having the same structure as the monovalent non-aromatic condensed polycyclic group.

[0320] The term “monovalent non-aromatic condensed heteropolycyclic group” as used herein refers to a monovalent group (for example, having 1 to 60 carbon atoms) having two or more rings condensed to each other, at least one heteroatom selected from N, O, Si, P, and S, other than carbon atoms, as a ring-forming atom, and no aromaticity in the entire molecular structure. An example of the monovalent non-aromatic condensed heteropolycyclic group is a carbazolyl group. The term “divalent non-aromatic condensed heteropolycyclic group,” used herein, refers to a divalent group having the same structure as the monovalent non-aromatic condensed heteropolycyclic group.

[0321] The term “ C_5 - C_{60} carbocyclic group” as used herein refers to a monocyclic or polycyclic group having 5 to 60 carbon atoms in which a ring-forming atom is a carbon atom only. The C_5 - C_{60} carbocyclic group may be an aromatic carbocyclic group or a non-aromatic carbocyclic group. The C_5 - C_{60} carbocyclic group may be a ring, such as a benzene group, a monovalent group, such as a phenyl group, or a divalent group, such as a phenylene group. In one or more embodiments, depending on the number of substituents connected to the C_5 - C_{60} carbocyclic group, the C_5 - C_{60} carbocyclic group may be a trivalent group or a quadrivalent group.

[0322] The term “ C_1 - C_{60} heterocyclic group” as used herein refers to a group having the same structure as the

C_1 - C_{60} carbocyclic group, except that as a ring-forming atom, at least one heteroatom selected from N, O, Si, P, and S is used in addition to carbon (the number of carbon atoms may be in a range of 1 to 60).

[0323] At least one substituent of the substituted C_5 - C_{60} carbocyclic group, the substituted C_1 - C_{60} heterocyclic group, the substituted C_3 - C_{10} cycloalkylene group, the substituted C_1 - C_{10} heterocycloalkylene group, the substituted C_3 - C_{10} cycloalkenylene group, the substituted C_1 - C_{10} heterocycloalkenylene group, the substituted C_6 - C_{60} arylene group, the substituted C_1 - C_{60} heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_1 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_1 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, the substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_1 - C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group may be selected from:

[0324] deuterium ($-D$), $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group;

[0325] a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, and a C_1 - C_{60} alkoxy group, each substituted with at least one selected from deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_{11})(Q_{12})(Q_{13})$, $-N(Q_{11})(Q_{12})$, $-B(Q_{11})(Q_{12})$, $-C(=O)(Q_{11})$, $-S(=O)_2(Q_{11})$, and $-P(=O)(Q_{11})(Q_{12})$,

[0326] a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group;

[0327] a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocy-

cloalkenyl group, a C₆-C₆₀ aryl group, a C₆-C₆₀ aryloxy group, a C₆-C₆₀ arylthio group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, —Si(Q₂₁)(Q₂₂)(Q₂₃), —N(Q₂₁)(Q₂₂), —B(Q₂₁)(Q₂₂), —C(=O)(Q₂₁), —S(=O)₂(Q₂₁), and —P(=O)(Q₂₁)(Q₂₂);

[0328] —Si(Q₃₁)(Q₃₂)(Q₃₃), —N(Q₃₁)(Q₃₂), —B(Q₃₁)(Q₃₂), —C(=O)(Q₃₁), —S(=O)₂(Q₃₁), and —P(=O)(Q₃₁)(Q₃₂); and

[0329] Q₁₁ to Q₁₃, Q₂₁ to Q₂₃ and Q₃₁ to Q₃₃ may each independently be selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₆₀ alkyl group, a C₂-C₆₀ alkenyl group, a C₂-C₆₀ alkynyl group, a C₁-C₆₀ alkoxy group, a C₃-C₁₀ cycloalkyl group, a C₁-C₁₀ heterocycloalkyl group, a C₃-C₁₀ cycloalkenyl group, a C₁-C₁₀ heterocycloalkenyl group, a C₆-C₆₀ aryl group, a C₁-C₆₀ heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, a biphenyl group, and a terphenyl group.

[0330] The term “Ph”, as used herein, may refer to a phenyl group; the term “Me”, as used herein, may refer to a methyl group; the term “Et”, as used herein, may refer to an ethyl group; the terms “ter-Bu” or “But”, as used herein, may refer to a tert-butyl group; and the term “OMe” as used herein may refer to a methoxy group.

[0331] The term “biphenyl group” as used therein refers to “a phenyl group substituted with a phenyl group.” In other words, the “biphenyl group” is a substituted phenyl group having a C₆-C₆₀ aryl group as a substituent.

[0332] The term “terphenyl group” as used herein refers to “a phenyl group substituted with a biphenyl group.” In other words, the “terphenyl group” is a phenyl group having, as a substituent, a C₆-C₆₀ aryl group substituted with a C₆-C₆₀ aryl group.

[0333] * and * used herein, unless defined otherwise, each refer to a binding site to a neighboring atom in a corresponding formula.

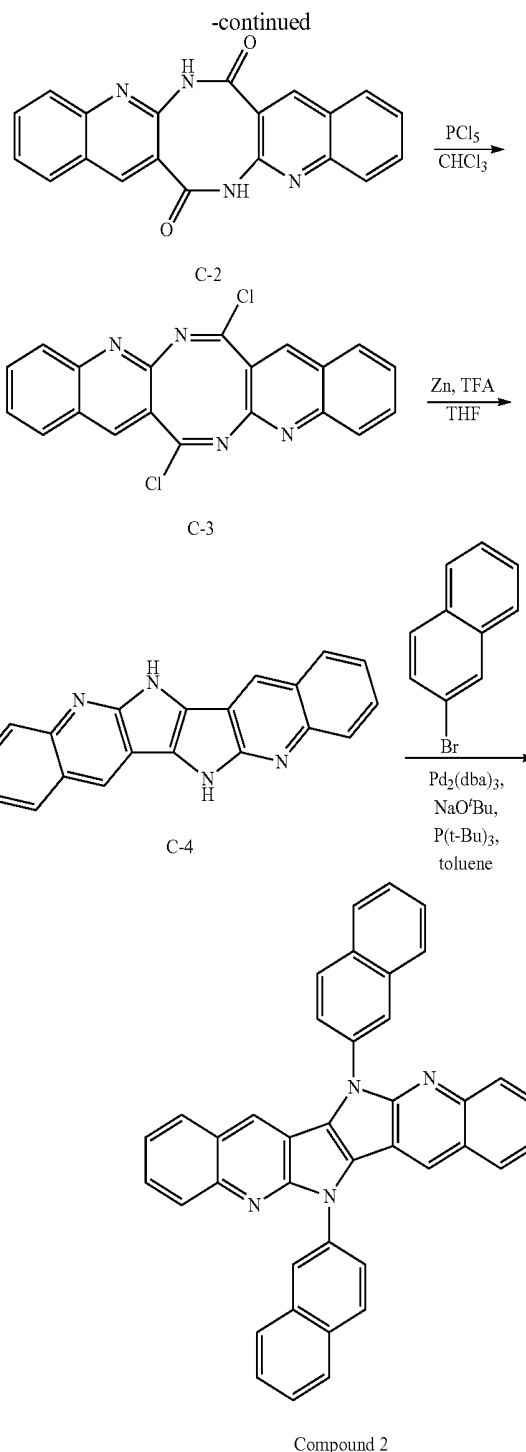
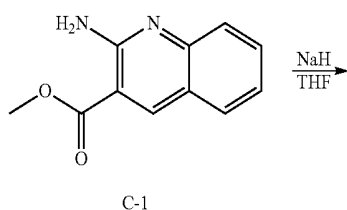
[0334] Hereinafter, a compound according to embodiments and an organic light-emitting device according to embodiments will be described in detail with reference to Synthesis Examples and Examples. The wording “B was used instead of A” used in describing Synthesis Examples refers to that an identical molar equivalent of B was used in place of A.

EXAMPLE

Synthesis Example 1

Synthesis of Compound 2

[0335]



Synthesis of Intermediate C-2

[0336] 200 mL of tetrahydrofuran (THF) was added to 15 g (74.6 mmol) of Intermediate C-1. While the mixture was slowly stirred, 2.98 g of NaH (74.6 mmol, 60% dispersion in mineral oil) was added thereto. Then, the mixture was refluxed at a temperature of 80° C. for 72 hours. The resultant obtained therefrom was cooled to room temperature and 250 mL of distilled water was added thereto. After the reaction was completed, 100 mL of 2N HCl was slowly added thereto and stirred for 80 minutes. The solid product

obtained therefrom was filtered by using a glass filter, washed several times by using distilled water, and vacuum-dried, thereby obtaining 3.22 g (31%) of Intermediate C-2.

[0337] ^1H NMR (DMSO- d_6): 9.41 (s, 2H), 8.00 (s, 2H), 7.82 (d, 2H), 7.56 (d, 2H), 7.52 (t, 2H), 7.20 (d, 2H)

Synthesis of Intermediate C-3

[0338] 400 mL of anhydrous CHCl_3 was added to 8.1 g (24 mmol) of Intermediate C-2 and stirred for 30 minutes in a nitrogen atmosphere. 11 g (52.8 mmol) of PCl_5 was slowly added thereto and the mixture was stirred at a temperature of 100°C . for 6 hours. The resultant mixture obtained therefrom was cooled to room temperature and distilled under reduced pressure. The product obtained therefrom was washed by using acetone (50 mL $\times$ 3) and vacuum-dried, thereby obtaining 4.70 g (53%) of Intermediate C-3. Intermediate C-3 was used to synthesize Intermediate C-4 without additional purification.

Synthesis of Intermediate C-4

[0339] 400 mL of anhydrous THF was added to 4.70 g (12.5 mmol) of Intermediate C-3 and stirred for 20 minutes in a nitrogen atmosphere. 12.5 g (191.8 mmol) of Zn was added thereto and strongly stirred for 30 minutes. 23.5 mL (315.1 mmol) of a trifluoroacetic acid (TFA) was slowly dropped down to the resultant obtained therefrom and stirred at room temperature for 8 hours. Then, 100 mL of a saturated NH_4Cl aqueous solution was added and the reaction was completed. A resultant obtained therefrom was filtered and a filtrate was extracted by using EtOAc. Washing thereof was performed by using distilled water and an organic solvent was distilled under reduced pressure. The product obtained therefrom was separated by n-hexane:THF (1:3), thereby obtaining 1.50 g (39%) of Intermediate C-4.

[0340] ^1H NMR (DMSO- d_6): 8.20-8.05 (m, 4H), 7.75-7.68 (m, 4H), 7.50 (d, 2H), 5.50 (s, 2H). EI^+ (mass): m/z =308.

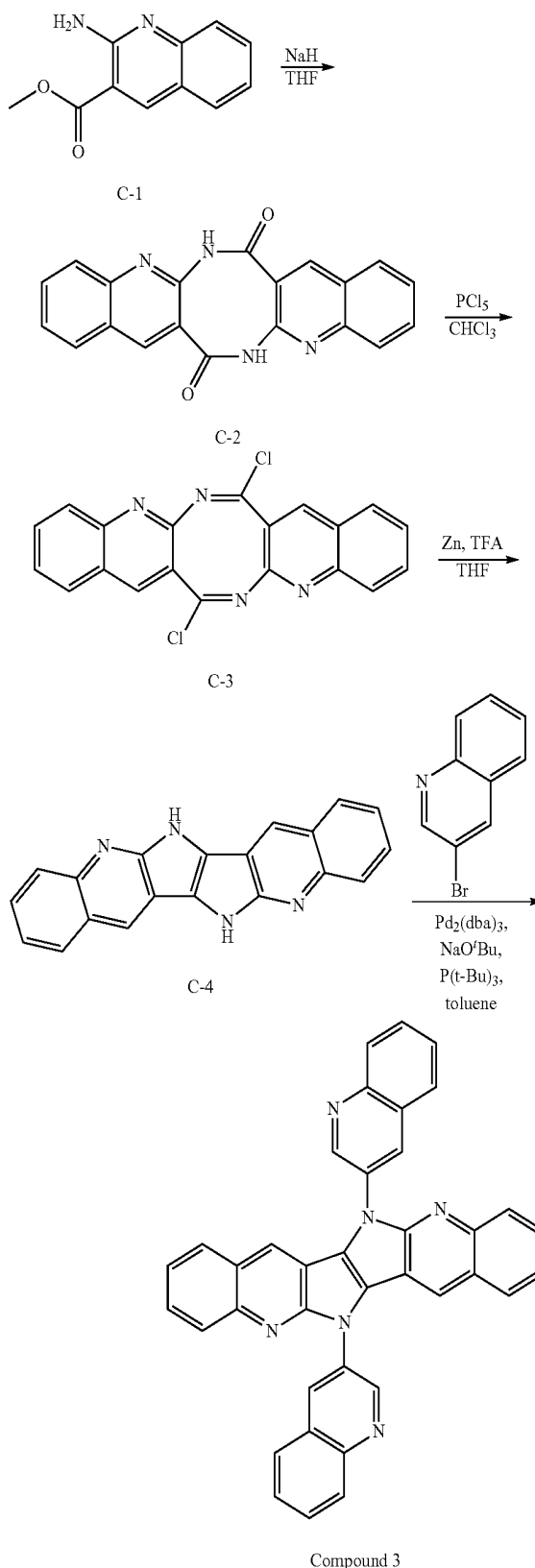
Synthesis of Compound 2

[0341] 0.66 g (2.14 mmol) of Intermediate C-4 was mixed with 30 mL of toluene, and 1.02 g (8.15 mmol) of 2-bromonaphthalene, 0.11 g (0.125 mmol) of $\text{Pd}_2(\text{dba})_3$, 0.26 mL (0.26 mmol) of $\text{P}(\text{t-Bu})_3$ (1M in toluene), and 1.23 g (12.8 mmol) of NaOt-Bu were added thereto and stirred at a temperature of 100°C . for 58 hours. The reaction was checked by using TLC. When the reaction was completed, EtOAc was extracted and washed by using distilled water. An organic layer obtained therefrom was dried by using MgSO_4 and distilled under reduced pressure. The compound obtained therefrom was column-separated by using n-hexane:THF (1:1), thereby obtaining 0.53 g (48%) of Compound 2.

[0342] ^1H NMR (DMSO- d_6): 8.31 (d, 2H), 8.04 (d, 2H), 7.75 (m, 8H), 7.65 (m, 4H), 7.55 (d, 2H), 7.4-7.35 (m, 6H). EI^+ (mass): m/z =560.

Synthesis Example 2 Synthesis of Compound 3

[0343]



[0344] 1.0 g (3.26 mmol) of Intermediate C-4 was mixed with 100 mL of toluene, and 1.7 g (8.15 mmol) of 3-bromoquinoline, 0.17 g (0.19 mmol) of $\text{Pd}_2(\text{dba})_3$, 0.39 mL (0.39 mmol) of $\text{P}(\text{t-Bu})_3$ (1M in toluene), and 1.87 g (19.5 mmol) of NaO^tBu were added thereto and stirred at a temperature of 100° C. for 48 hours. The reaction was checked by using TLC. When the reaction was completed, EtOAc was extracted and washed by using distilled water. An organic layer obtained therefrom was dried by using MgSO_4 and distilled under reduced pressure. The resultant obtained therefrom was column-separated by using n-hexane:THF (1:1), thereby obtaining 1.4 g (76%) of Compound 3.

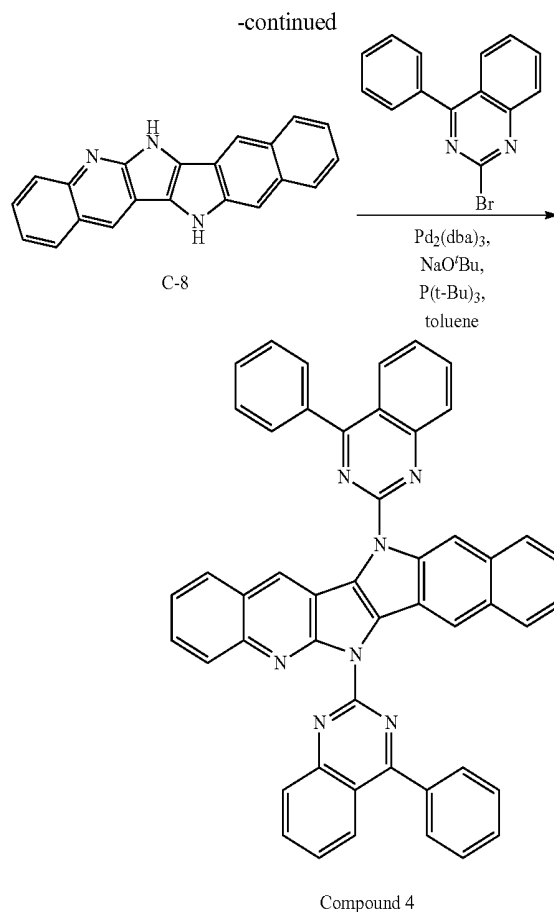
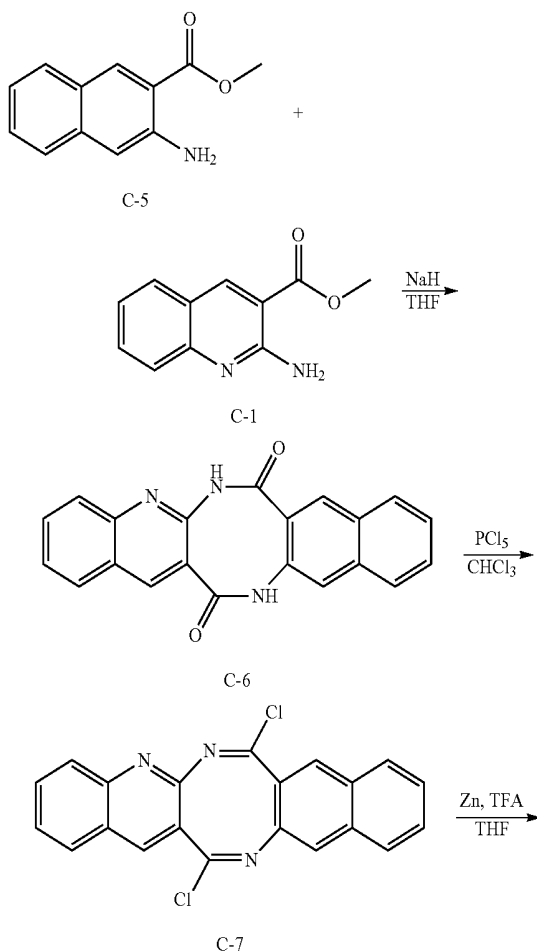
[0345] ^1H NMR ($\text{DMSO}-d_6$): 9.35 (s, 2H), 8.44-8.35 (m, 8H), 7.91-7.83 (m, 8H), 7.60-7.55 (m, 4H)

[0346] EI^+ (mass): $m/z=562$.

Synthesis Example 3

Synthesis of Compound 4

[0347]



Synthesis of Intermediate C-6

[0348] Intermediate C-6 was synthesized in the same manner as in Synthesis of Intermediate C-2 of Synthesis Example 1, except that 37.2 mmol of Intermediate C-5 and 37.2 mmol of Intermediate C-1 were used instead of Intermediate C-1.

Synthesis of Intermediate C-7

[0349] Intermediate C-7 was synthesized in the same manner as in Synthesis of Intermediate C-3 of Synthesis Example 1, except that Intermediate C-6 was used instead of Intermediate C-2.

Synthesis of Intermediate C-8

[0350] Intermediate C-8 was synthesized in the same manner as in Synthesis of Intermediate C-4 of Synthesis Example 1, except that Intermediate C-7 was used instead of Intermediate C-3.

Synthesis of Compound 4

[0351] 1.0 g (3.26 mmol) of Intermediate C-8 was mixed with 100 mL of toluene, and 2.32 g (8.15 mmol) of 2-bromo-4-phenylquinazoline, 0.17 g (0.19 mmol) of $\text{Pd}_2(\text{dba})_3$, 0.39 mL (0.39 mmol) of $\text{P}(\text{t-Bu})_3$ (1M in toluene), and 1.87 g (19.5 mmol) of NaO^tBu were added thereto and stirred at a temperature of 100° C. for 48 hours. The reaction was checked by using TLC. When the reaction was completed, EtOAc was extracted and washed by using distilled water.

An organic layer obtained therefrom was dried by using MgSO_4 and distilled under reduced pressure. The compound obtained therefrom was column-separated by using n-hexane:THF (1:1), thereby obtaining 1.52 g (65%) of Compound 4.

[0352] ^1H NMR ($\text{DMSO}-d_6$): 9.05-8.93 (m, 4H), 8.74-8.55 (m, 10H), 8.45-8.33 (m, 6H), 7.95-7.82 (m, 8H), 7.68 (s, 2H)

[0353] EI^+ (mass): $m/z=715$.

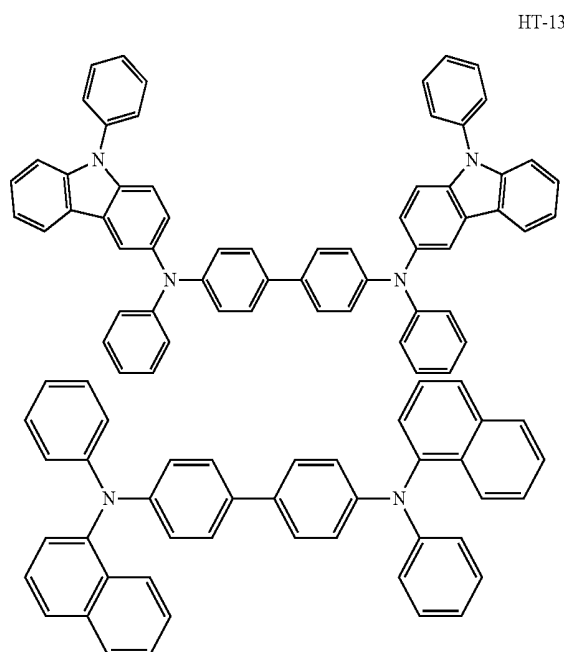
Example 1

[0354] An ITO/Ag/ITO anode was prepared by cutting an glass substrate on which ITO/Ag/ITO were deposited, ultrasonically cleaning the glass substrate by using isopropyl alcohol and pure water each for 5 minutes, and then, exposing the glass substrate to UV irradiation and ozone for 10 minutes to clean the glass substrate. The glass substrate was loaded into a vacuum deposition apparatus.

[0355] Compound HT-13 was vacuum-deposited on the ITO/Ag/ITO anode to form a hole injection layer having a thickness of 600 Å, NPB was vacuum-deposited on the hole injection layer to form a hole transport layer having a thickness of 600 Å, and Compound X was deposited on the hole transport layer to form an emission auxiliary layer having a thickness of 550 Å.

[0356] Compound 2 (host) and Compound 2-7 (dopant) were co-deposited on the emission auxiliary layer at a weight ratio of 97:3 to form an emission layer having a thickness of 400 Å.

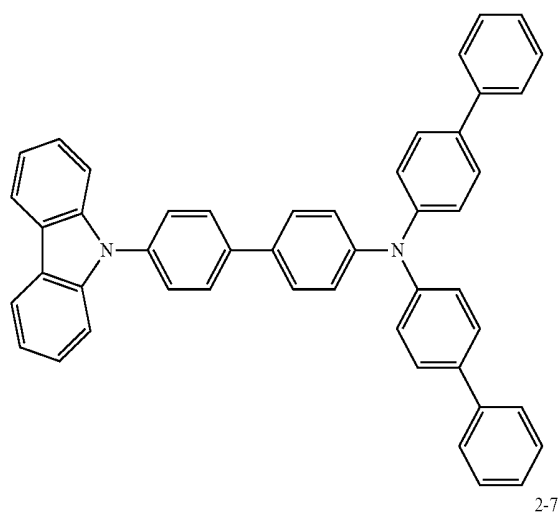
[0357] Compound ET1 was deposited on the emission layer to form an electron transport layer having a thickness of 300 Å, LiQ was deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, Mg and Ag were co-deposited on the electron injection layer at a weight ratio of 90:10 to form a cathode having a thickness of 130 Å, thereby completing the manufacture of an organic light-emitting device.



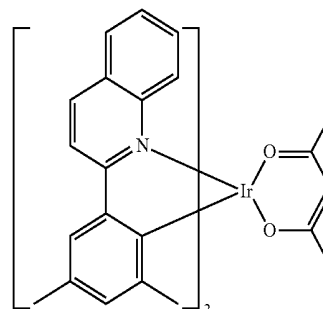
NPB

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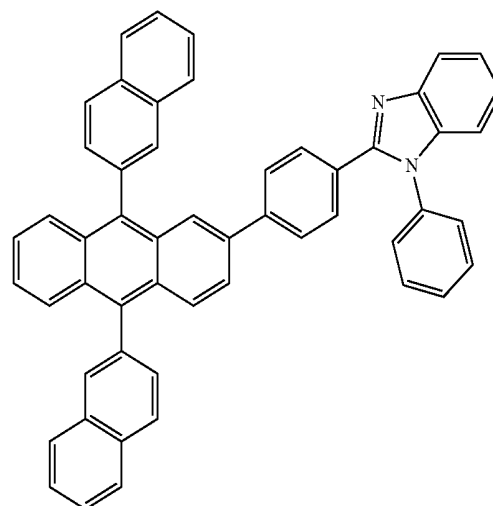
Compound X



2-7



ET1



Examples 2 and 3 and Comparative Examples 1 to 3

[0358] Organic light-emitting devices of Examples 2 and 3 and Comparative Examples 1 to 3 were manufactured in the same manner as in Example 1, except that Compounds shown in Table 1 were each used instead of Compound 2 as a host in forming an emission layer.

Evaluation Example 1

[0359] The driving voltage, current density, luminance, efficiency, and color coordinates, of the organic light-emitting device were measured.

ting devices manufactured according to Examples 1 to 3 and Comparative Examples 1 to 3 were evaluated by using a Keithley SMU 236 and a luminance meter PR650, and results thereof are shown in Table 1.

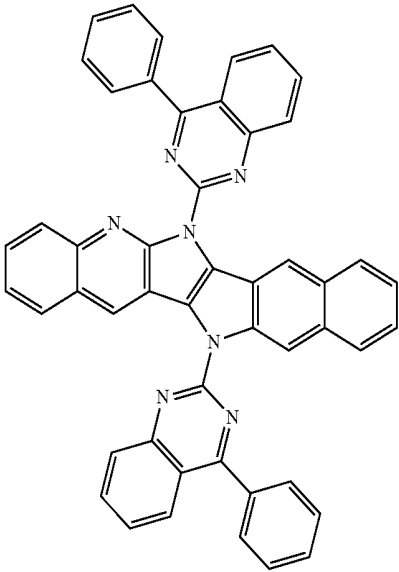
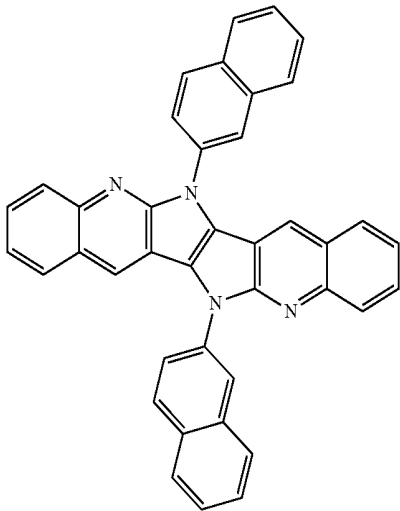
TABLE 1

	Host in emission layer	Driving voltage (V)	Current density (mA/cm ²)	Luminance (cd/m ²)	Efficiency (cd/A)	CIE color coordinates	
						x	y
Example 1	Compound 2	5.2	11.2	3700	33	0.664	0.333
Example 2	Compound 3	4.8	10.9	3700	38	0.657	0.343
Example 3	Compound 4	4.0	8.56	3700	38	0.662	0.334
Comparative Example 1	Compound A	4.2	15.1	3700	25	0.646	0.352
Comparative Example 2	Compound B	6	20.4	3700	18.1	0.648	0.35
Comparative Example 3	Compound C	4.3	12.6	3700	31	0.659	0.341

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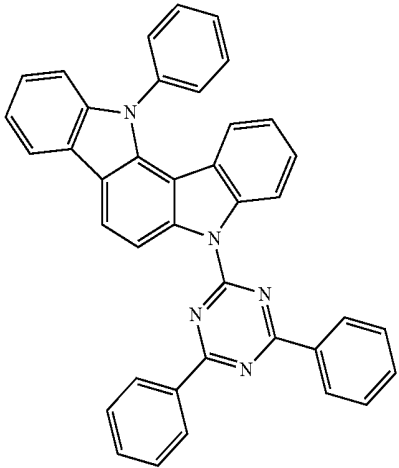
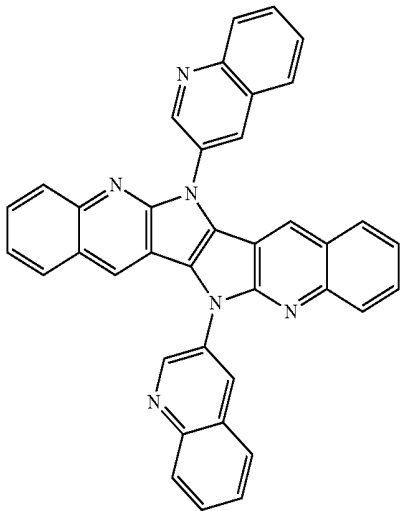
2

4

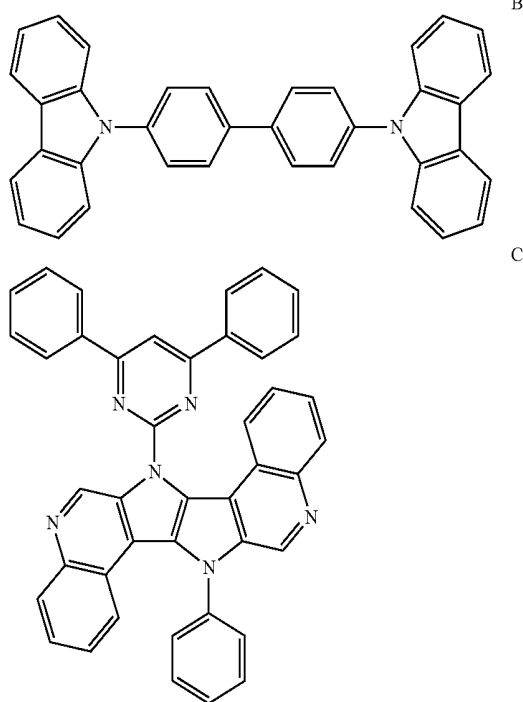


3

A



-continued



[0360] Referring to Table 1, it was confirmed that the organic light-emitting devices of Examples 1 to 3 had excellent driving voltage, current density, and efficiency characteristics, those of the organic light-emitting devices of Comparative Examples 1 to 3.

[0361] According to one or more embodiments, an organic light-emitting device including the condensed cyclic compound may have a low driving voltage, high efficiency, high luminance, and a long lifespan.

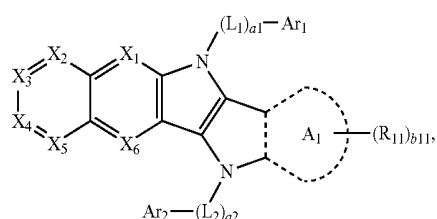
[0362] It should be understood that embodiments described herein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

[0363] While one or more embodiments have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope as defined by the following claims.

What is claimed is:

1. A condensed cyclic compound represented by Formula 1:

<Formula 1>



wherein, in Formula 1,

X_1 is N or C(R_1), X_2 is N or C(R_2), X_3 is N or C(R_3), X_4 is N or C(R_4), X_5 is N or C(R_5), and X_6 is N or C(R_6),

ring A_1 is a C_5 - C_{60} carbocyclic group or a C_2 - C_{60} heterocyclic group, provided that ring A_1 is not a benzene,

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

a_1 and a_2 are each independently an integer between 0 and 3, inclusive, wherein, when a_1 is two or more, two or more L_1 (s) are identical to or different from each other and a_2 is two or more, two or more L_2 (s) are identical to or different from each other,

Ar_1 and Ar_2 are each independently selected from a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, and a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group,

R_1 to R_6 and R_{11} are each independently selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1 - C_{60} alkyl group, a substituted or unsubstituted C_2 - C_{60} alkenyl group, a substituted or unsubstituted C_2 - C_{60} alkynyl group, a substituted or unsubstituted C_1 - C_{60} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkyl group, a substituted or unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group, $-Si(Q_1)(Q_2)(Q_3)$, $-N(Q_1)(Q_2)$, $-B(Q_1)(Q_2)$, $-C(=O)(Q_1)$, $-S(=O)_2(Q_1)$, and $-P(=O)(Q_1)(Q_2)$,

b_{11} is an integer between 0 and 6, inclusive, wherein, when b_{11} is two or more, two or more R_{11} (s) are identical to or different from each other, and

at least one substituent of the substituted C_3 - C_{10} cycloalkylene group, the substituted C_1 - C_{10} heterocyclo-

cloalkylene group, the substituted C_3 - C_{10} cycloalkenylene group, the substituted C_1 - C_{10} heterocycloalkenylene group, the substituted C_6 - C_{60} arylene group, the substituted C_1 - C_{60} heteroarylene group, the substituted divalent non-aromatic condensed polycyclic group, the substituted divalent non-aromatic condensed heteropolycyclic group, the substituted C_1 - C_{60} alkyl group, the substituted C_2 - C_{60} alkenyl group, the substituted C_2 - C_{60} alkynyl group, the substituted C_1 - C_{60} alkoxy group, the substituted C_3 - C_{10} cycloalkyl group, the substituted C_1 - C_{10} heterocycloalkyl group, the substituted C_3 - C_{10} cycloalkenyl group, the substituted C_1 - C_{10} heterocycloalkenyl group, the substituted C_6 - C_{60} aryl group, the substituted C_6 - C_{60} aryloxy group, the substituted C_6 - C_{60} arylthio group, the substituted C_1 - C_{60} heteroaryl group, the substituted monovalent non-aromatic condensed polycyclic group, and the substituted monovalent non-aromatic condensed heteropolycyclic group is selected from:

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

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

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

a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, and a monovalent non-aromatic condensed heteropolycyclic group, each substituted with at least one selected from deuterium, -F, -Cl, -Br, -I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{60} alkyl group, a C_2 - C_{60} alkenyl group, a C_2 - C_{60} alkynyl group, a C_1 - C_{60} alkoxy group, a C_3 - C_{10} cycloalkyl group, a C_1 - C_{10} heterocycloalkyl group, a C_3 - C_{10} cycloalkenyl group, a C_1 - C_{10} heterocycloalkenyl group, a C_6 - C_{60} aryl group, a C_6 - C_{60} aryloxy group, a C_6 - C_{60} arylthio group, a C_1 - C_{60} heteroaryl group, a monovalent non-aromatic condensed polycyclic group, a monovalent non-aromatic condensed heteropolycyclic group, $-\text{Si}(\text{Q}_{21})(\text{Q}_{22})(\text{Q}_{23})$, $-\text{N}(\text{Q}_{21})$

(Q_{22}) , $-\text{B}(\text{Q}_{21})(\text{Q}_{22})$, $-\text{C}(=\text{O})(\text{Q}_{21})$, $-\text{S}(=\text{O})_2(\text{Q}_{21})$, and $-\text{P}(=\text{O})(\text{Q}_{21})(\text{Q}_{22})$; and $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$, $-\text{N}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{B}(\text{Q}_{31})(\text{Q}_{32})$, $-\text{C}(=\text{O})(\text{Q}_{31})$, $-\text{S}(=\text{O})_2(\text{Q}_{31})$, and $-\text{P}(=\text{O})(\text{Q}_{31})(\text{Q}_{32})$,

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

2. The condensed cyclic compound of claim 1, wherein at least one of X_1 to X_6 is N.

3. The condensed cyclic compound of claim 1, wherein X_1 is N, X_2 is $\text{C}(\text{R}_2)$, X_3 is $\text{C}(\text{R}_3)$, X_4 is $\text{C}(\text{R}_4)$, X_5 is $\text{C}(\text{R}_5)$, and X_6 is $\text{C}(\text{R}_6)$.

4. The condensed cyclic compound of claim 1, wherein ring A_1 is a pyridine group, a pyrimidine group, a naphthalene group, a quinoline group, or an isoquinoline group.

5. The condensed cyclic compound of claim 1, wherein L_1 and L_2 are each independently selected from:

a phenylene group, a pentalenylene group, an indenylene group, a naphthalenylene group, an azulenylene group, a heptalenylene group, an indacenylene group, an acenaphthalenylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthrenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, a pentaphenylene group, a hexacenylene group, a pentacenylene group, a rubicenylene group, a coronenylene group, an ovalenylene group, a pyrrolylene group, a thiophenylene group, a furanylene group, an imidazolylene group, a pyrazolylene group, a thiazolylene group, an isothiazolylene group, an oxazolylene group, an 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 benzimidazolylene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolylene group, a benzoxazolylene group, an isobenzoxazolylene group, a triazolylene group, a tetrazolylene group, an oxadiazolylene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolylene group, a dibenzocarpa-

zolyene group, a thiadiazolyene group, an imidazopyridinylene group, and an imidazopyrimidinylene group; and

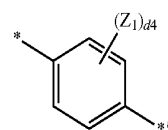
a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylenylene group, a heptalenylene group, an indacenylene group, an acenaphthylene group, a fluorenylene group, a spiro-bifluorenylene group, a benzofluorenylene group, a dibenzofluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthracenylene group, a fluoranthylene 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 imidazolyene group, a pyrazolyene group, a thiazolyene group, an isothiazolyene group, an oxazolyene group, an isoxazolyene group, a pyridinylene group, a pyrazinylene group, a pyrimidinylene group, a pyridazinylene group, an isoindolylene group, an indolylene group, an indazolyene 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 carbazolyene group, a phenanthridinylene group, an acridinylene group, a phenanthrolinylene group, a phenazinylene group, a benzimidazolyene group, a benzofuranylene group, a benzothiophenylene group, an isobenzothiazolyene group, a benzoxazolyene group, a triazolyene group, a tetrazolyene group, an oxadiazolyene group, a triazinylene group, a dibenzofuranylene group, a dibenzothiophenylene group, a benzocarbazolyene group, a dibenzocarbazolyene group, a thiadiazolyene group, an imidazopyridinylene group, and an imidazopyrimidinylene group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphe-nyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a

benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a 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 $-\text{Si}(\text{Q}_{31})(\text{Q}_{32})(\text{Q}_{33})$,

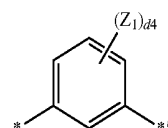
wherein Q_{31} to Q_{33} are each independently selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

6. The condensed cyclic compound of claim 1, wherein

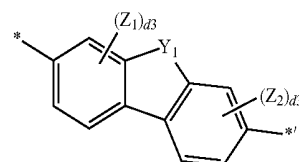
L_1 and L_2 are each independently selected from groups represented by Formulae 3-1 to 3-6:



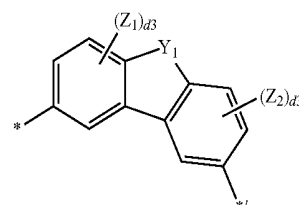
Formula 3-1



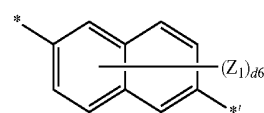
Formula 3-2



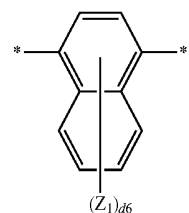
Formula 3-3



Formula 3-4

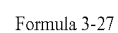
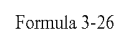
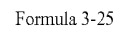
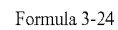
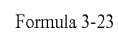
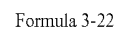
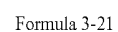
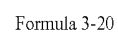
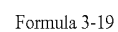
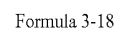
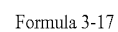


Formula 3-5

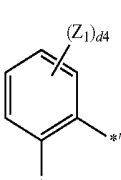
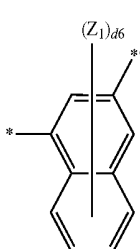
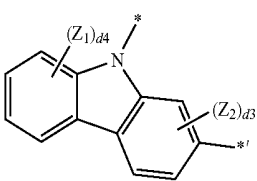
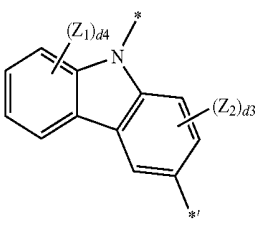
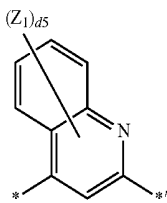
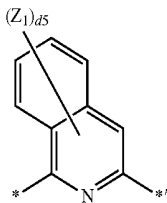
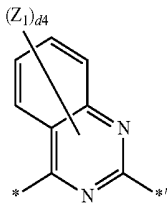


Formula 3-6

-continued



-continued



Formula 3-28

Formula 3-29

Formula 3-30

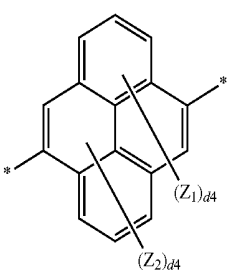
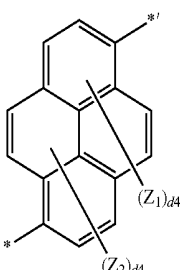
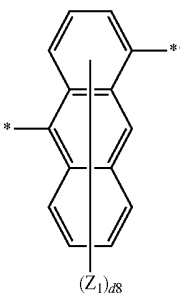
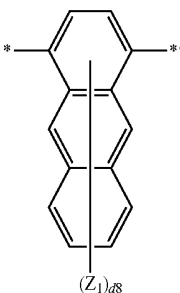
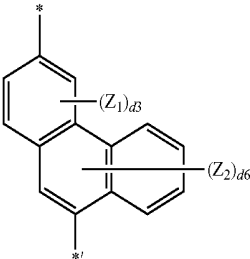
Formula 3-31

Formula 3-32

Formula 3-33

Formula 3-34

-continued



Formula 3-35

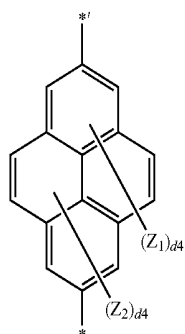
Formula 3-36

Formula 3-37

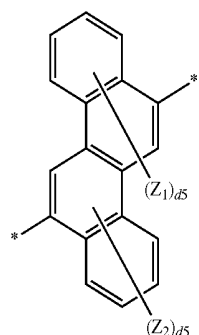
Formula 3-38

Formula 3-39

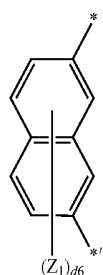
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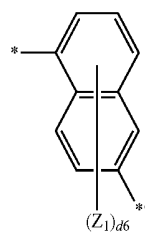
Formula 3-40



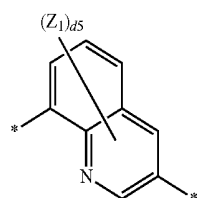
Formula 3-41



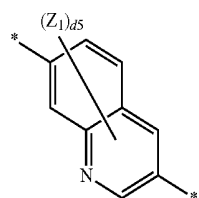
Formula 3-42



Formula 3-43



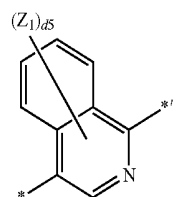
Formula 3-44



Formula 3-45

-continued

Formula 3-46



wherein, in Formulae 3-1 to 3-46,

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

Z_1 to Z_7 are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzo-fluorenyl 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 dibenzofuran-yl group, a dibenzothiophenyl group, a triazinyl group, a benzimidazolyl group, a phenanthrolinyl group, and —Si(Q_{31})(Q_{32})(Q_{33}),

Q_{31} to Q_{33} are each independently selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

$d2$ is an integer between 0 and 2, inclusive,

$d3$ is an integer between 0 and 3, inclusive,

$d4$ is an integer between 0 and 4, inclusive,

$d5$ is an integer between 0 and 5, inclusive,

$d6$ is an integer between 0 and 6, inclusive,

$d8$ is an integer between 0 and 8, inclusive, and

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

7. The condensed cyclic compound of claim 6, wherein L_1 and L_2 are each independently selected from group represented by Formulae 3-1 to 3-9, 3-25 to 3-27, and 3-31 to 3-43, and

Z_1 to Z_7 in Formulae 3-1 to 3-9, 3-25 to 3-27, and 3-31 to 3-43 are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzo-fluorenyl 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 dibenzofuran-yl group, a dibenzothiophenyl group, a triazinyl group, a benzimidazolyl group, a phenanthrolinyl group, and a dibenzothiophenyl group.

8. The condensed cyclic compound of claim 1, wherein $a1$ and $a2$ are each independently 0, 1, or 2.

9. The condensed cyclic compound of claim 1, wherein Ar_1 and Ar_2 are each independently selected from: a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a

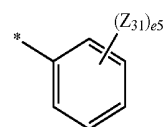
spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a 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 benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group; and

a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a 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 benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a dibenzosilolyl group, a thiadiazolyl group, an imidazopyridinyl group, and an imidazopyrimidinyl group, each substituted with at least one selected from deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a cyclo-

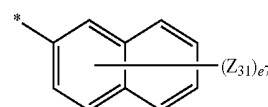
pentyl group, a cyclohexyl group, a cycloheptyl group, a cyclopentenyl group, a cyclohexenyl group, a phenyl group, a biphenyl group, a terphenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, a heptalenyl group, an indacenyl group, an acenaphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenalenyl group, a phenanthrenyl group, an anthracenyl group, a fluoranthenyl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, a naphthacenyl group, a picenyl group, a perylenyl group, a pentaphenyl group, a hexacenyl group, a pentacenyl group, a rubicenyl group, a coronenyl group, an ovalenyl group, a pyrrolyl group, a thiophenyl group, a furanyl group, an imidazolyl group, a pyrazolyl group, a thiazolyl group, an isothiazolyl group, an oxazolyl group, an isoxazolyl group, a pyridinyl group, a pyrazinyl group, a pyrimidinyl group, a pyridazinyl group, an isoindolyl group, an indolyl group, an indazolyl group, a purinyl group, a quinolinyl group, an isoquinolinyl group, a benzoquinolinyl group, a phthalazinyl group, a naphthyridinyl group, a quinoxalinyl group, a quinazolinyl group, a cinnolinyl group, a carbazolyl group, a phenanthridinyl group, an acridinyl group, a phenanthrolinyl group, a phenazinyl group, a benzimidazolyl group, a benzofuranyl group, a benzothiophenyl group, an isobenzothiazolyl group, a benzoxazolyl group, an isobenzoxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a triazinyl group, a dibenzofuranyl group, a dibenzothiophenyl group, a benzocarbazolyl group, a dibenzocarbazolyl group, a thiadiazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, —N(Q₃₁)(Q₃₂), and —Si(Q₃₁)(Q₃₂)(Q₃₃),

wherein Q₃₁ to Q₃₃ are each independently selected from a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group.

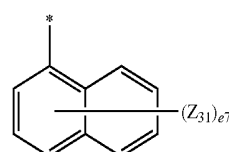
10. The condensed cyclic compound of claim 1, wherein Ar₁ and Ar₂ are each independently selected from Formulae 5-1 to 5-79:



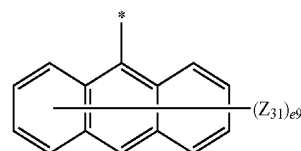
Formula 5-1



Formula 5-2

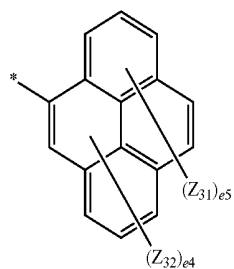
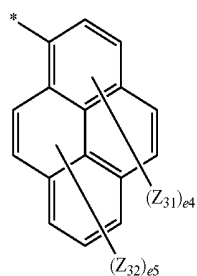
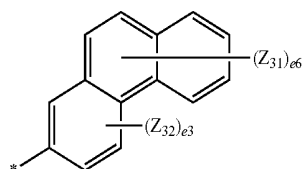
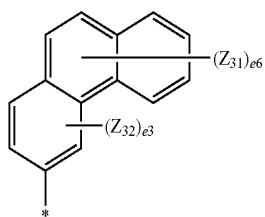
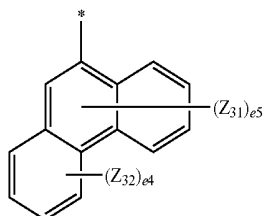
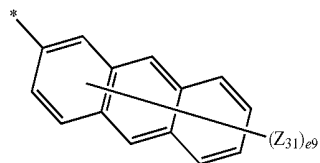
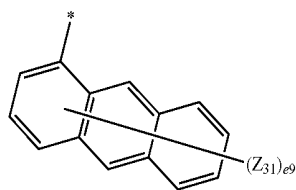


Formula 5-3



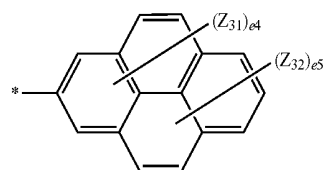
Formula 5-4

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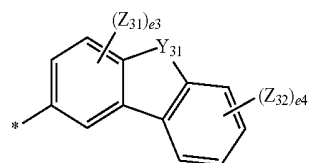
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Formula 5-5



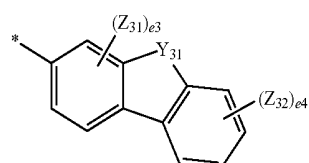
Formula 5-12

Formula 5-6



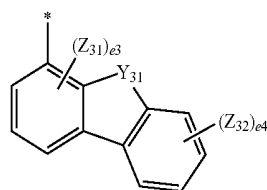
Formula 5-13

Formula 5-7



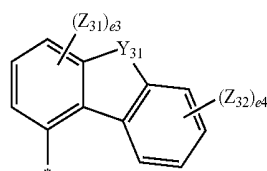
Formula 5-14

Formula 5-8



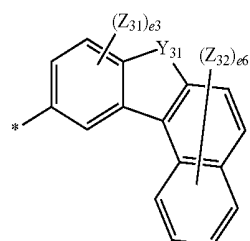
Formula 5-15

Formula 5-9



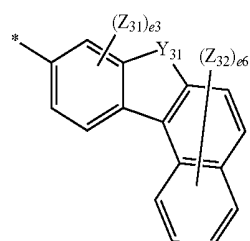
Formula 5-16

Formula 5-10



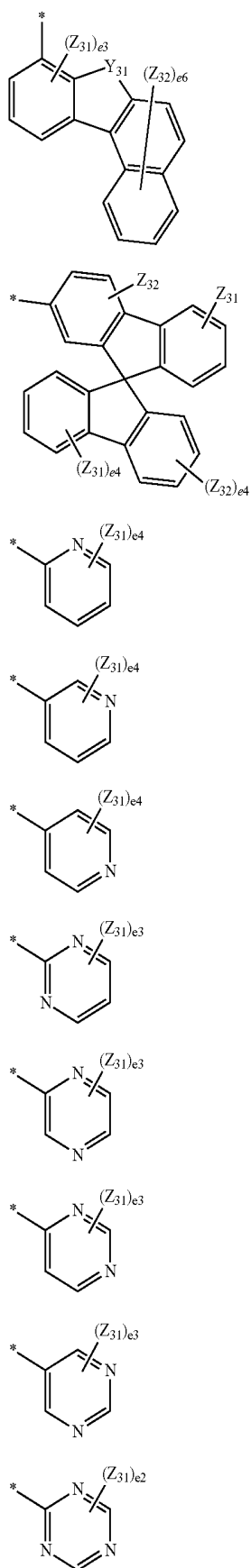
Formula 5-17

Formula 5-11



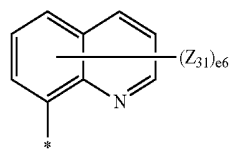
Formula 5-18

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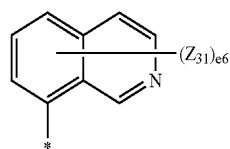


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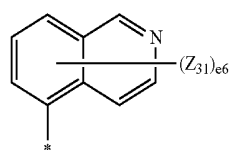
Formula 5-19



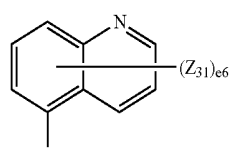
Formula 5-20



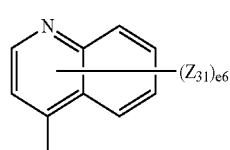
Formula 5-21



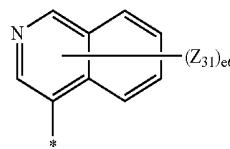
Formula 5-22



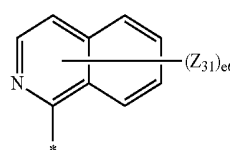
Formula 5-23



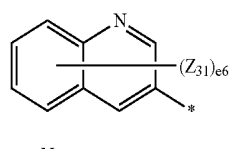
Formula 5-24



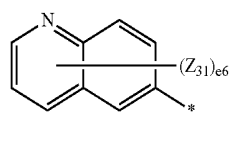
Formula 5-25



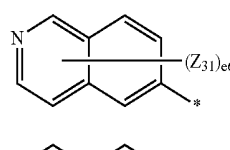
Formula 5-26



Formula 5-27



Formula 5-28



Formula 5-29

Formula 5-30

Formula 5-31

Formula 5-32

Formula 5-33

Formula 5-34

Formula 5-35

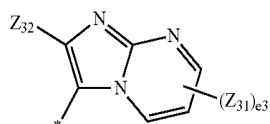
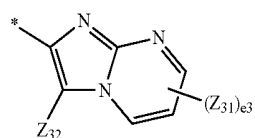
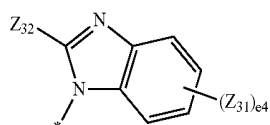
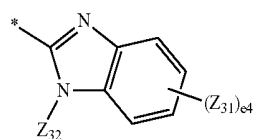
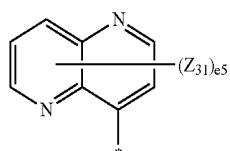
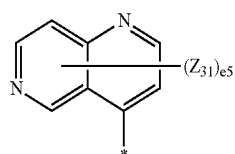
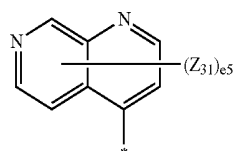
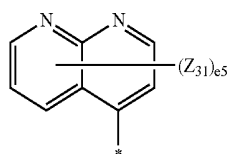
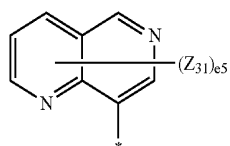
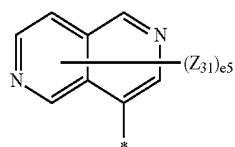
Formula 5-36

Formula 5-37

Formula 5-38

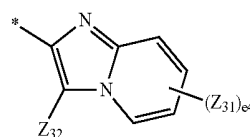
Formula 5-39

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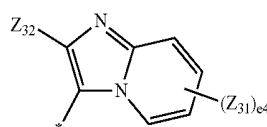


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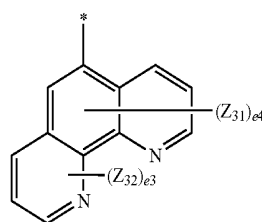
Formula 5-64



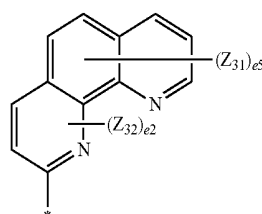
Formula 5-65



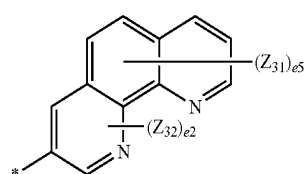
Formula 5-66



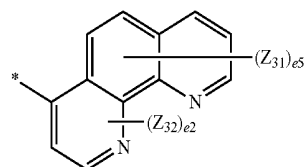
Formula 5-67



Formula 5-68



Formula 5-69



Formula 5-70

wherein, in Formulae 5-1 to 5-79,

Formula 5-71

Y₃₁ is O, S, C(Z₃₃)(Z₃₄), N(Z₃₅), or Si(Z₃₆)(Z₃₇);

Formula 5-72

Z₃₁ to Z₃₇ are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C₁-C₂₀ alkyl group, a C₁-C₂₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, a fluorenyl group, a spiro-bifluorenyl group, a benzofluorenyl group, a dibenzofluorenyl group, a phenanthrenyl group, an anthracenyl group, a 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 dibenzofuran group, a dibenzothiophenyl group, a benzimidazolyl group, a phenanthrolyl group, a triazinyl group, —N(Q₃₁)(Q₃₂), and —Si(Q₃₁)(Q₃₂)(Q₃₃),

Formula 5-73

Q₃₁ to Q₃₃ are each independently selected from a C₁-C₁₀ alkyl group, a C₁-C₁₀ alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group,

e2 is an integer between 0 and 2, inclusive,

e3 is an integer between 0 and 3, inclusive,

e4 is an integer between 0 and 4, inclusive,

e5 is an integer between 0 and 5, inclusive,

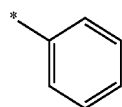
e6 is an integer between 0 and 6, inclusive,

e7 is an integer between 0 and 7, inclusive,

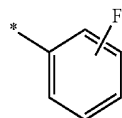
e9 is an integer between 0 and 9, inclusive, and

* indicates a binding site to a neighboring atom.

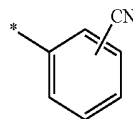
11. The condensed cyclic compound of claim 1, wherein Ar₁ and Ar₂ are each independently selected from groups represented by Formulae 6-1 to 6-100 and groups represented by Formulae 10-1 to 10-121:



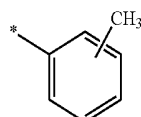
Formula 6-1



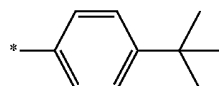
Formula 6-2



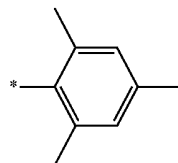
Formula 6-3



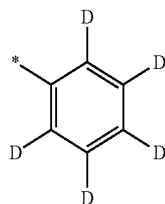
Formula 6-4



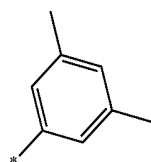
Formula 6-5



Formula 6-6



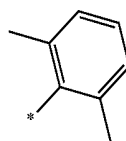
Formula 6-7



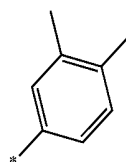
Formula 6-8

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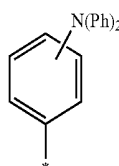
Formula 6-9



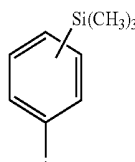
Formula 6-10



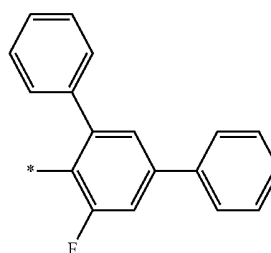
Formula 6-11



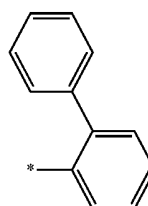
Formula 6-12



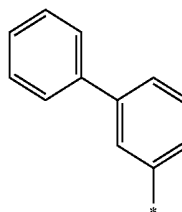
Formula 6-13



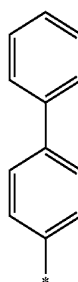
Formula 6-14



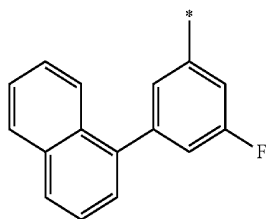
Formula 6-15



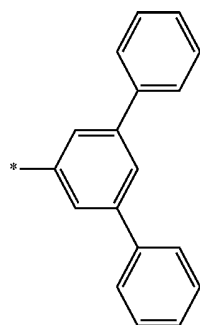
Formula 6-16



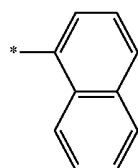
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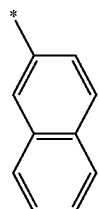
Formula 6-17



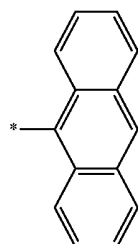
Formula 6-18



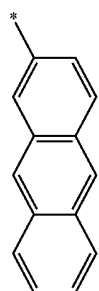
Formula 6-19



Formula 6-20

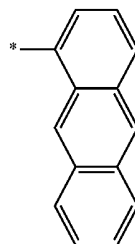


Formula 6-21

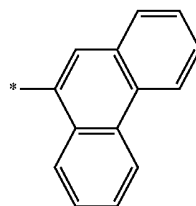


Formula 6-22

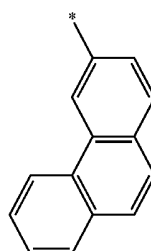
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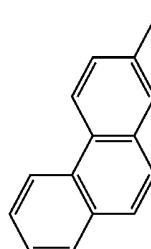
Formula 6-23



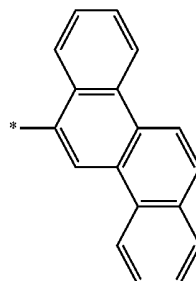
Formula 6-24



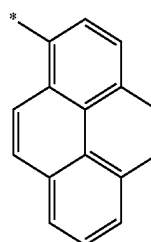
Formula 6-25



Formula 6-26

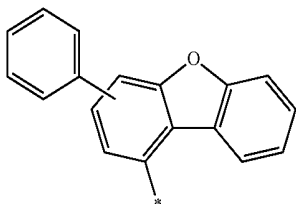
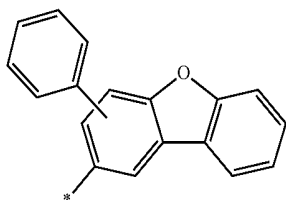
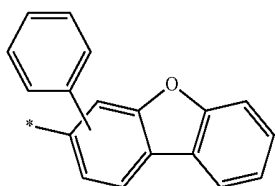
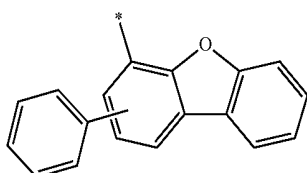
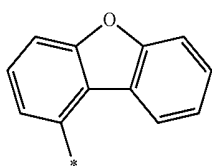
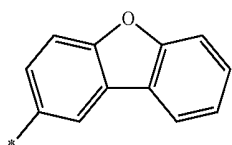
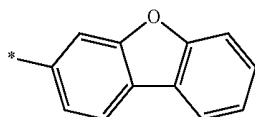
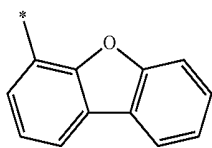


Formula 6-27



Formula 6-28

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Formula 6-29

Formula 6-30

Formula 6-31

Formula 6-32

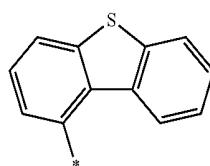
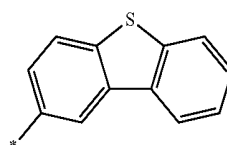
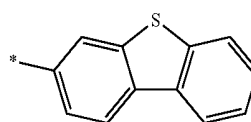
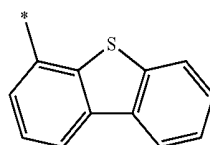
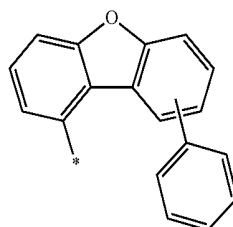
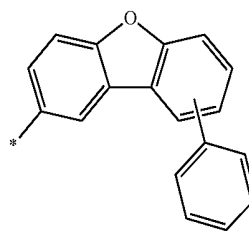
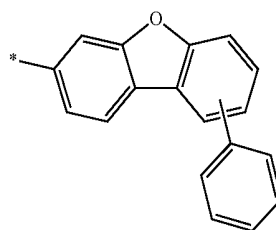
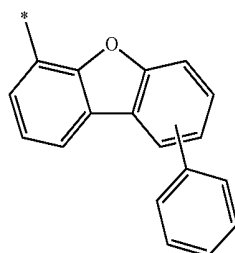
Formula 6-33

Formula 6-34

Formula 6-35

Formula 6-36

-continued



Formula 6-37

Formula 6-38

Formula 6-39

Formula 6-40

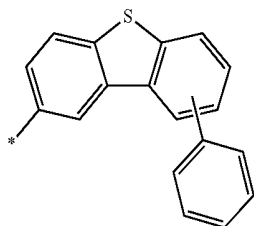
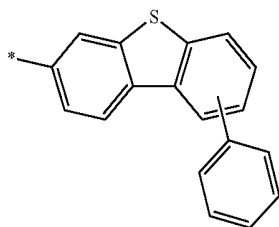
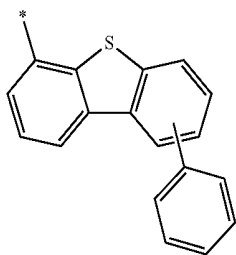
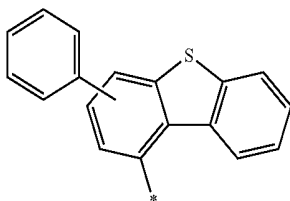
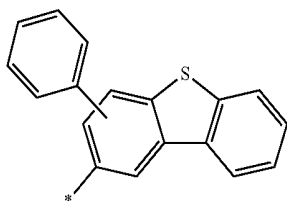
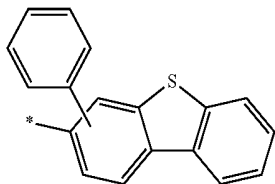
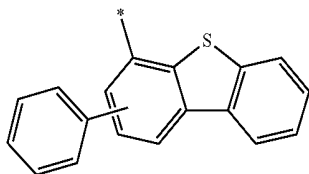
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Formula 6-44

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Formula 6-45

Formula 6-46

Formula 6-47

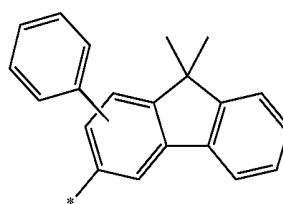
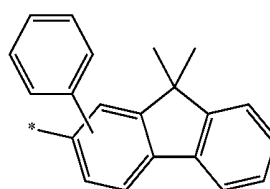
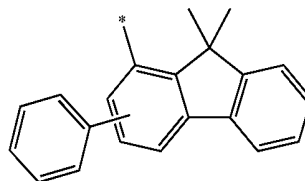
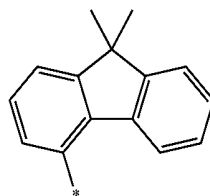
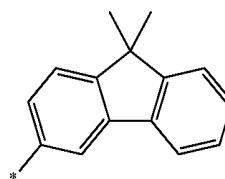
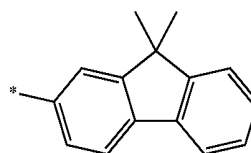
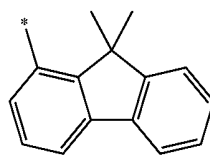
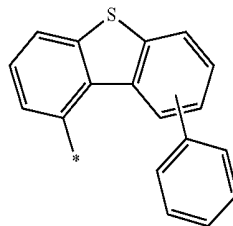
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Formula 6-52

Formula 6-53

Formula 6-54

Formula 6-55

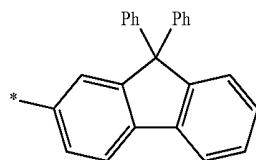
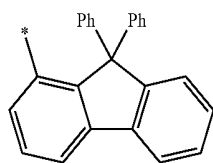
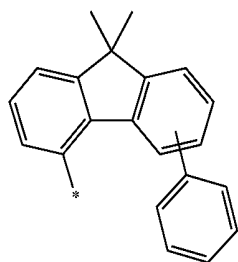
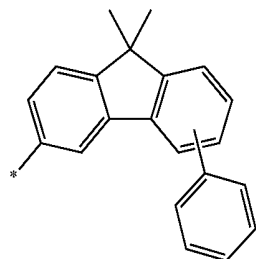
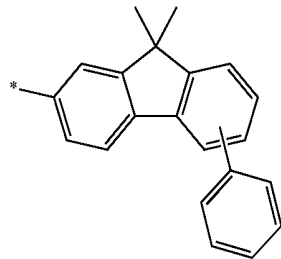
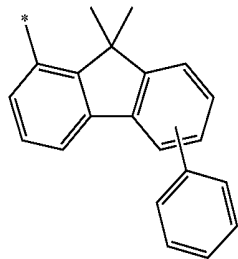
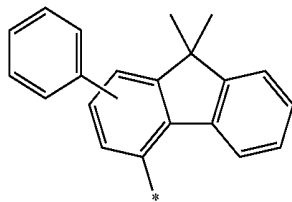
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Formula 6-60

Formula 6-61

Formula 6-62

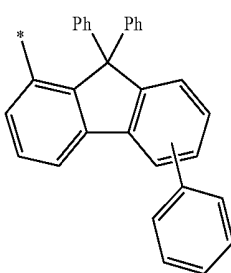
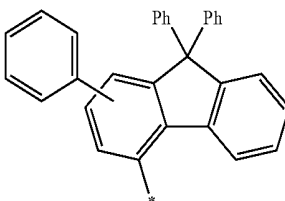
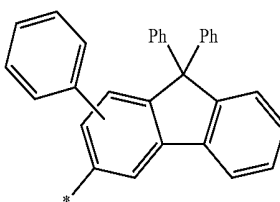
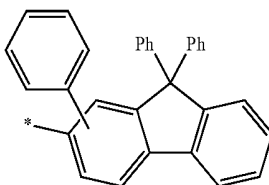
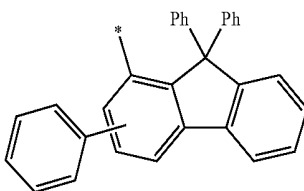
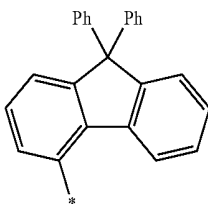
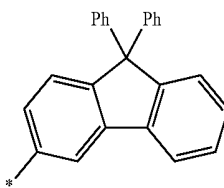
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Formula 6-66

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Formula 6-67

Formula 6-68

Formula 6-69

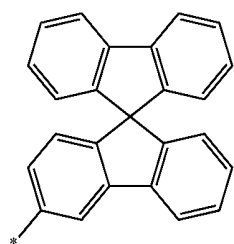
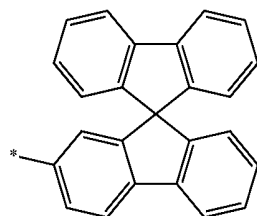
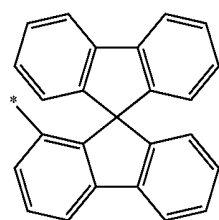
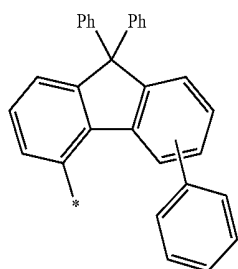
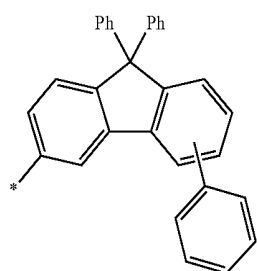
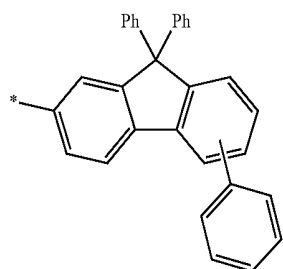
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Formula 6-74

Formula 6-75

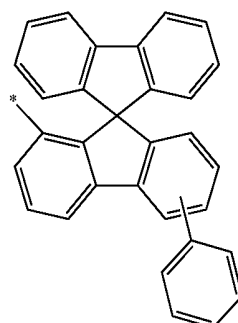
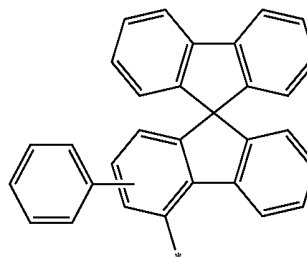
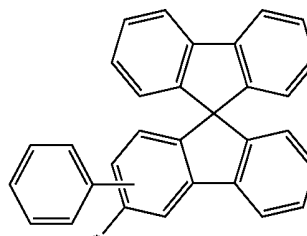
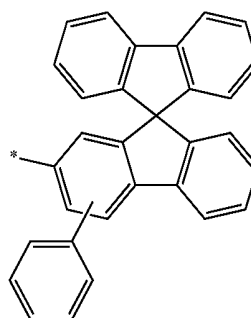
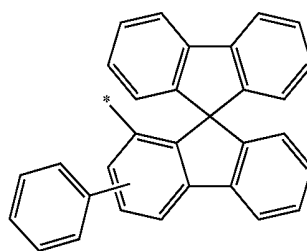
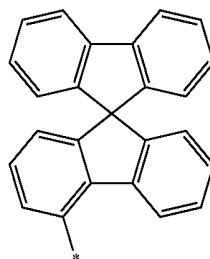
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Formula 6-79

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Formula 6-80

Formula 6-81

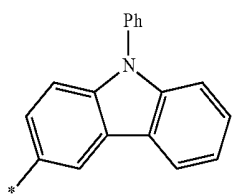
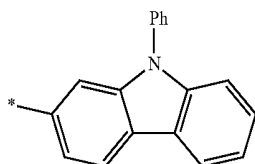
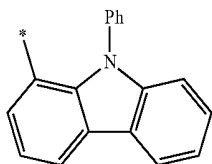
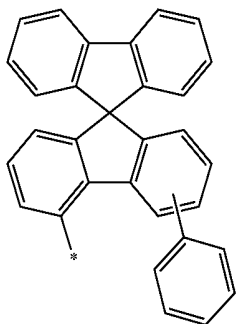
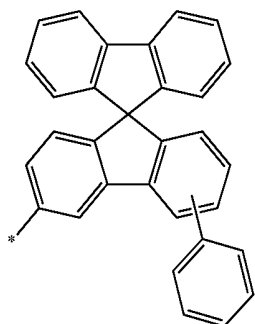
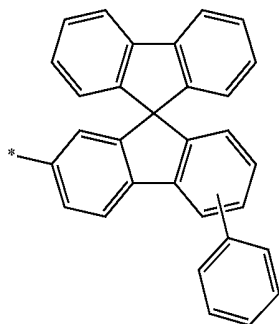
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Formula 6-86

Formula 6-87

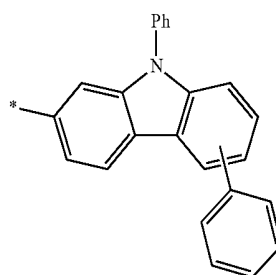
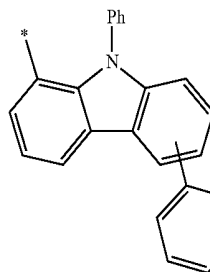
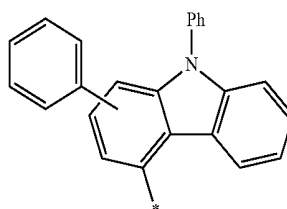
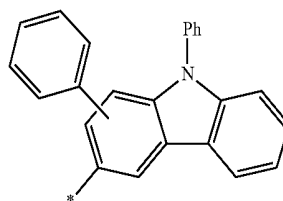
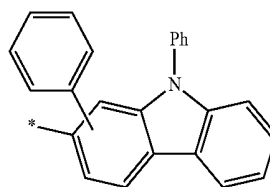
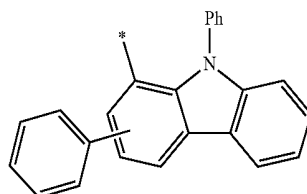
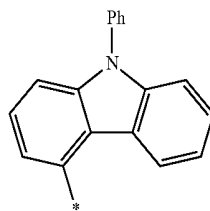
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Formula 6-91

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Formula 6-92

Formula 6-93

Formula 6-94

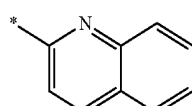
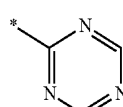
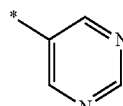
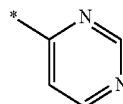
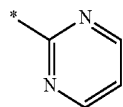
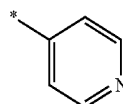
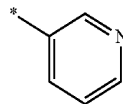
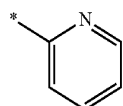
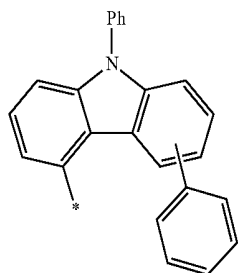
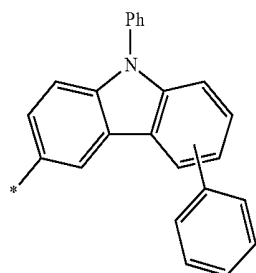
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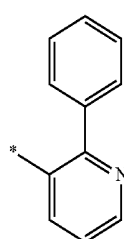
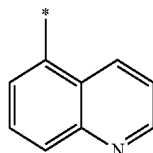
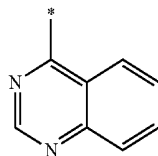
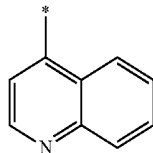
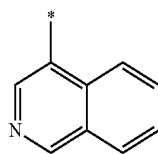
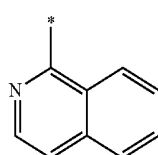
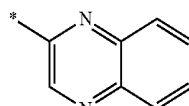
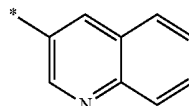
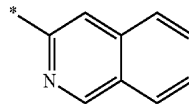
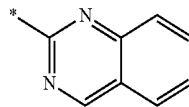
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Formula 6-99

Formula 6-100

Formula 10-1

Formula 10-2

Formula 10-3

Formula 10-4

Formula 10-5

Formula 10-6

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Formula 10-8

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Formula 10-10

Formula 10-11

Formula 10-12

Formula 10-13

Formula 10-14

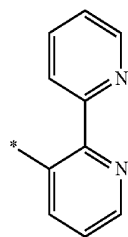
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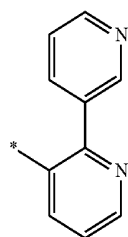
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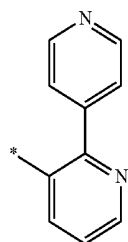
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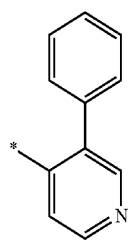
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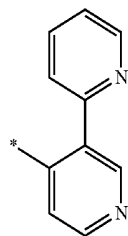
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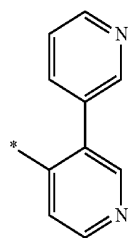
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Formula 10-22

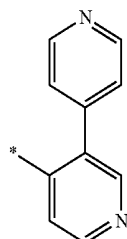


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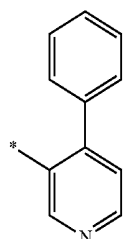


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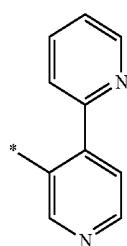
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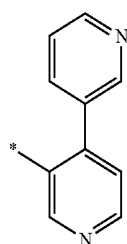
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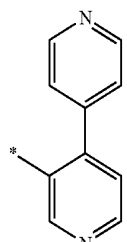
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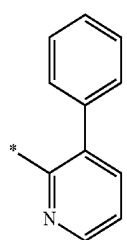
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Formula 10-28

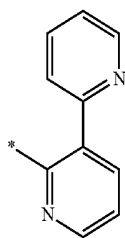


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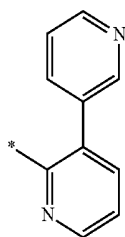


Formula 10-30

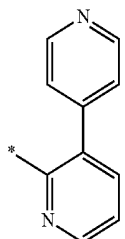
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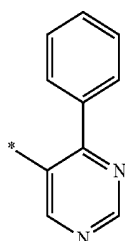
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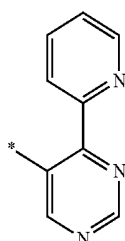
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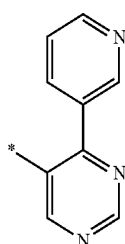
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Formula 10-34

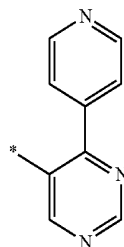


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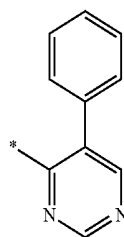


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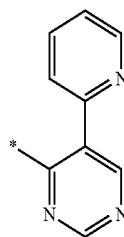
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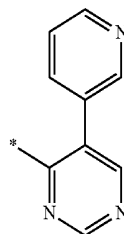
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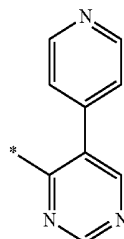
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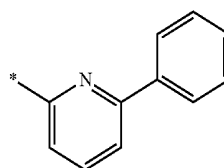
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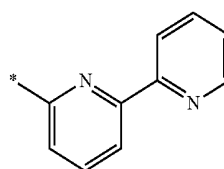
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Formula 10-41

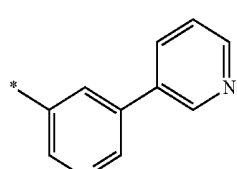
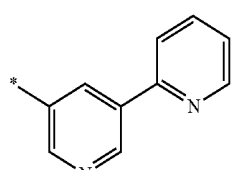
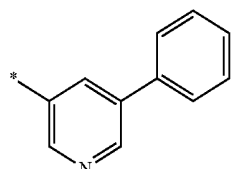
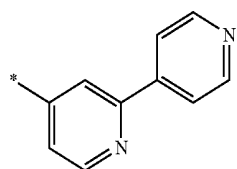
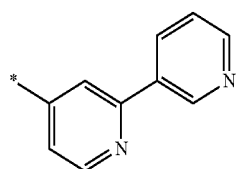
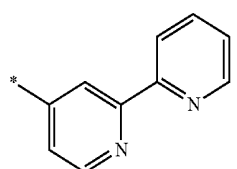
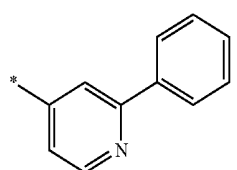
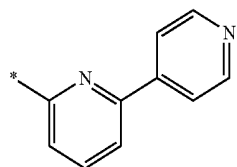
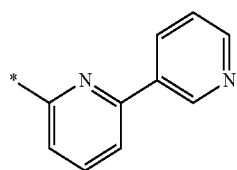


Formula 10-42



Formula 10-43

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Formula 10-44

Formula 10-45

Formula 10-46

Formula 10-47

Formula 10-48

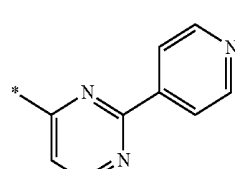
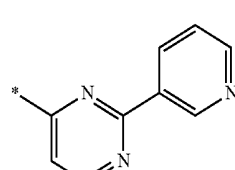
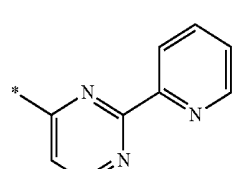
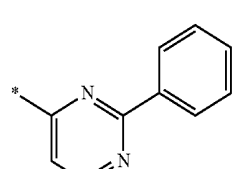
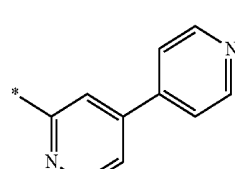
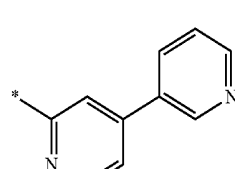
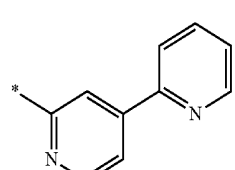
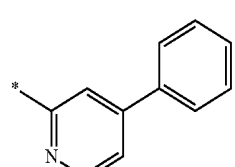
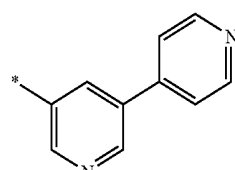
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Formula 10-50

Formula 10-51

Formula 10-52

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Formula 10-53

Formula 10-54

Formula 10-55

Formula 10-56

Formula 10-57

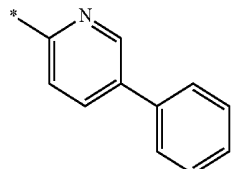
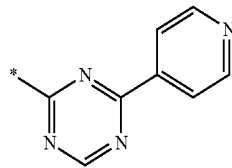
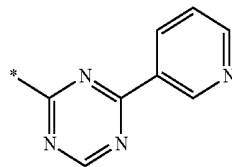
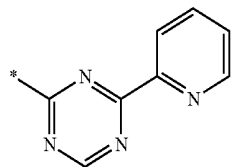
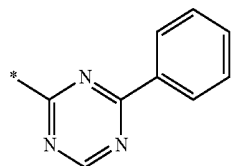
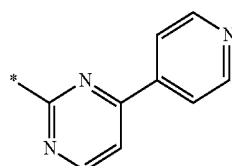
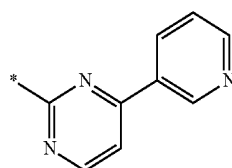
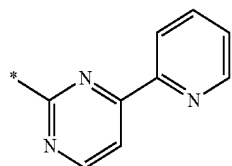
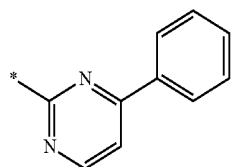
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Formula 10-59

Formula 10-60

Formula 10-61

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Formula 10-62

Formula 10-63

Formula 10-64

Formula 10-65

Formula 10-66

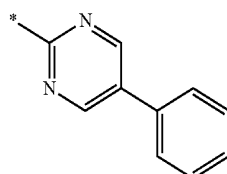
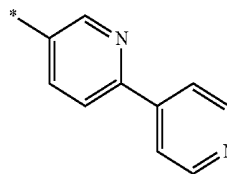
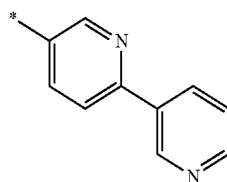
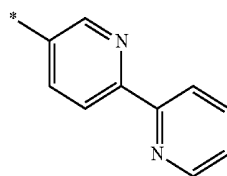
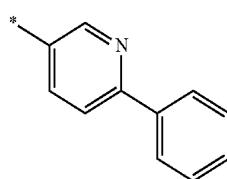
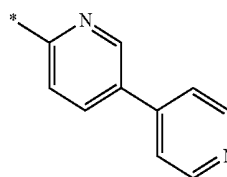
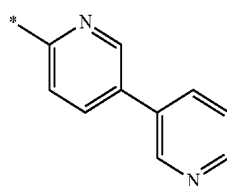
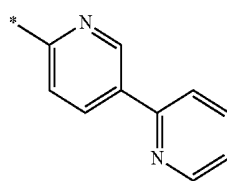
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Formula 10-69

Formula 10-70

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Formula 10-71

Formula 10-72

Formula 10-73

Formula 10-74

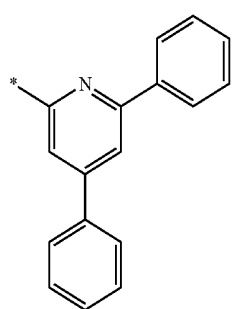
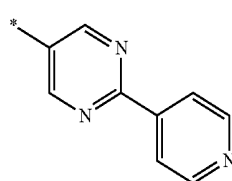
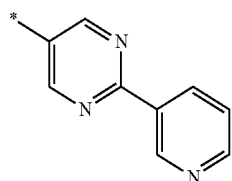
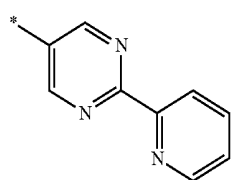
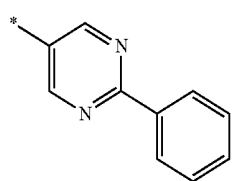
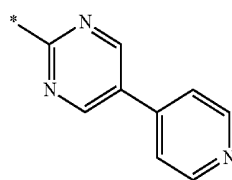
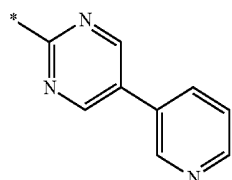
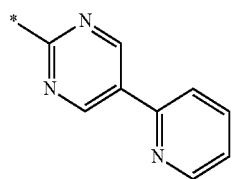
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Formula 10-76

Formula 10-77

Formula 10-78

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Formula 10-79

Formula 10-80

Formula 10-81

Formula 10-82

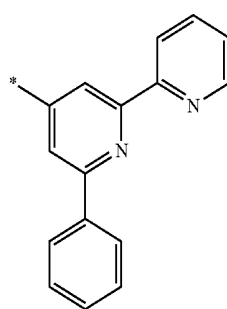
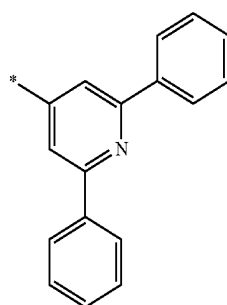
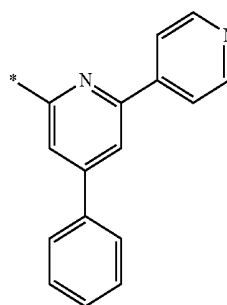
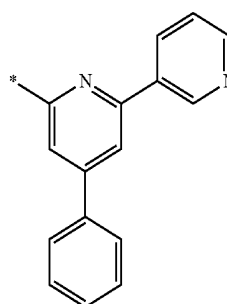
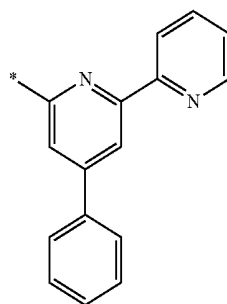
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Formula 10-85

Formula 10-86

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Formula 10-87

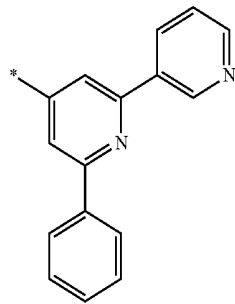
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Formula 10-89

Formula 10-90

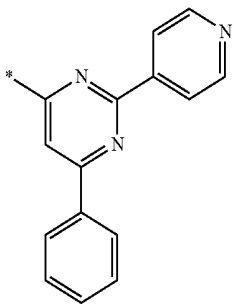
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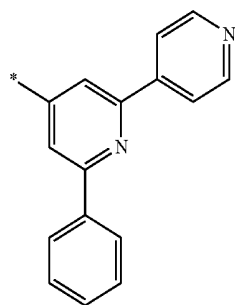


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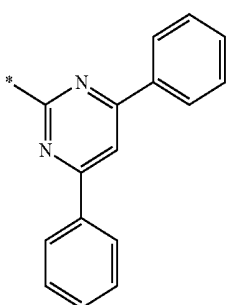
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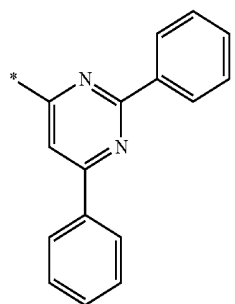
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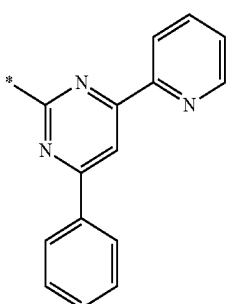
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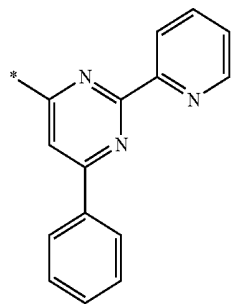
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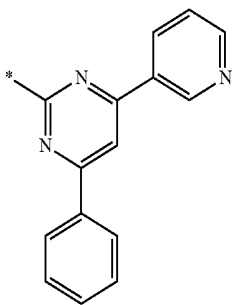
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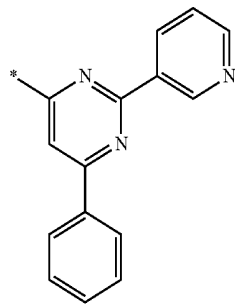
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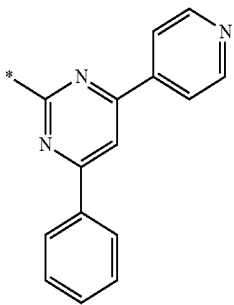
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Formula 10-100

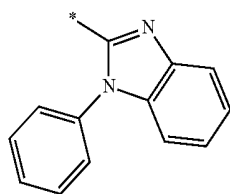
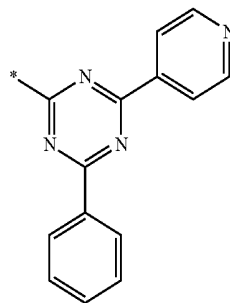
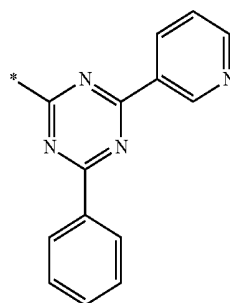
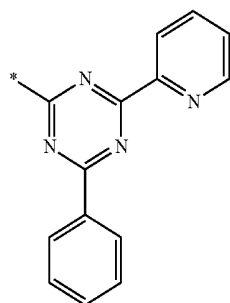
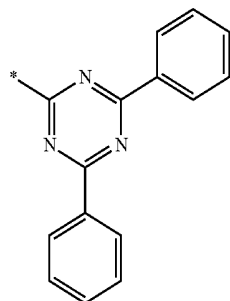


Formula 10-96



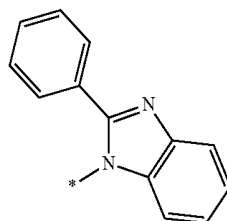
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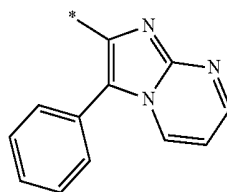
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Formula 10-102



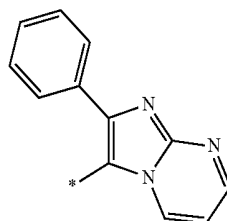
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Formula 10-103



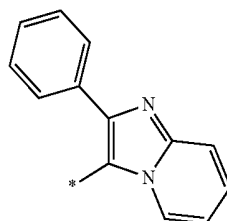
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Formula 10-104



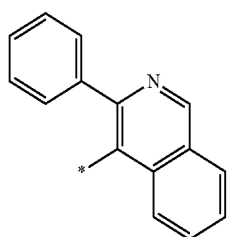
Formula 10-109

Formula 10-105



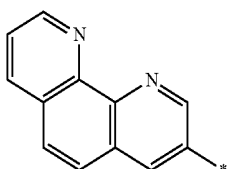
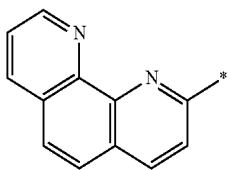
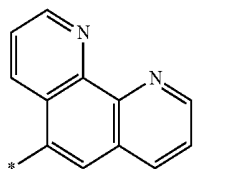
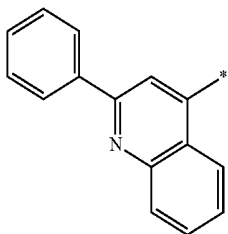
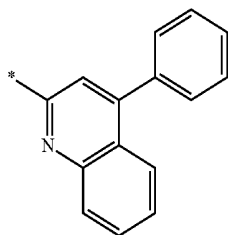
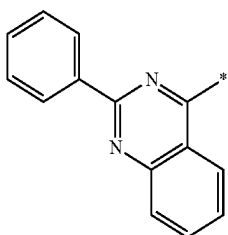
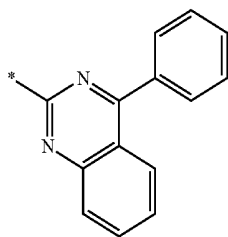
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Formula 10-106



Formula 10-113

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Formula 10-114

Formula 10-115

Formula 10-116

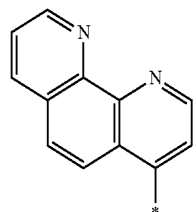
Formula 10-117

Formula 10-118

Formula 10-119

Formula 10-120

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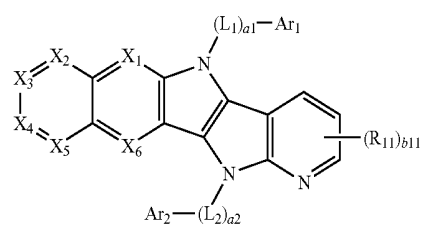
Formula 10-121

wherein Ph in Formulae 6-1 to 6-100 and 10-1 to 10-121 indicates a phenyl group, and * indicates a binding site to a neighboring atom.

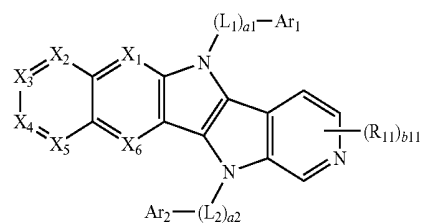
12. The condensed cyclic compound of claim 1, wherein

R_1 to R_6 and R_{11} are each independently selected from hydrogen, deuterium, —F, —Cl, —Br, —I, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, a naphthyl group, and —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, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, and a naphthyl group).

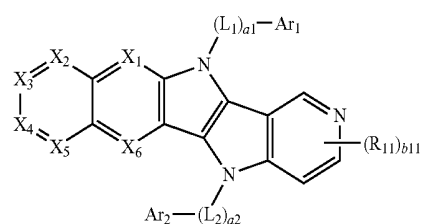
13. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound is represented by one of Formulae 1-1 to 1-7:



Formula 1-1



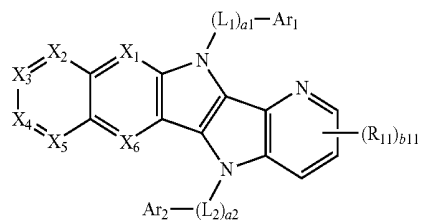
Formula 1-2



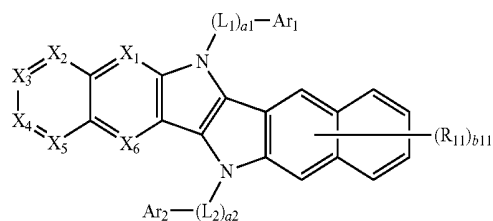
Formula 1-3

-continued

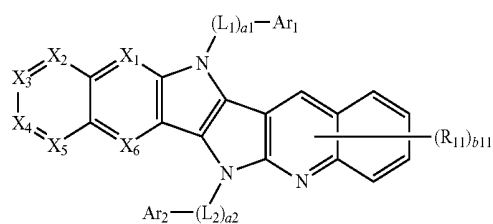
Formula 1-4



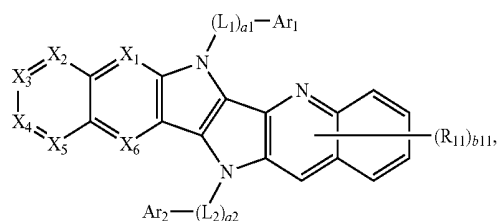
Formula 1-5



Formula 1-6



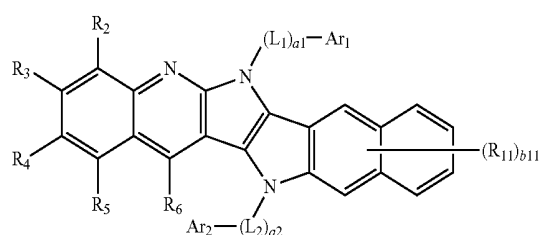
Formula 1-7



L_1 , L_2 , a_1 , a_2 , Ar_1 , Ar_2 , X_1 to X_6 , R_{11} , and b_{11} in Formulae 1-1 to 1-7 are the same as described in claim 1.

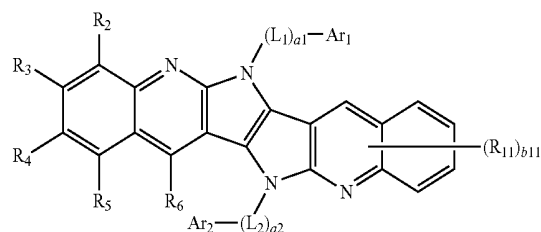
14. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound is represented by one of Formulae 1-5(1) to 1-7(1):

Formula 1-5(1)

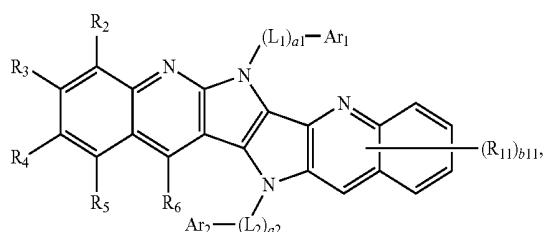


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Formula 1-6(1)



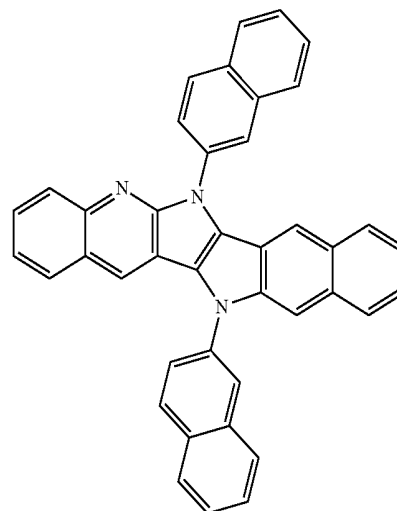
Formula 1-7(1)



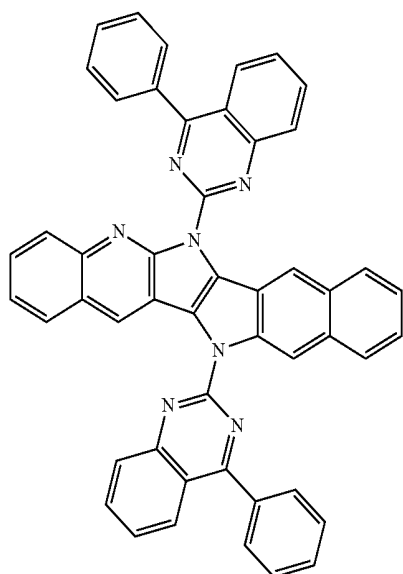
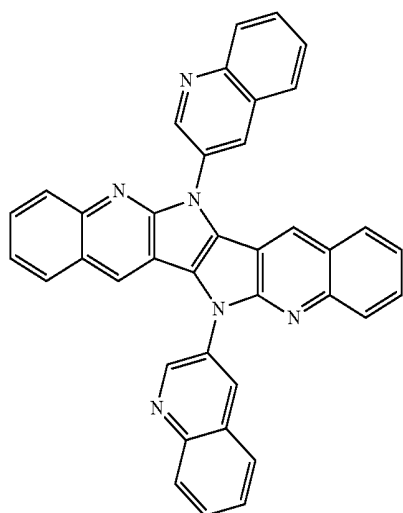
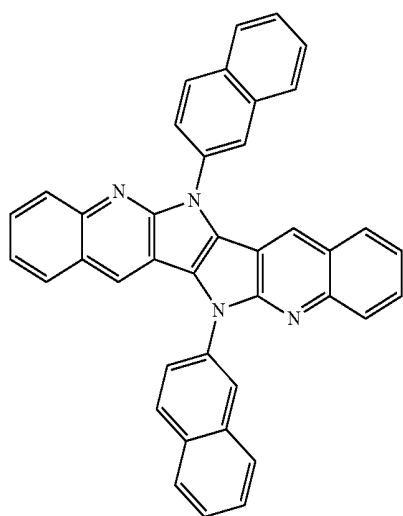
wherein L_1 , L_2 , a_1 , a_2 , Ar_1 , Ar_2 , R_2 to R_6 , R_{11} , and b_{11} in Formulae 1-5(1) to 1-7(1) are the same as described in claim 1.

15. The condensed cyclic compound of claim 1, wherein the condensed cyclic compound is one of Compounds 1 to 4:

1



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16. An organic light-emitting device comprising:
a first electrode;
a second electrode facing the first electrode; and

an organic layer between the first electrode and the second electrode, the organic layer comprising an emission layer;

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

17. The condensed cyclic compound of claim 16, wherein the first electrode is an anode,
the second electrode is a cathode,

the organic layer further comprises a hole transport region between the first electrode and the emission layer and an electron transport region between the emission layer and the second electrode,

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

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

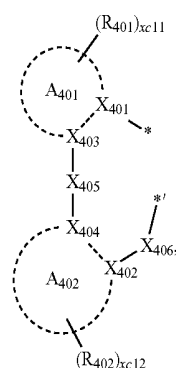
18. The organic light-emitting device of claim 16, wherein the emission layer comprises the condensed cyclic compound.

19. The organic light-emitting device of claim 16, wherein the emission layer further comprises a phosphorescent dopant, and the condensed cyclic compound acts as a host.

20. The organic light-emitting device of claim 19, wherein the phosphorescent dopant comprises an organometallic complex represented by Formula 401:



<Formula 402>



wherein, in Formulae 401 and 402,

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

L_{401} is selected from ligands represented by Formula 402, and xc1 is 1, 2, or 3, wherein, when xc1 is two or more, two or more $L_{401}(S)$ are identical to or different from each other,

L_{402} is an organic ligand, and xc2 is an integer between 0 and 4, inclusive, wherein, when xc2 is two or more, two or more $L_{402}(s)$ are identical to or different from each other,

X_{401} to X_{404} are each independently nitrogen or carbon,

X_{401} and X_{403} are linked via a single bond or a double bond, and X_{402} and X_{404} are linked via a single bond or a double bond,

A_{401} and A_{402} are each independently a C_5 - C_{60} carbocyclic group or a C_1 - C_{60} heterocyclic group,

X_{405} is a single bond, $*-O-*$, $*-S-*$, $*-C(=O)-*$, $*-N(Q_{411})-*$, $*-C(Q_{411})(Q_{412})-*$, $*-C(Q_{411})=C(Q_{412})-*$, $*-C(Q_{411})=*$, or $*=C(Q_{411})=*$, wherein Q_{411} and Q_{412} are hydrogen, deuterium, a C_1 - C_{20} alkyl group, a C_1 - C_{20} alkoxy group, a phenyl group, a biphenyl group, a terphenyl group, or a naphthyl group,

X_{406} is a single bond, O, or S,

R_{401} and R_{402} are each independently selected from hydrogen, deuterium, $-F$, $-Cl$, $-Br$, $-I$, a hydroxyl group, a cyano group, a nitro group, an amidino group, a hydrazino group, a hydrazono group, a substituted or unsubstituted C_1 - C_{20} alkyl group, a substituted or unsubstituted C_1 - C_{20} alkoxy group, a substituted or unsubstituted C_3 - C_{10} cycloalkyl group, a substituted or unsubstituted heterocycloalkyl group, a substituted or

unsubstituted C_3 - C_{10} cycloalkenyl group, a substituted or unsubstituted C_1 - C_{10} heterocycloalkenyl group, a substituted or unsubstituted C_6 - C_{60} aryl group, a substituted or unsubstituted C_6 - C_{60} aryloxy group, a substituted or unsubstituted C_6 - C_{60} arylthio group, a substituted or unsubstituted C_1 - C_{60} heteroaryl group, a substituted or unsubstituted monovalent non-aromatic condensed polycyclic group, a substituted or unsubstituted monovalent non-aromatic condensed heteropolycyclic group $-Si(Q_{401})(Q_{402})(Q_{403})$, $-N(Q_{401})(Q_{402})$, $-B(Q_{401})(Q_{402})$, $-C(=O)(Q_{401})$, $-S(=O)_2(Q_{401})$, and $-P(=O)(Q_{401})(Q_{402})$, wherein Q_{401} to Q_{403} are each independently selected from a C_1 - C_{10} alkyl group, a C_1 - C_{10} alkoxy group, a C_6 - C_{20} aryl group, and a C_1 - C_{20} heteroaryl group,

$xc11$ and $xc12$ are each independently an integer between 0 and 10, inclusive, and

$*$ and $*$ in Formula 402 each indicate a binding site to M in Formula 401.

* * * * *

专利名称(译)	缩合环状化合物和包括其的有机发光器件		
公开(公告)号	US20170256721A1	公开(公告)日	2017-09-07
申请号	US15/452392	申请日	2017-03-07
[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. 产学合作基础庆尚大学		
当前申请(专利权)人(译)	三星DISPLAY CO. , LTD. 产学合作基础庆尚大学		
[标]发明人	KIM MIKYUNG KIM YUNHI KIM HEEYEON KWON SOONKI BAEK JANGYEOL SEO JIHYUN JEONG HYEIN		
发明人	KIM, MIKYUNG KIM, YUNHI KIM, HEEYEON KWON, SOONKI BAEK, JANGYEOL SEO, JIHYUN JEONG, HYEIN		
IPC分类号	H01L51/00 C09K11/06 C07D471/22 C09K11/02		
CPC分类号	H01L51/0072 C09K2211/185 C09K11/06 H01L51/0085 C07D471/22 H01L51/0058 H01L51/5056 H01L51/5072 H01L51/5096 H01L51/5024 H01L51/5092 H01L51/5016 C09K2211/1007 C09K2211 /1029 C09K11/025 C09K2211/1011 C09K2211/1074 H01L51/0061		
优先权	1020160027153 2016-03-07 KR		
外部链接	Espacenet USPTO		

摘要(译)

提供缩合环状化合物和包含其的有机发光装置。该化合物可由以下结构表示：其中X 1 是N或C (R 1) , X 2 是N或C (R 2) , X 3 是N或C (R 3) , X 4 是N或C (R 4) , X 5 是N或C (R 5) , X 6 是N或C (R 6) , 环A 1 是C 5 -C 60 碳环基团或C 2 -C 60 杂环基, 条件是环A 1 不是苯。

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190

150

110