US 20150263290A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2015/0263290 A1**

(43) **Pub. Date: Sep. 17, 2015**

Cho et al.

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

(71) Applicant: **SAMSUNG DISPLAY CO., LTD.**, Yongin-City (KR)

(72) Inventors: **Se-Jin Cho**, Yongin-City (KR); **Chang-Min Lee**, Yongin-City (KR)

(21) Appl. No.: **14/340,442**

(22) Filed: **Jul. 24, 2014**

(30) **Foreign Application Priority Data**

Mar. 11, 2014 (KR) 10-2014-0028599

Publication Classification

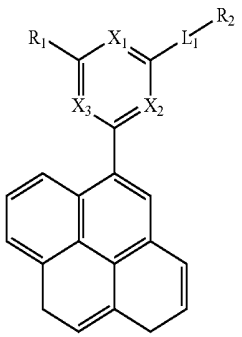
(51) **Int. Cl.**
H01L 51/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H01L 51/0058*** (2013.01); ***H01L 51/0067*** (2013.01); ***H01L 51/0072*** (2013.01); ***H01L 51/0065*** (2013.01); *H01L 51/5092* (2013.01)

(57) **ABSTRACT**

A condensed cyclic compound is represented by Formula 1, and an organic light-emitting device includes the condensed cyclic compound.

Formula 1



In Formula 1, X_1, X_2, X_3, L_1, R_1, and R_2 are already stated in the detailed description. An organic light-emitting device including an organic layer having the condensed cyclic compound has improved color change in a relatively low-gradation region.

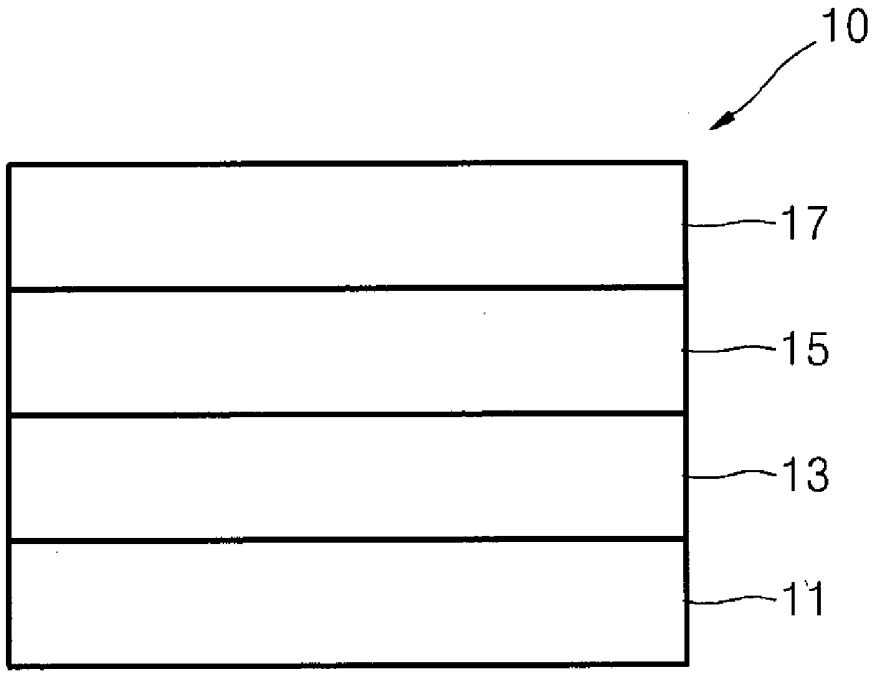


FIG. 1

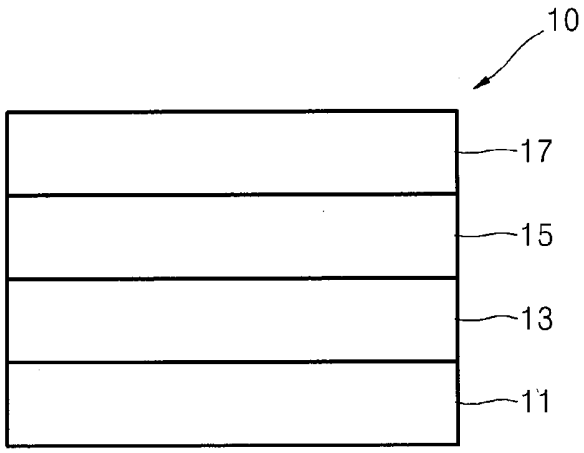
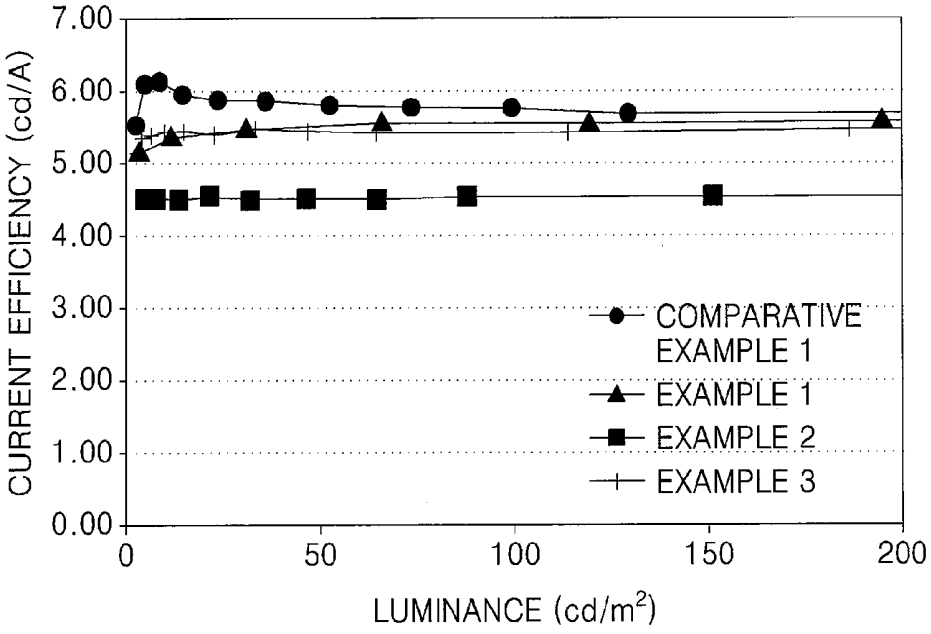

10
17
15
13
11

FIG. 2


7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
CURRENT EFFICIENCY (cd/A)
0
50
100
150
200
LUMINANCE (cd/m2)
COMPARATIVE EXAMPLE 1
EXAMPLE 1
EXAMPLE 2
EXAMPLE 3

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

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to and the benefit of Korean Patent Application No. 10-2014-0028599, filed on Mar. 11, 2014, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

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

[0004] 2. Description of the Related Art

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

[0006] A typical organic light-emitting device has a structure including a substrate, and an anode, a hole transport layer, an emission layer, an electron transport layer, and a cathode sequentially stacked on the substrate. The hole transport layer, the emission layer, and the electron transport layer are organic thin films formed of organic compounds.

[0007] In typical organic light-emitting devices, the mobility of electrons is lower than that of holes, and thus, electrons and holes may less likely to meet and combine in the emission layer, leading to low emission efficiency. In addition, the energy band of the emission layer does not match with that of the electron transport layer. Accordingly, electrons may have difficulty to enter into the emission layer.

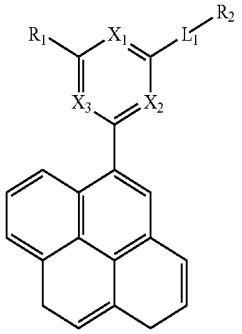
SUMMARY

[0008] Aspects of one or more embodiments of the present invention are directed toward a material that provides good energy band matching and ease of electron supply to improve color change in a relatively low gradation region. Aspects of one or more embodiments of the present invention are directed toward a novel condensed cyclic compound for an organic light-emitting device (which improves color change in a relatively low-gradation region), and an organic light-emitting device including the novel condensed cyclic compound.

[0009] 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.

[0010] According to one or more embodiments of the present invention, a condensed cyclic compound is represented by Formula 1 below:

Formula 1



[0011] wherein in Formula 1,

[0012] X_1, X_2, and X_3 may be each independently N or —CH, and at least one of X_1, X_2, and X_3 may be N.

[0013] R_1 and R_2 may be each independently selected from a hydrogen, a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, a C_1-C_{40} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group;

[0014] a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, and a C_1-C_{40} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group; and

[0015] a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group.

[0016] L_1 may be selected from a direct bond; a C_6-C_{40} arylene group; a C_2-C_{40} heteroarylene group; and a C_6-C_{40} arylene group and a C_2-C_{40} heteroarylene group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt

thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, a C_6-C_{40} arylthio group, —$N(Q_{11})(Q_{12})$, and —$Si(Q_{13})(Q_{14})(Q_{15})$; and

[0017] Q_{11} to Q_{15} may be each independently selected from a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, a C_1-C_{40} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group;

[0018] a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, and a C_1-C_{40} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group; and

[0019] a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group.

[0020] According to one or more embodiments of the present invention, 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, wherein the organic layer includes at least one of the condensed cyclic compounds.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] These and/or other aspects will become apparent and more readily appreciated from the following description of the embodiments, taken in conjunction with the drawings, in which

[0022] FIG. **1** is a schematic view of an organic light-emitting device according to an embodiment; and

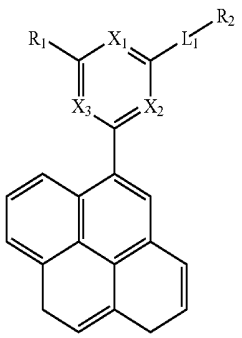
[0023] FIG. **2** is a graph showing current efficiency with respect to luminance of the organic light-emitting devices of Comparative Example 1 and Examples 1 to 3.

DETAILED DESCRIPTION

[0024] Reference will now be made in more detail to embodiments, examples of which are illustrated in the accompanying drawings, wherein like reference numerals refer to like elements throughout. In this regard, the present embodiments may have different forms and should not be construed as being limited to the descriptions set forth herein. Accordingly, the embodiments are merely described below, by referring to the figures, to explain aspects of the present description. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items. Expressions such as "at least one of," when preceding a list of elements, modify the entire list of elements and do not modify the individual elements of the list. Further, the use of "may" when describing embodiments of the present invention refers to "one or more embodiments of the present invention."

[0025] A condensed cyclic compound according to an embodiment may be represented by Formula 1 illustrated below:

Formula 1



[0026] wherein in Formula 1,

[0027] X_1, X_2, and X_3 may be each independently N or —CH, and at least one of X_1, X_2, and X_3 may be N.

[0028] R_1 and R_2 may be each independently selected from a hydrogen, a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, a C_1-C_{40} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group;

[0029] a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, and a C_1-C_{40} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group; and

[0030] a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} het-

erocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group.

[0031] L_1 may be selected from a direct bond; a C_6-C_{40} arylene group; a C_2-C_{40} heteroarylene group; and a C_6-C_{40} arylene group and a C_2-C_{40} heteroarylene group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group, —$N(Q_{11})(Q_{12})$, and —$Si(Q_{13})(Q_{14})(Q_{15})$; and

[0032] Q_{11} to Q_{15} may be each independently selected from a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, a C_1-C_{40} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group;

[0033] a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, and a C_1-C_{40} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group; and

[0034] a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group.

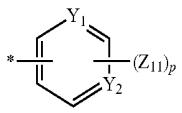
[0035] For example, R_1 and R_2 may be each independently selected from a hydrogen, a deuterium, a phenyl group, a pentalenyl group, and indenyl group, a naphthyl group, an azulenyl group, an indacenyl group, an acenaphthyl group, a biphenyl group, a heptalenyl group, a phenalenyl group, a fluorenyl group, a phenanthrenyl group, an anthyrl group, a fluoranthenyl group, a pyrenyl group, a benzofluorenyl group, a naphthacenyl group, a chrysenyl group, a triphenylenyl group, a terphenyl group, a perylenyl group, a picenyl group, a hexacenyl group, a spiro-fluorenyl group, a pyrrolyl group, a furyl group, a pyrazolyl group, an imidazolyl group, an oxazolyl group, an isooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a pyridyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a pyranyl group, a thiophenyl group, a thiazolyl group, an isothiazolyl group, a thiopyran group, an indolyl group, an isoindolyl group, an indolizinyl group, a benzofuryl group, an isobenzofuryl group, an indazolyl group, a benzimidazolyl group, a benzoxazolyl group, a benzisooxazolyl group, an imidazopyridyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a phthalazinyl group, a quinazolinyl group, a quinoxalinyl group, a naphthyridinyl group, a cinnolinyl group, a benzothiophenyl group, a benzothiazolyl group, a carbazolyl group, a pyridoindolyl group, a dibenzofuryl group, a phenanthridinyl group, a benzoquinolyl group, a phenazinyl group, a dibenzosilolyl group, a dibenzothiophenyl group, and a benzocarbazolyl group; and

[0036] a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, an indacenyl group, an acenaphthyl group, a biphenyl group, a heptalenyl group, a phenalenyl group, a fluorenyl group, a phenanthrenyl group, an anthryl group, a fluoranthenyl group, a pyrenyl group, a benzofluorenyl group, a naphthacenyl group, a chrysenyl group, a triphenylenyl group, a terphenyl group, a perylenyl group, a picenyl group, a hexacenyl group, a spiro-fluorenyl group, a pyrrolyl group, a furyl group, a pyrazolyl group, an imidazolyl group, an oxazolyl group, an isooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a pyridyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a pyranyl group, a thiophenyl group, a thiazolyl group, an isothiazolyl group, a thiopyran group, an indolyl group, an isoindolyl group, an indolizinyl group, a benzofuryl group, an isobenzofuryl group, an indazolyl group, a benzimidazolyl group, a benzoxazolyl group, a benzisooxazolyl group, an imidazopyridyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a phthalazinyl group, a quinazolinyl group, a quinoxalinyl group, a naphthyridinyl group, a cinnolinyl group, a benzothiophenyl group, a benzothiazolyl group, a carbazolyl group, a pyridoindolyl group, a dibenzofuryl group, a phenanthridinyl group, a benzoquinolyl group, a phenazinyl group, a dibenzosilolyl group, a dibenzothiophenyl group and a benzocarbazolyl group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} het-

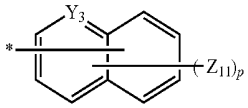
erocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group.

[0037] For example, R_1 and R_2 may each be independently represented by any one of Formulae 2A to 2D below:

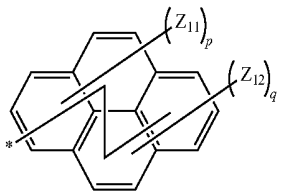
Formula 2A



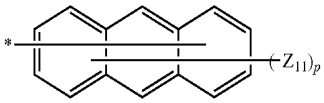
Formula 2B



Formula 2C



Formula 2D



[0038] in Formulae 2A to 2D,

[0039] Y_1, Y_2, and Y_3 may be each independently N or —CH.

[0040] Z_{11} and Z_{12} may be each independently selected from a hydrogen, a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a C_6-C_{20} aryl group, and a C_2-C_{20} heteroaryl group;

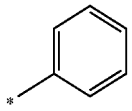
[0041] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof; and

[0042] a C_6-C_{20} aryl group and a C_2-C_{20} heteroaryl group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a C_6-C_{20} aryl group, and a C_2-C_{20} heteroaryl group.

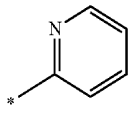
[0043] p may be an integer of 3 to 9; q may be 4 or 5; and * may be a binding site. For example, p may be an integer of 3 to 5 in Formula 2A, an integer of 3 to 7 in Formula 2B, an integer of 3 to 5 in Formula 2C, and an integer of 3 to 9 in Formula 2D. For example, p may be 3 in Formula 2A, 6 in Formula 2B, 5 in Formula 2C, and 9 in Formula 2D.

[0044] For example, R_1 and R_2 may each be independently represented by any one of Formulae 3A to 3J below:

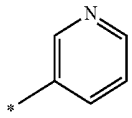
Formula 3A



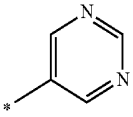
Formula 3B



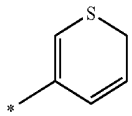
Formula 3C



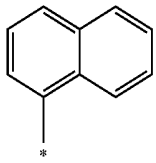
Formula 3D



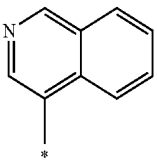
Formula 3E



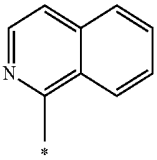
Formula 3F



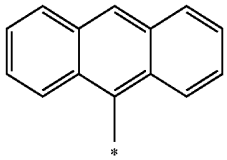
Formula 3G



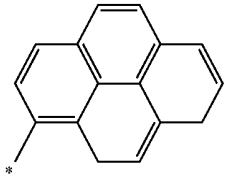
Formula 3H



Formula 3I



Formula 3J



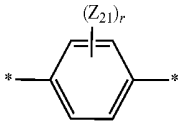
[0045] in the formulae above, * indicates a binding site.

[0046] L_1 may be selected from a direct bond, a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, an indacenylene group, an acenaphthylene group, a biphenylene group, a heptalenylene group, a phenalenylene group, a fluorenylene group, a phenanthrenylene group, an anthrylene group, a fluoranthenylene group, a pyrenylene group, a benzofluorenylene group, a naphthacenylene group, a chrysenylene group, and a triphenylenylene group; and

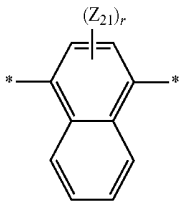
[0047] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, an indacenylene group, an acenaphthylene group, a biphenylene group, a heptalenylene group, a phenalenylene group, a fluorenylene group, a phenanthrenylene group, an anthrylene group, a fluoranthenylene group, a pyrenylene group, a benzofluorenylene group, a naphthacenylene group, a chrysenylene group, and a triphenylenylene group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group.

[0048] For example, L_1 may be a direct bond, or may be represented by any one of Formulae 4A and 4B illustrated below.

Formula 4A



Formula 4B



[0049] wherein in Formulae 4A and 4B,

[0050] Z_{21} may be each independently selected from a hydrogen, a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_2-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a C_6-C_{20} aryl group, and a C_2-C_{20} heteroaryl group;

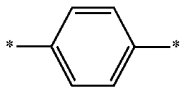
[0051] a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof; and

[0052] a C_6-C_{20} aryl group and a C_2-C_{20} heteroaryl group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a C_6-C_{20} aryl group, and a C_2-C_{20} heteroaryl group.

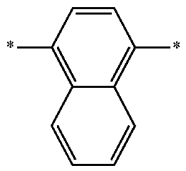
[0053] r may be an integer of 4 to 6, and * indicates a binding site. For example, r may be 4 in Formula 4A, and 6 for Formula 4B.

[0054] For example, L_1 may be a direct bond, or may be represented by any one of Formulae 5A and 5B illustrated below.

Formula 5A



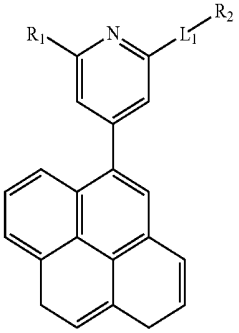
Formula 5B



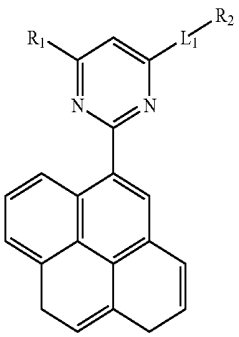
[0055] In Formulae 5A and 5B, * indicates a binding site.

[0056] The condensed cyclic compound of Formula 1 may be represented by any one of Formulae 1A to 1C below:

Formula 1A

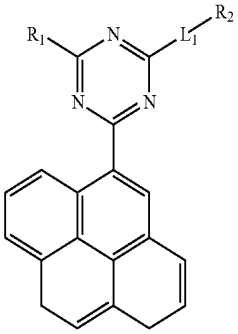


Formula 1B



-continued

Formula 1C

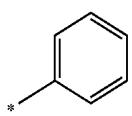


[0057] R_1 and R_2 in Formulae 1A to 1C may be each independently selected from a C_6-C_{40} aryl group and a C_2-C_{40} heteroaryl group. L_1 may be selected from a direct bond, a C_6-C_{40} arylene group, and a C_2-C_{40} heteroarylene group.

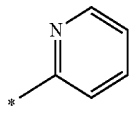
[0058] R_1 and R_2 in Formulae 1A to 1C may be each independently selected from a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, an indacenyl group, an acenaphthyl group, a biphenyl group, a heptalenyl group, a phenalenyl group, a fluorenyl group, a phenanthrenyl group, an anthryl group, a fluoranthenyl group, a pyrenyl group, a benzofluorenyl group, a naphthacenyl group, a chrysenyl group, a triphenylenyl group, a terphenyl group, a perylenyl group, a picenyl group, a hexacenyl group, a spiro-fluorenyl group, a pyrrolyl group, a furyl group, a pyrazolyl group, an imidazolyl group, an oxazolyl group, an isooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a pyridyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a pyranyl group, a thiophenyl group, a thiazolyl group, an isothiazolyl group, a thiopyran group, an indolyl group, an isoindolyl group, an indolizinyl group, a benzofuryl group, an isobenzofuryl group, an indazolyl group, a benzimidazolyl group, a benzoxazolyl group, a benzisooxazolyl group, an imidazopyridyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a phthalazinyl group, a quinazolinyl group, a quinoxalinyl group, a naphthyridinyl group, a cinnolinyl group, a benzothiophenyl group, a benzothiazolyl group, a carbazolyl group, a pyridoindolyl group, a dibenzofuryl group, a phenanthridinyl group, a benzoquinolyl group, a phenazinyl group, a dibenzosilolyl group, a dibenzothiophenyl group, and a benzocarbazolyl group.

[0059] For example, R_1 and R_2 may each be independently represented by any one of Formulae 3A to 3J below:

Formula 3A

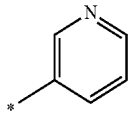


Formula 3B

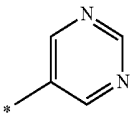


-continued

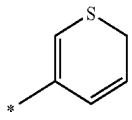
Formula 3C



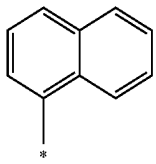
Formula 3D



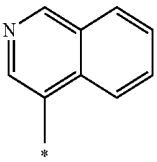
Formula 3E



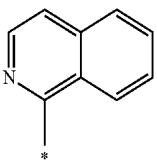
Formula 3F



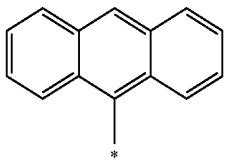
Formula 3G



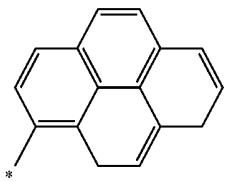
Formula 3H



Formula 3I



Formula 3J



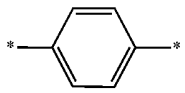
[0060] in the formulae above, * indicates a binding site.

[0061] For example, R_2 may be represented by any one of Formulae 3A, 3F, 3I, and 3J.

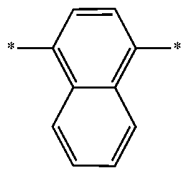
[0062] L_1 may be selected from a direct bond, a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, an indacenylene group, an acenaphthylene group, a biphenylene group, a heptalenylene group, a phenalenylene group, a fluorenylene group, a phenanthrenylene group, an anthrylene group, a fluoranthenylene group, a pyrenylene group, a benzofluorenylene group, a naphthacenylene group, a chrysenylene group, and a triphenylenylene group.

[0063] For example, L_1 may be a direct bond, or may be represented by any one of Formulae 5A and 5B illustrated below.

Formula 5A



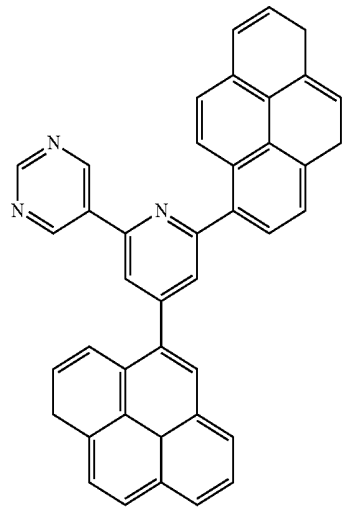
Formula 5B



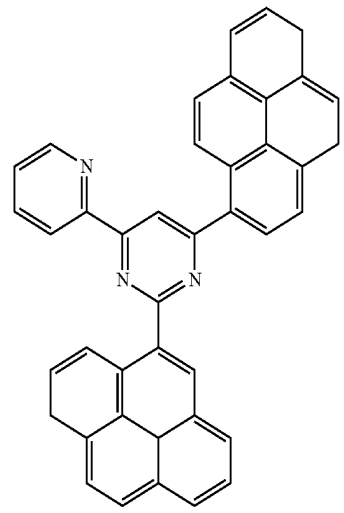
[0064] In Formulae 5A and 5B, * indicates a binding site.

[0065] The condensed cyclic compound represented by Formula 1 may be one of Compounds 1 to 18 below, but is not limited thereto:

1

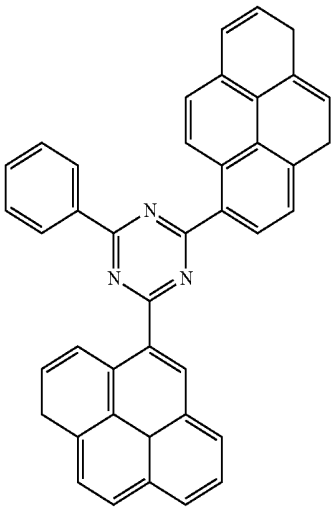


2

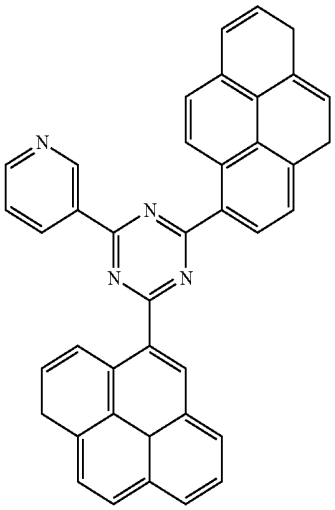


-continued

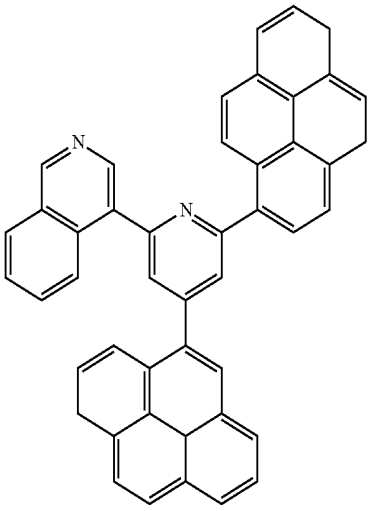
3



4

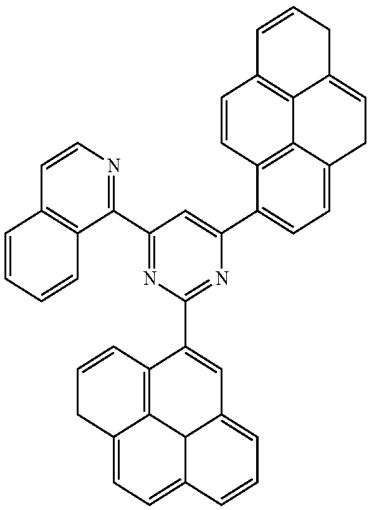


5

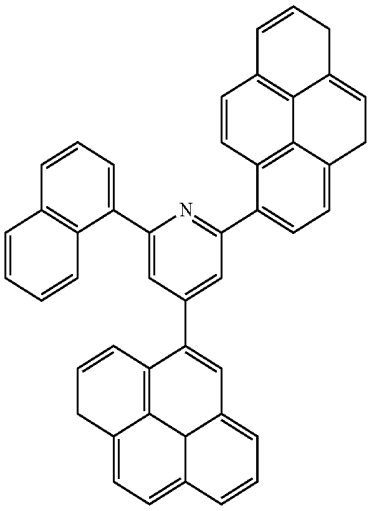


-continued

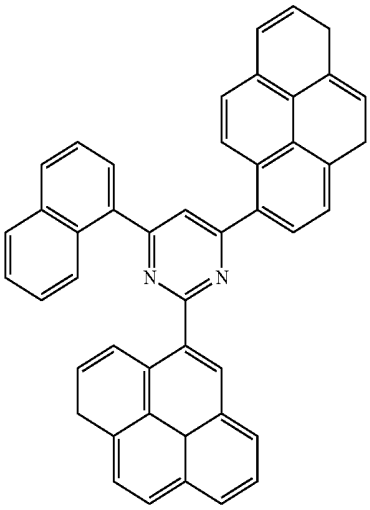
6



7

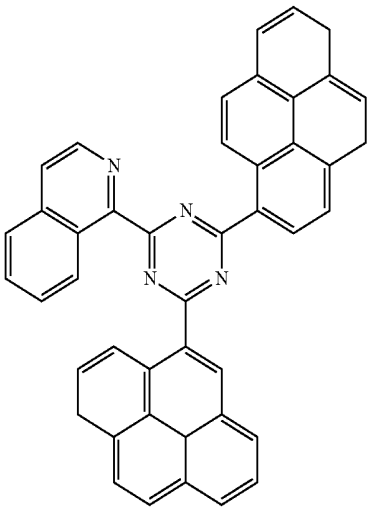


8

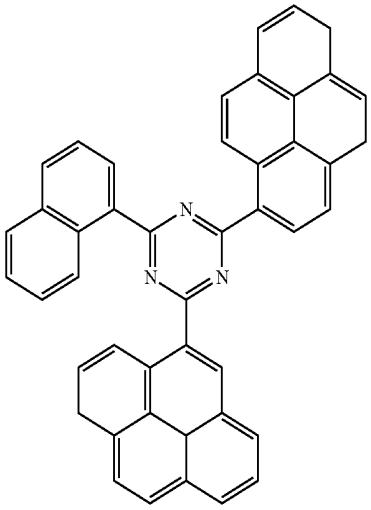


-continued

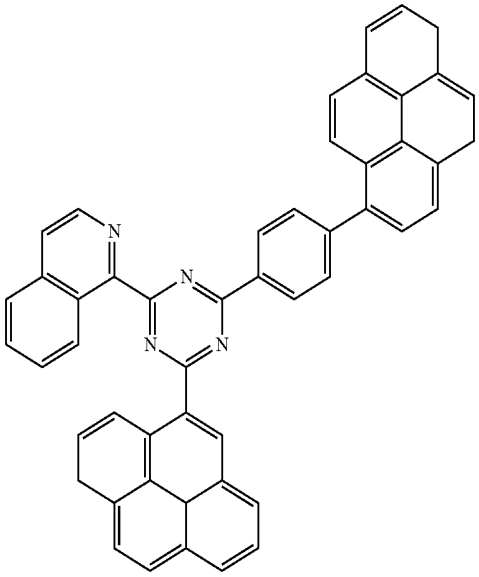
9



10

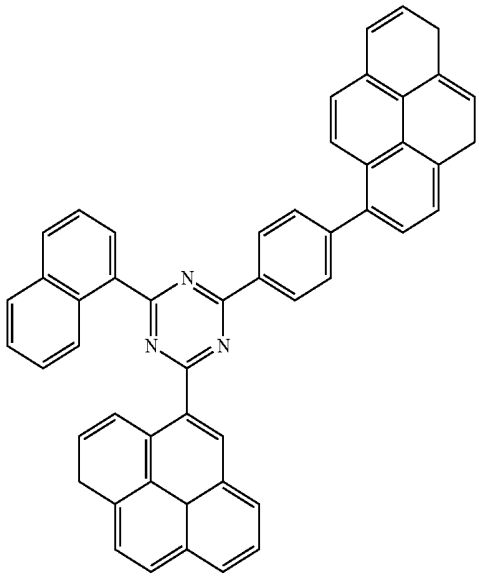


11

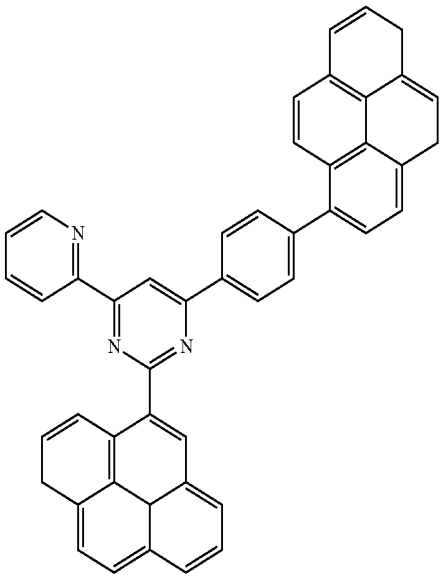


-continued

12

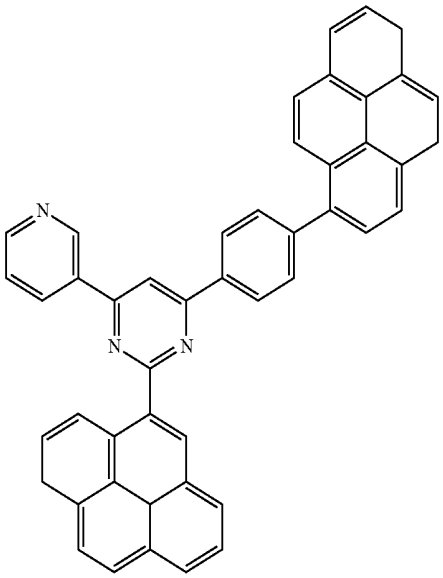


13

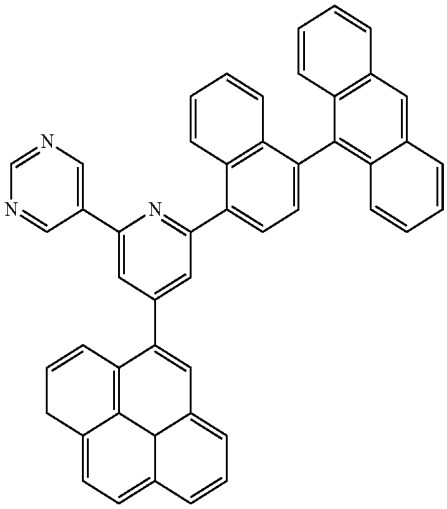


-continued

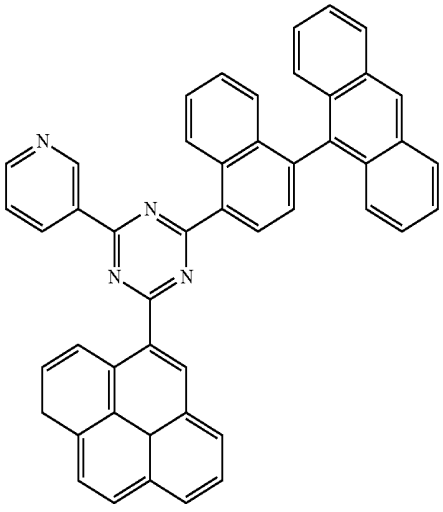
14



15

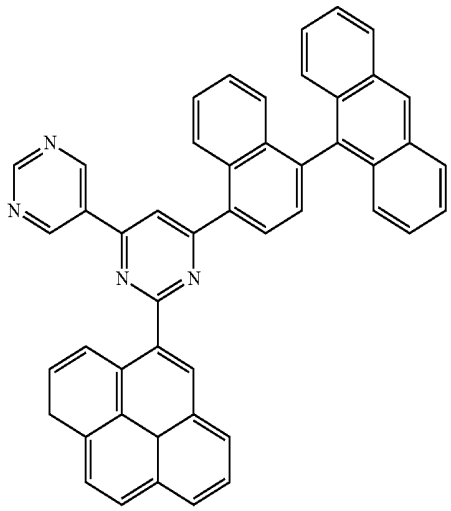


16

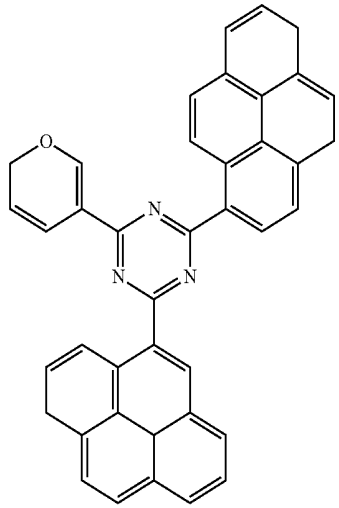


-continued

17



18



[0066] The condensed cyclic compound of Formula 1 may be used (utilized) as a material for an electron transport region of an organic light-emitting device.

[0067] The condensed cyclic compound of Formula 1 has excellent energy band matching characteristics with respect to an emission layer; and allows electrons to be easily supplied, thereby improving the color change in a relatively low-gradation region.

[0068] The unsubstituted C_1-C_{40} alkyl group (or C_1-C_{40} alkyl group) used herein may be a linear or branched C_1-C_{40} alkyl group, and examples thereof are a methyl group, an ethyl group, a propyl group, an isobutyl group, a sec-butyl group, a pentyl group, an iso-amyl group, and a hexyl group.

[0069] The unsubstituted C_1-C_{40} alkoxy group (or C_1-C_{40} alkoxy group) used herein may be represented by —OA (A is an unsubstituted C_1-C_{40} alkyl group described above), and examples thereof are a methoxy group, an ethoxy group, and an isopropyloxy group.

[0070] The unsubstituted C_2-C_{40} alkenyl group (or C_2-C_{40} alkenyl group) used herein refers to an unsubstituted C_2-C_{40} alkyl group that has at least one carbon double bond in the middle or end thereof, and examples thereof are an ethenyl group, a propenyl group, and a butenyl group.

[0071] The unsubstituted C_2-C_{40} alkynyl group (or C_2-C_{40} alkynyl group) used herein refers to an unsubstituted C_2-C_{60} alkyl group that has at least one carbon triple bond in the middle or end thereof, and examples thereof are an ethynyl group and a propynyl group.

[0072] The C_6-C_{40} aryl group is a monovalent group having a carbocyclic aromatic system having 6 to 40 carbon atoms including at least one aromatic ring. The C_6-C_{40} arylene group is a divalent group having a carbocyclic aromatic system having 6 to 40 carbon atoms including at least one aromatic ring. When the aryl group and the arylene group have at least two rings, they may be fused to each other.

[0073] Examples of the C_6-C_{40} aryl group are a phenyl group, a C_1-C_{10} alkylphenyl group (for example, an ethylphenyl group), a C_1-C_{10} alkylbiphenyl group (for example, an ethylbiphenyl group), a halophenyl group (for example, an o-, m- or p-fluorophenyl group, or a dichlorophenyl group), a dicyanophenyl group, a trifluoromethoxyphenyl group, an o-, m-, or p-tollyl group, an o-, m-, or p-cumenyl group, a mesityl group, a phenoxyphenyl group, a (α,α-dimethylbenzene) phenyl group, a (N,N'-dimethyl)aminophenyl group, a (N,N'-a diphenyl)aminophenyl group, a pentalenyl group, an indenyl group, a naphthyl group, a halonaphthyl group (for example, a fluoronaphthyl group), a C_1-C_{10} alkylnaphthyl group (for example, a methylnaphthyl group), a C_1-C_{10} alkoxynaphthyl group (for example, a methoxynaphthyl group), an anthracenyl group, an azulenyl group, a heptalenyl group, an acenaphthylenyl group, a phenalenyl group, a fluorenyl group, an anthraquinolyl group, a methylanthryl group, a phenanthryl group, a triphenylenyl group, a pyrenyl group, a chrysenyl group, an ethylchrysenyl group, a picenyl group, a perylenyl group, a chloroperylenyl group, a pentaphenyl group, a pentacenyl group, a tetraphenylenyl group, a hexaphenyl group, a hexacenyl group, a rubicenyl group, a coroneryl group, a trinaphthylenyl group, a heptaphenyl group, a heptacenyl group, a pyranthrenyl group, and an ovalenyl group.

[0074] The C_2-C_{40} heteroaryl group used herein refers to a monovalent group having one or more aromatic rings that have at least one hetero atom selected from nitrogen (N), oxygen (O), phosphorous (P), silicon (Si), and sulfur (S) (as a ring-forming atom), and carbon atoms as the remaining ring atoms. The C_2-C_{40} heteroarylene group used herein refers to a divalent group having one or more aromatic rings that have at least one hetero atom selected from nitrogen (N), oxygen (O), phosphorous (P), silicon (Si), and sulfur (S) (as a ring-forming atom), and carbon atoms as the remaining ring atoms. In this regard, when the heteroaryl group and the heteroarylene group each include two or more rings, the rings may be fused to each other.

[0075] Examples of the C_2-C_{40} heteroaryl group are a pyrazolyl group, an imidazolyl group, an oxazolyl group, a thiazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a pyridinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a carbazolyl group, an indolyl group, a quinolinyl group, an isoquinolinyl group, a benzoan imidazolyl group, an imidazo pyridinyl group, and an imidazo pyrimidinyl group.

[0076] The C_6-C_{40} aryloxy group may be represented by —OA_2 (wherein A_2 indicates the substituted or unsubstituted C_6-C_{40} aryl group), and the C_6-C_{40} arylthio group may be represented by —SA_3 (wherein A_3 indicates a substituted or unsubstituted C_6-C_{40} aryl group).

[0077] The condensed cyclic compound represented by Formula 1 may be synthesized by using (utilizing) a known (or suitable) organic synthesis method. The synthesis method for the condensed cyclic compound may be obvious to one of ordinary skill in the art by referring to the Examples to be explained hereinafter.

[0078] The condensed cyclic compound of Formula 1 may be used (utilized) in an organic layer between a pair of electrodes of an organic light-emitting device. For example, the condensed cyclic compound may be used (utilized) in an electron transport region disposed between a cathode and an emission layer.

[0079] Accordingly, an organic light-emitting device may include a first electrode; a second electrode facing the first electrode, and an organic layer disposed between the first electrode and the second electrode, wherein the organic layer includes at least one of the condensed cyclic compound of Formula 1 described above.

[0080] The "organic layer" used herein refers to a layer that includes an organic compound and that is constituted of one or more layers. For example, the organic layer may include an emission layer, a hole transport region, and an electron transport region.

[0081] The hole transport region may include at least one of a hole injection layer, a hole transport layer, and an electron blocking layer.

[0082] The electron transport region may include at least one of an electron injection layer, an electron transport layer, and a hole blocking layer. The electron transport region may further include a buffer layer located near the emission layer.

[0083] An organic layer may not be formed of only an organic compound, and may further include an inorganic compound or an inorganic material. For example, the organic layer may include, in the same single layer, in addition to an organic compound, an inorganic compound or an inorganic material, for example, an organometallic complex. In some embodiments, an organic layer may include, in addition to a layer that includes only an organic compound, a layer that includes only an inorganic compound or an inorganic material.

[0084] In the organic layer, the buffer layer of the electron transport region may further include at least one of the condensed cyclic compound of Formula 1.

[0085] The emission layer may further include an anthracene compound, an arylamine compound, or a styryl compound.

[0086] The electron transport layer may include an electron transport organic compound and a metal-containing material. The metal-containing material may include a Li complex.

[0087] The hole transport region may include a charge-generation layer. The charge-generation material (for the charge-generation layer) may be, for example, a p-dopant.

[0088] FIG. **1** is a schematic view of an organic light-emitting device **10** according to an embodiment. Hereinafter, the structure of an organic light-emitting device according to an embodiment, and a method of manufacturing an organic light-emitting device according to an embodiment will be described in connection with FIG. **1**.

[0089] The organic light-emitting device **10** includes a substrate **11**, a first electrode **13**, an organic layer **15**, and a second electrode **17**, which are sequentially stacked.

[0090] For use (usage) as the substrate **11**, any suitable substrate that is used (utilized) in general organic light-emitting devices may be used (utilized), and the substrate **11** may be a glass substrate or transparent plastic substrate, each with excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and water repellency.

[0091] The first electrode **13** may be formed by, for example, depositing or sputtering a material for a first electrode on the substrate **11**. When the first electrode **13** is an anode, the material for the first electrode may be selected from materials with a high work function to make holes easily injected. The first electrode **13** may be a reflective electrode or a transmissive electrode. The material for the first electrode **13** may be a transparent and highly conductive material, and examples of such a material are indium tin oxide (ITO), indium zinc oxide (IZO), tin oxide (SnO_2), and zinc oxide (ZnO). According to another embodiment, magnesium (Mg), silver (Ag), aluminum (Al), aluminum:lithium (Al:Li), calcium (Ca), silver:indium tin oxide (Ag:ITO), magnesium:indium (Mg:In), or magnesium:silver (Mg:Ag) may be used (utilized) to form a reflective electrode for use (usage) as the first electrode **13**. The first electrode **13** may have a single-layer structure, or a multi-layer structure including two or more layers. For example, the first electrode **13** may have a three-layered structure of ITO/Ag/ITO, but the structure of the first electrode **110** is not limited thereto.

[0092] The organic layer **15** is disposed on the first electrode **13**.

[0093] The organic layer **15** may include a hole transport region, an emission layer, and an electron transport region.

[0094] The hole transport region may include at least one of a hole injection layer, a hole transport layer, and an electron blocking layer. The electron transport region may include at least one of an electron injection layer, an electron transport layer, and a hole blocking layer. The electron transport region may further include a buffer layer located near the emission layer.

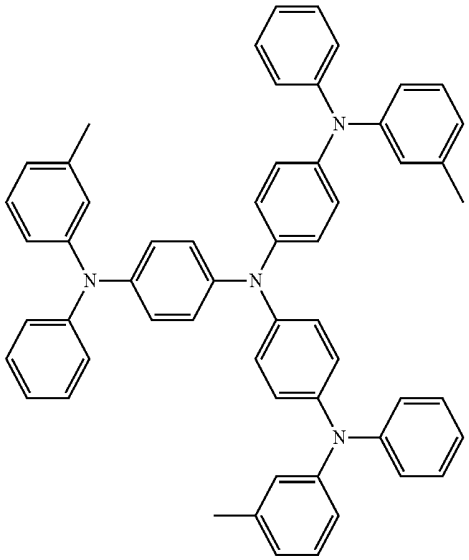
[0095] A hole injection layer (HIL) may be formed on the first electrode **13** by using (utilizing) various suitable methods, such as vacuum deposition, spin coating, casting, langmuir-blodgett (LB) deposition, or the like.

[0096] When a hole injection layer is formed by vacuum deposition, the deposition conditions may vary according to a material that is used (utilized) to form the hole injection layer, and the structure and thermal characteristics of the hole injection layer. For example, the deposition conditions may include a deposition temperature of about 100 to about 500° C., a vacuum pressure of about 10^{-8} to about 10^{-3} torr, and a deposition rate of about 0.01 to about 100 Å/sec. However, the deposition conditions are not limited thereto.

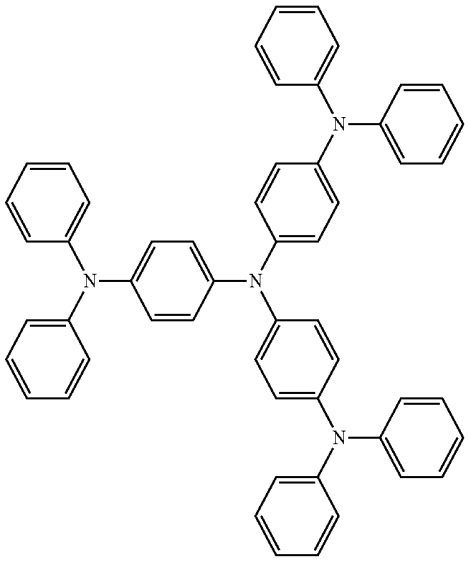
[0097] When the hole injection layer is formed using (utilizing) spin coating, coating conditions may vary according to the material used (utilized) to form the hole injection layer, and the structure and thermal properties of the hole injection layer. For example, a coating speed may be from about 2000 rpm to about 5000 rpm, and a temperature at which a heat treatment is performed to remove the solvent after coating may be from about 80° C. to about 200° C. However, the coating conditions are not limited thereto.

[0098] A material for the hole injection layer may be, for example, a known (or suitable) hole injection material. Examples of the known (or suitable) hole injection material are N,N'-diphenyl-N,N'-bis-[4-(phenyl-m-tolyl-amino)-phenyl]-biphenyl-4,4'-diamine (DNTPD), a phthalocyanin compound (such as copper phthalocyanine), 4,4',4"-tris(3-methylphenylphenylamino) triphenylamine (m-MTDATA),

4,4'4"-tris(N,N-diphenylamino)triphenylamine (TDATA), 4,4',4"-tris{N,-(2-naphthyl)-N-phenylamino}-tripheny-lamine (2T-NATA), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), poly(3,4-ethylenedioxythiophene)/poly (4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonic acid (PANI/CSA), and polyaniline/poly(4-styrene-sulfonate) (PANI/PSS), but are not limited thereto.

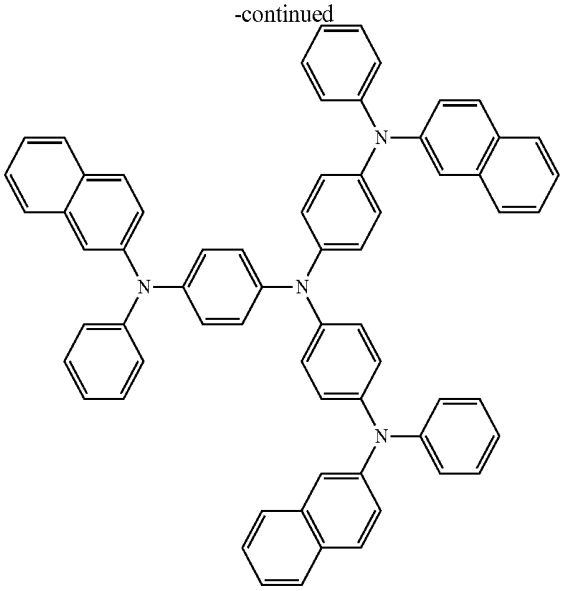


m-MTDATA

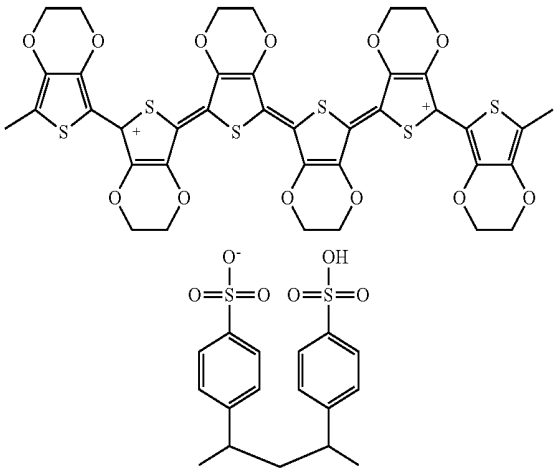


TDATA

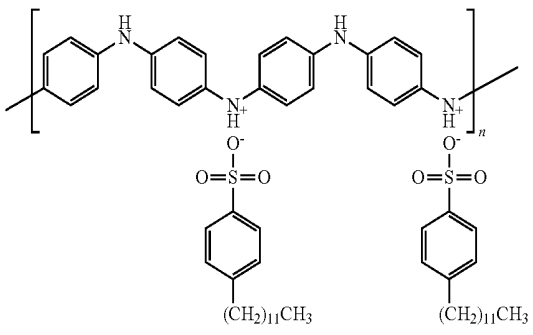
-continued



27-NATA



PEDOT/PSS

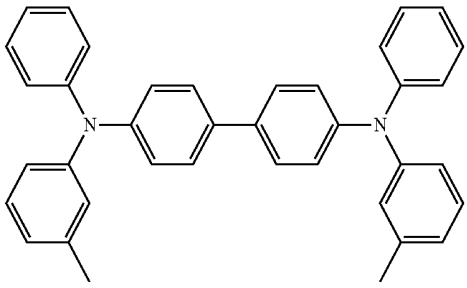


PANI/DBSA

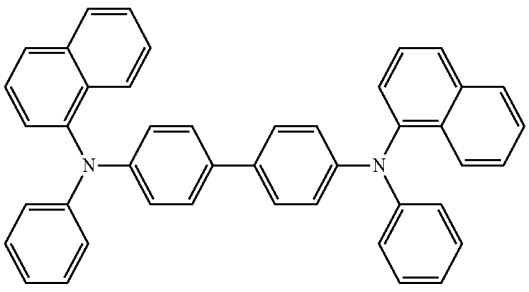
[0099] A thickness of the hole injection layer may be in a range of about 100 Å to about 10,000 Å, for example, about 100 Å to about 1,000 Å. In one embodiment, when the thickness of the hole injection layer is within the range described above, the hole injection layer has satisfactory hole injection characteristics without a substantial increase in a driving voltage.

[0100] Then, a hole transport layer (HTL) may be formed on the hole injection layer by using (utilizing) vacuum deposition, spin coating, casting, or LB. When the hole transport layer is formed by vacuum deposition or spin coating, the deposition or coating conditions may be similar to those applied to form the hole injection layer although the deposition or coating conditions may vary according to the material that is used (utilized) to form the hole transport layer.

[0101] A material for the hole transport layer may be, for example, a known (or suitable) hole transport material. Examples of the known (or suitable) hole transport material are a carbazole derivative, such as N-phenylcarbazole or polyvinylcarbazole, a triphenylamine-based material, such as N,N'-bis(3-methylphenyl)-N,N'-diphenyl-[1,1-biphenyl]-4,4'-diamine (TPD), N,N'-bis(naphthalen-2-yl)-N,N'-bis(phenyl)-benzidine (NPB), N,N'-bis(naphthalen-1-yl)-N,N'-bis(phenyl)-2,2'-dimethylbenzidine (α-NPD), and 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA), but are not limited thereto.

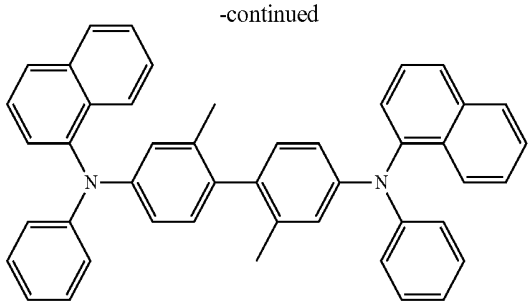


TPD

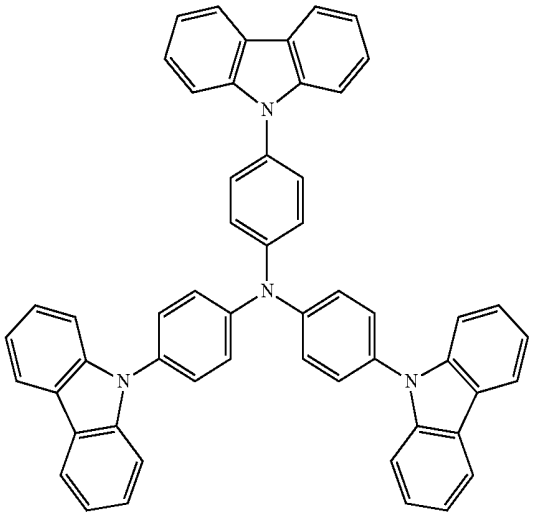


NPB

-continued



α-NPD



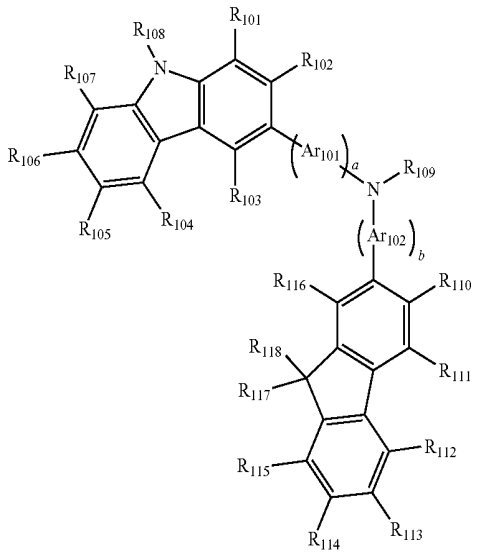
TCTA

[0102] A thickness of the hole transport layer may be in a range of about 50 Å to about 1,000 Å, for example, about 100 Å to about 800 Å. In one embodiment, when the thickness of the hole transport layer is within these ranges, satisfactory hole transport characteristics are obtained without a substantial increase in driving voltage.

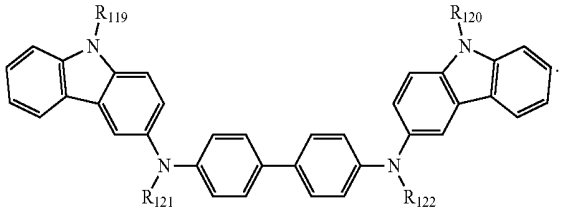
[0103] In some embodiments, instead of the hole injection layer and the hole transport layer, a hole injection and transport layer may be formed. The hole injection and transport layer may include at least one material selected from the materials for the hole injection layer and at least one material selected from the materials for the hole transport layer, and may have a thickness of about 500 Å to about 10,000 Å, and for example, about 100 Å to about 1,000 Å. In one embodiment, when the thickness of the hole injection and transport layer is within these ranges, satisfactory hole injection and transport characteristics are obtained without a substantial increase in driving voltage.

[0104] In addition, at least one layer of the hole injection layer, the hole transport layer, and the hole injection and transport layer may include at least one of a compound represented by Formula 100 below and a compound represented by Formula 101 below:

Formula 100



Formula 101



[0105] Ar_{101} and Ar_{102} in Formula 100 may be each independently selected from a substituted or unsubstituted C_6-C_{40} arylene group. For example, Ar_{101} and Ar_{102} may be each independently selected from:

[0106] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, a substituted or unsubstituted acenaphthylene group, a fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthrylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group; and

[0107] a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, a heptalenylene group, a substituted or unsubstituted an acenaphthylene group, a fluorenylene group, a phenalenylene group, a phenanthrenylene group, an anthrylene group, a fluoranthenylene group, a triphenylenylene group, a pyrenylene group, a chrysenylenylene group, a naphthacenylene group, a picenylene group, a perylenylene group, and a pentacenylene group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, a C_1-C_{40} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_6-C_{40} aryloxy group, a C_6-C_{40} arylthio group, and a C_2-C_{40} heteroaryl group.

[0108] a and b in Formula 100 may be each independently an integer of 0 to 5, or 0, 1, or 2. For example, a may be 1 and b may be 0, but a and b are not limited thereto.

[0109] R_{101} to R_{122} in Formulae 100 and 101 may be each independently a hydrogen, a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{40} alkyl group, a substituted or unsubstituted C_2-C_{40} alkenyl group, a substituted or unsubstituted C_2-C_{40} alkynyl group, a substituted or unsubstituted C_1-C_{40} alkoxy group, a substituted or unsubstituted C_3-C_{40} cycloalkyl group, a substituted or unsubstituted C_6-C_{40} aryl group, a substituted or unsubstituted C_6-C_{40} aryloxy group, or a substituted or unsubstituted C_6-C_{40} arylthio group.

[0110] For example, R_{101} to R_{108} and R_{110} to R_{122} may be each independently selected from: a hydrogen, a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{10} alkyl group (for example, a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, or a hexyl group), a C_1-C_{10} alkoxy group (for example, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, or a pentoxy group), a phenyl group, a naphthyl group, an anthryl group, a fluorenyl group, and a pyrenyl group;

[0111] a C_1-C_{10} alkyl group, a C_1-C_{10} alkoxy group, a phenyl group, a naphthyl group, an anthryl group, a fluorenyl group, and a pyrenyl group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof, but is not limited thereto.

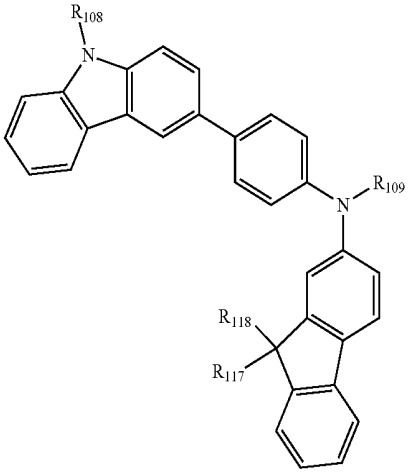
[0112] R_{109} in Formula 100 may be one selected from:

[0113] a phenyl group; a naphthyl group; an anthryl group; a biphenyl group; a pyridyl group; and

[0114] a phenyl group, a naphthyl group, an anthryl group, a biphenyl group and a pyridyl group, each substituted with at least one selected from a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a substituted or unsubstituted C_1-C_{20} alkyl group, and a substituted or unsubstituted C_1-C_{20} alkoxy group.

[0115] According to an embodiment, the compound represented by Formula 100 may be represented by Formula 100A below, but is not limited thereto:

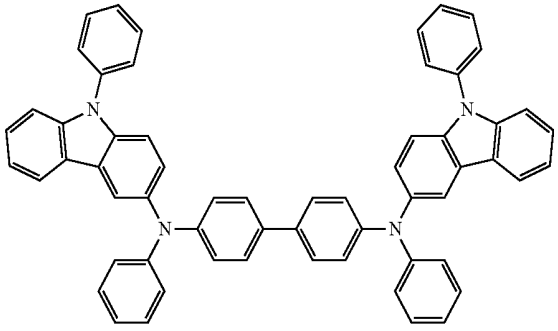
Formula 100A



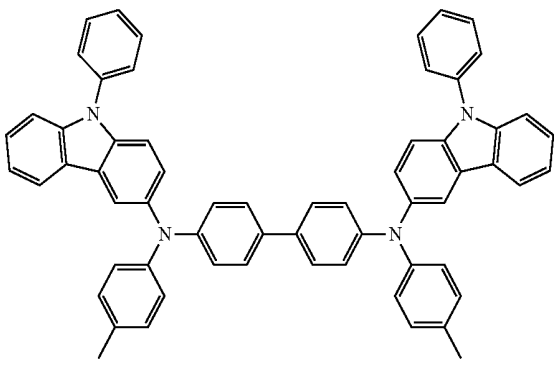
[0116] Detailed description about R_{108}, R_{109}, R_{117}, and R_{118} in Formula 100A are already provided above.

[0117] For example, at least one layer of the hole injection layer, the hole transport layer, and the hole injection and transport layer may include at least one of Compounds 102 to 121 below, but these layers are not limited thereto and may instead include other materials.

102

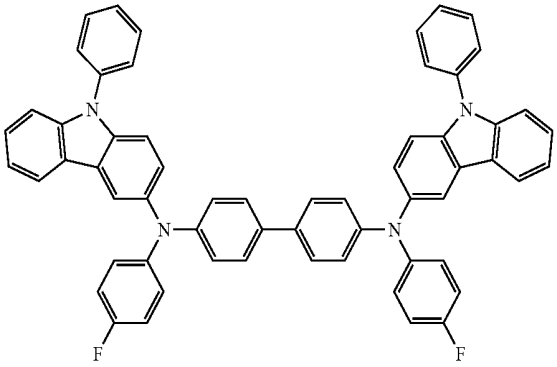


103

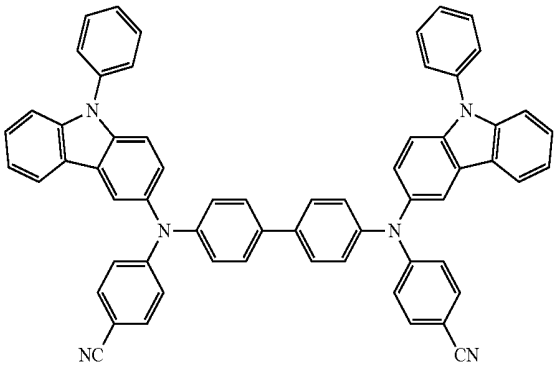


-continued

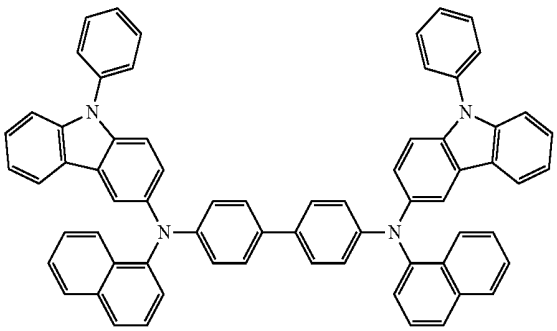
104



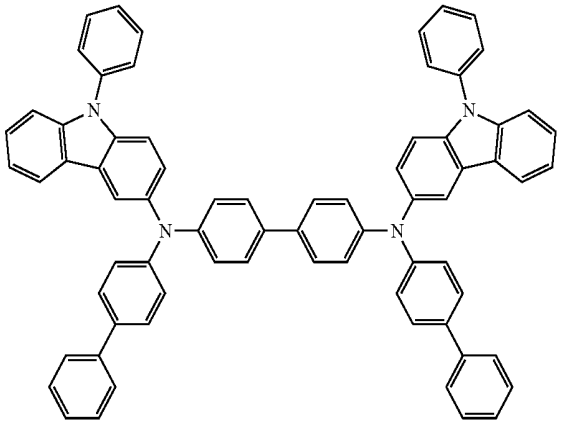
105



106

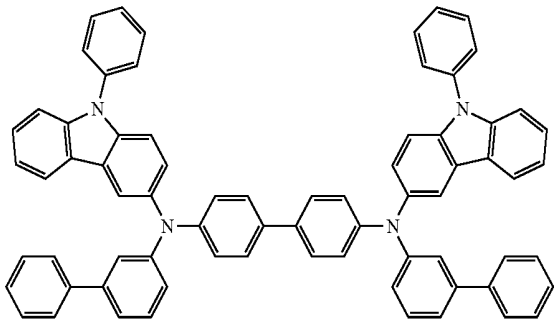


107

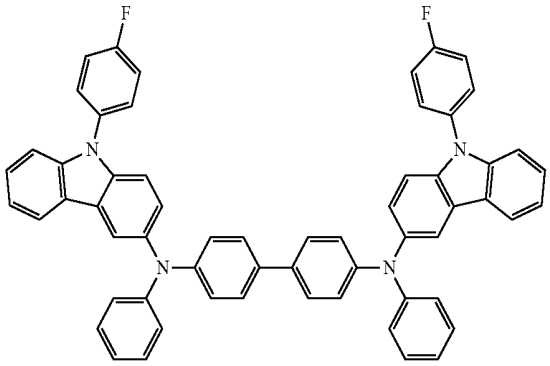


-continued

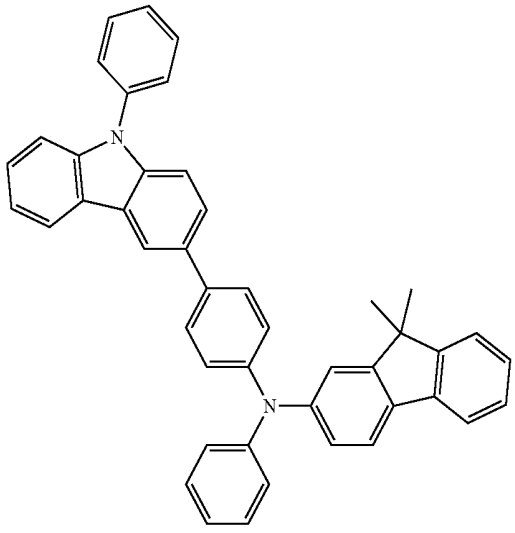
108



109

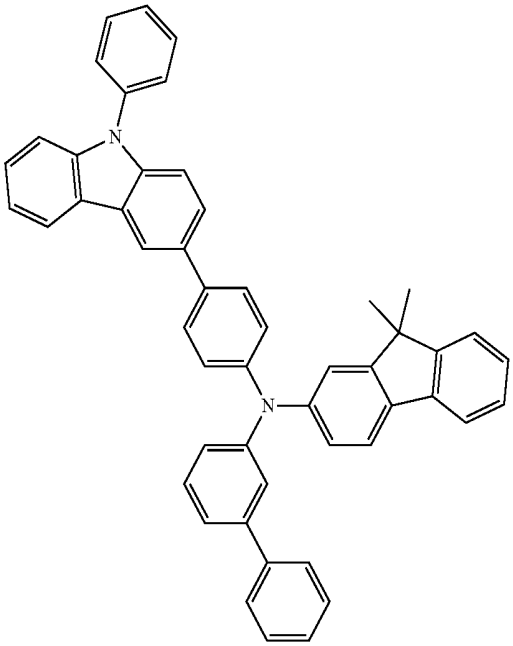


110

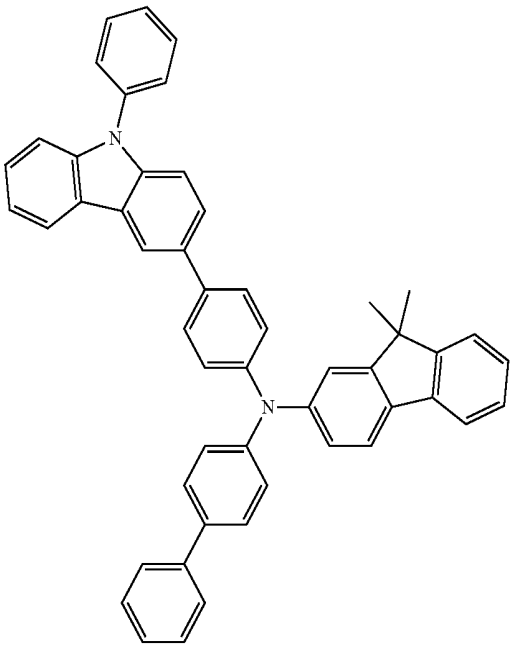


-continued

111

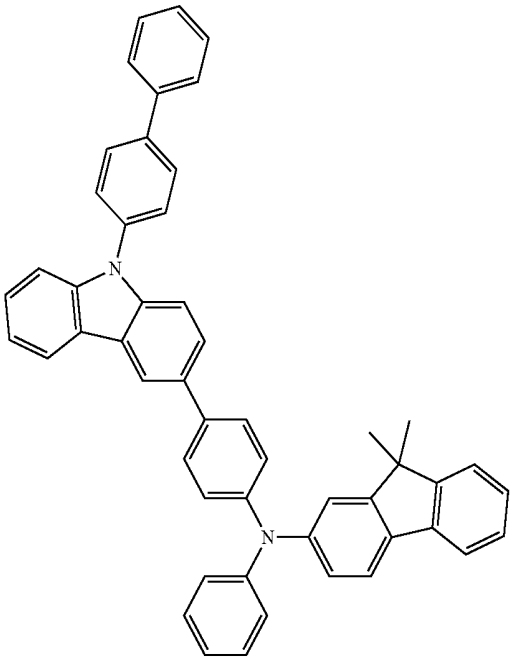


112

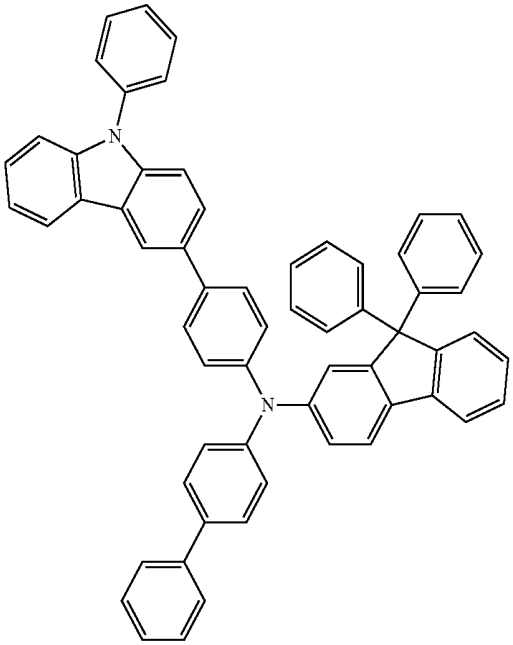


-continued

113

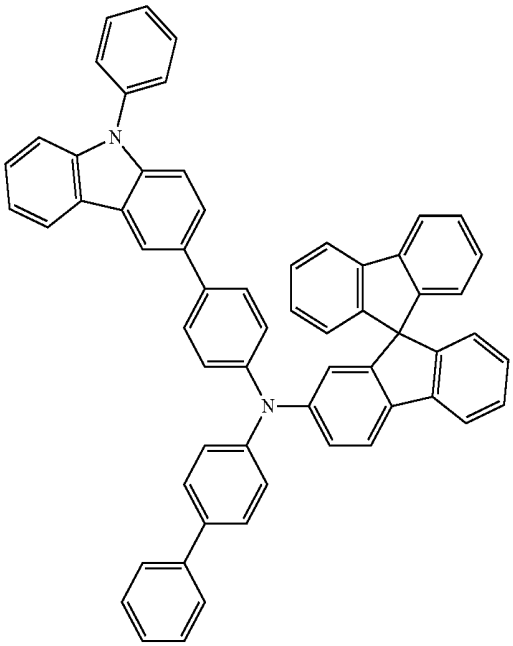


114

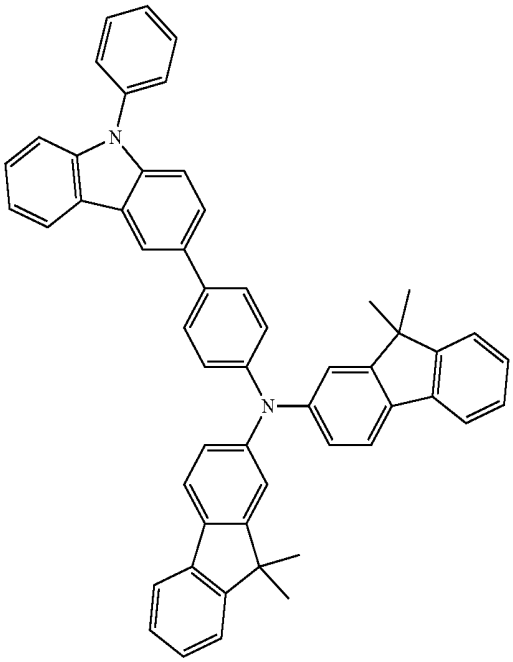


-continued

115

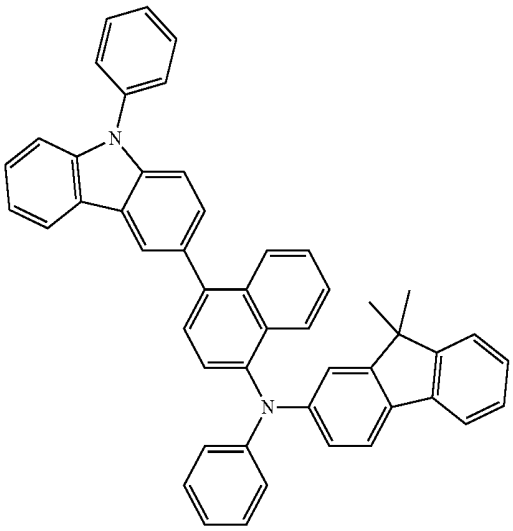


116

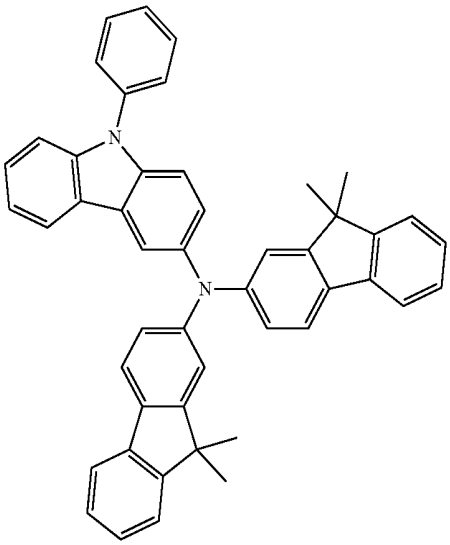


-continued

117

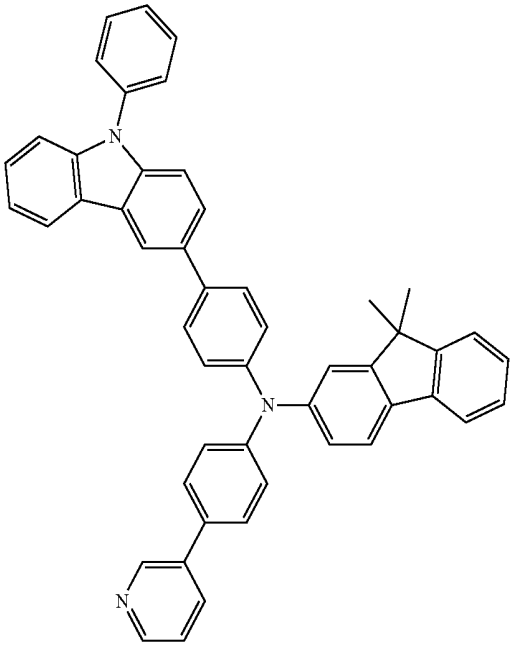


118

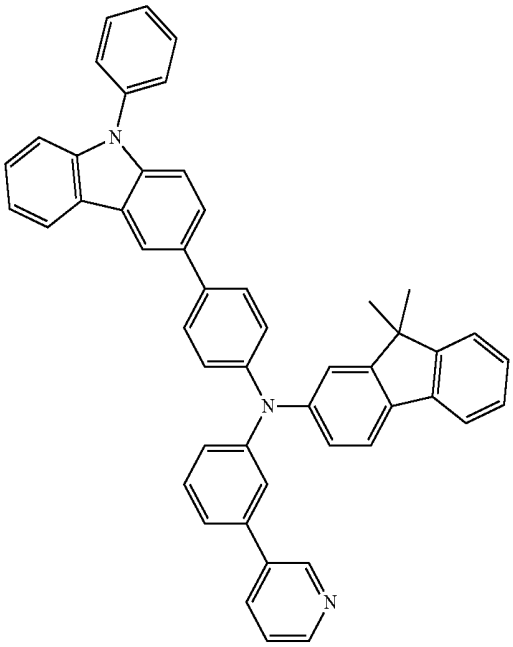


-continued

119

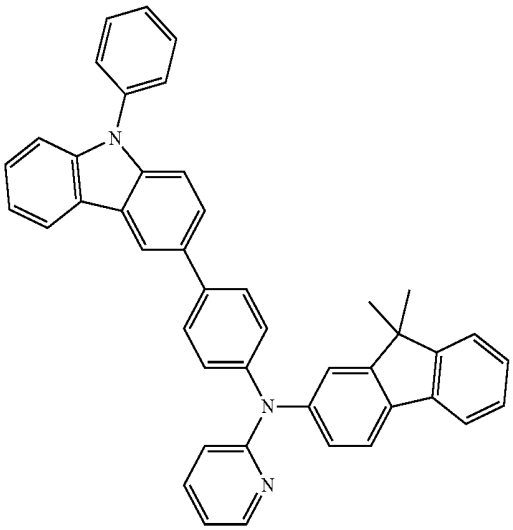


120



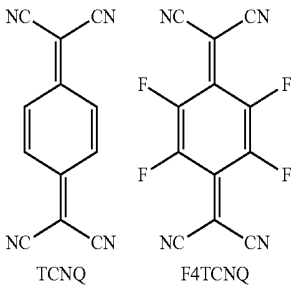
-continued

121



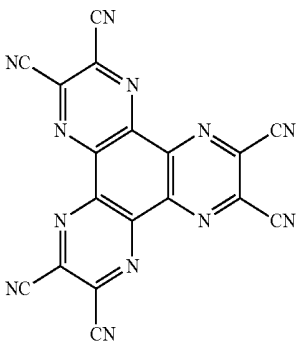
[0118] At least one of the hole injection layer, the hole transport layer, and the hole injection and transport layer may further include a charge-generation material to increase the conductivity of the layer, in addition to such known (or suitable) hole injection materials, known (or suitable) hole transport materials, and/or known (or suitable) materials having both hole injection and hole transport capabilities.

[0119] The charge-generation material may be, for example, a p-dopant. Non-limiting examples of the p-dopant are a quinone derivative (such as tetracyanoquinonedimethane (TCNQ) or 2,3,5,6-tetrafluoro-tetracyano-1,4-benzoquinonedimethane (F4TCNQ)); a metal oxide (such as tungsten oxide or molybdenium oxide); and a cyano group-containing compound (such as Compound 200 below).



TCNQ F4TCNQ

<200>



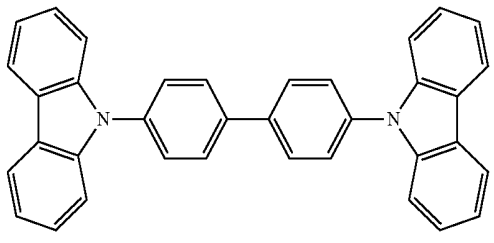
[0120] When the hole injection layer, the hole transport layer, and/or the hole injection and transport layer further include the charge-generation material, the charge-generation material may be homogeneously or inhomogeneously dispersed in the layers.

[0121] A resonance control layer may be disposed between an emission layer and at least one of the hole injection layer, the hole transport layer, and the hole injection and transport layer. Also, the resonance control layer may compensate for an optical resonance distance according to a wavelength of light emitted from the emission layer, and thus, efficiency of a formed organic light-emitting device may be improved. The resonance control layer may include a known (or suitable) hole injection material and a known (or suitable) hole transport material. Also, the resonance control layer may include a material that is identical to one of the materials included in the hole injection layer, the hole transport layer, and the hole injection and transport layer formed under the resonance control layer.

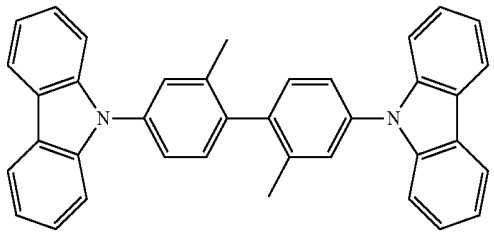
[0122] Subsequently, an emission layer (EML) may be formed on the hole transport layer, the hole injection and transport layer, or the resonance control layer by spin coating, casting, or an LB method. When the emission layer is formed by vacuum deposition or spin coating, the deposition and coating conditions may be similar to those for the formation of the hole injection layer, though the conditions for deposition and coating may vary according to the material that is used (utilized) to form the emission layer.

[0123] As a material for forming the emission layer, at least one material selected from any known (or suitable) emission materials (including a host and a dopant) may be used (utilized).

[0124] Examlpes of a known (or suitable) host are tris(8-quinolinorate)aluminum (Alq_3), 4,4'-N,N'-dicabazole-biphenyl (CBP), poly(n-vinylcabazole) (PVK), 9,10-di(naphthalene-2-yl)anthracene (ADN), TCTA, 1,3,5-tris(N-phenylbenzimidazole-2-yl)benzene (TPBI), 3-tert-butyl-9, 10-di(naphth-2-yl) anthracene (TBADN), distyrylarylene (DSA), E3, dmCBP (illustrated below), and Compounds 301 to 309 illustrated below, but are not limited thereto.

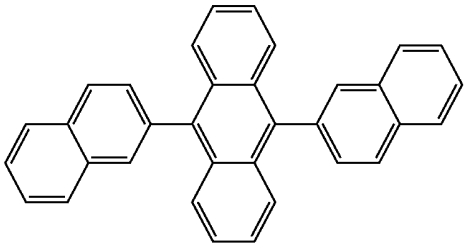


CBP

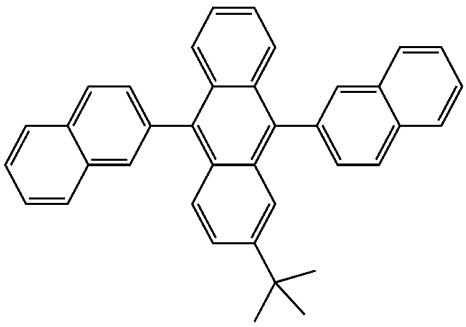


dmCBP

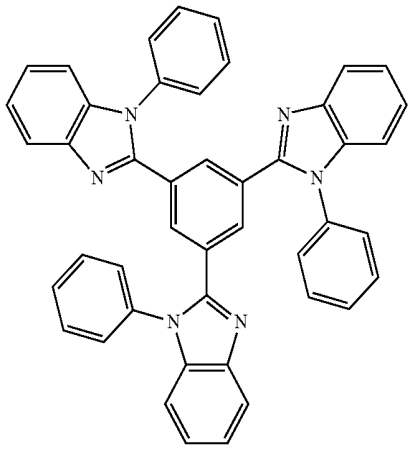
-continued



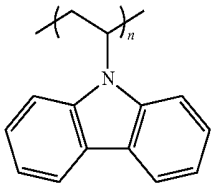
ADN



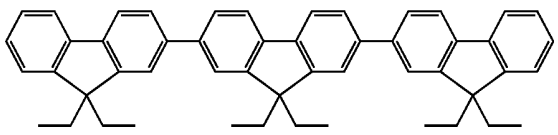
TBADN



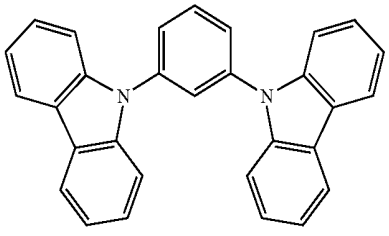
TPBI



PVK

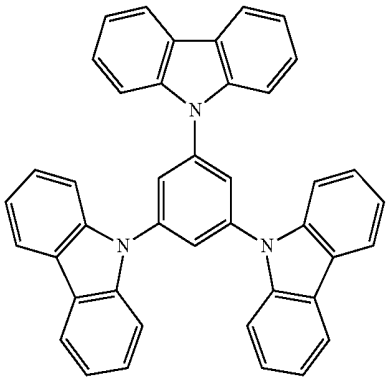


E3

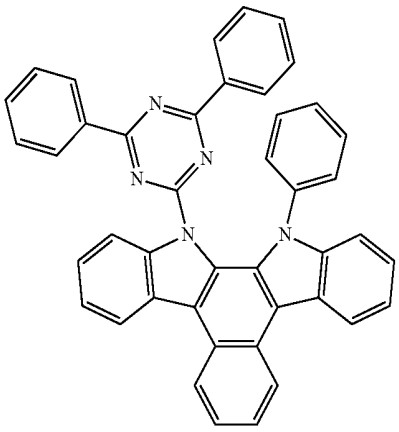


301

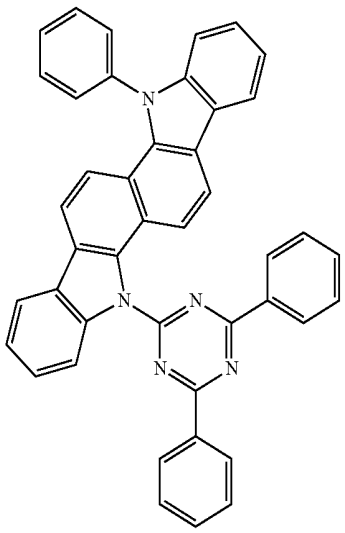
-continued



302

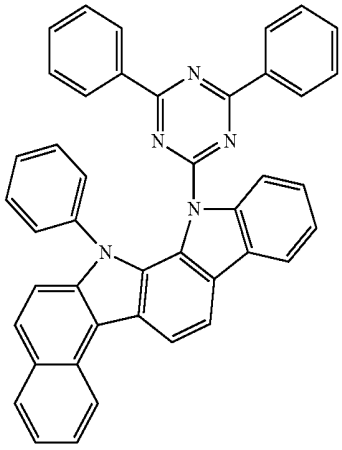


303

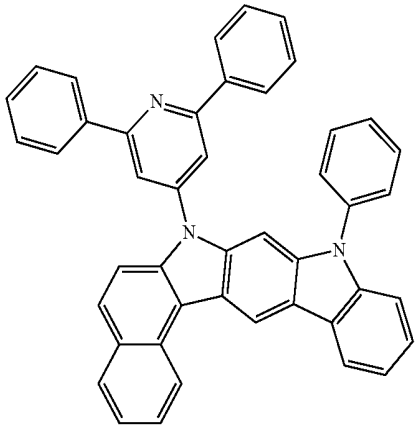


304

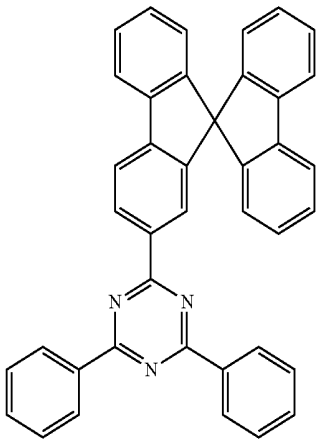
-continued



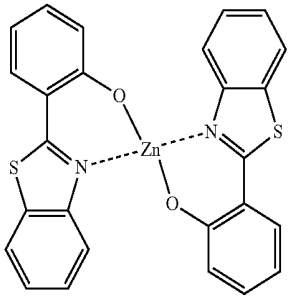
305



306

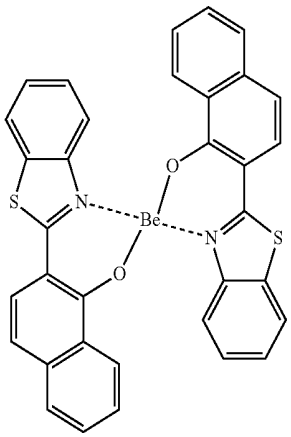


307



308

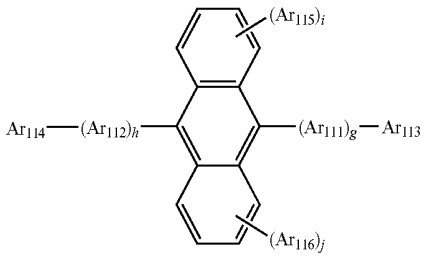
-continued



309

[0125] An example of the the host may be an anthracene-based compound represented by Formula 400 below:

Formula 400



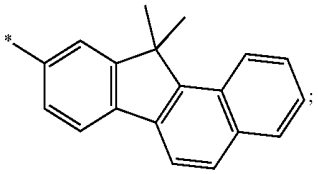
[0126] wherein, in Formula 400, Ar_{111} and Ar_{112} may be each independently a substituted or unsubstituted C_6-C_{60} arylene group; Ar_{113} to Ar_{116} may be each independently a substituted or unsubstituted C_1-C_{10} alkyl group, or a substituted or unsubstituted C_6-C_{60} aryl group; and g, h, I, and j are each independently an integer of 0 to 4.

[0127] For example, Ar_{111} and Ar_{112} in Formula 400 may be each independently a phenylene group, a naphthylene group, a phenanthrenylene group, or a pyrenylene group; or a phenylene group, a naphthylene group, a phenanthrenylene group, a fluorenyl group, or a pyrenylene group, each substituted with at least one of a phenyl group, a naphthyl group, and an anthryl group, but are not limited thereto.

[0128] g, h, i, and j in Formula 400 may each be independently 0, 1, or 2.

[0129] Ar_{113} to Ar_{116} in Formula 400 may be each independently selected from a C_1-C_{10} alkyl group substituted with at least one of a phenyl group, a naphthyl group, and an anthryl group; a phenyl group; a naphthyl group; an anthryl group; a pyrenyl group; a phenanthrenyl group; a fluorenyl group; and a phenyl group, a naphthyl group, an anthryl group, a pyrenyl group, a phenanthrenyl group, and a fluorenyl group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine, a hydrazone, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{60} alkyl group, a C_2-C_{60} alkenyl group, a C_2-C_{60} alkynyl

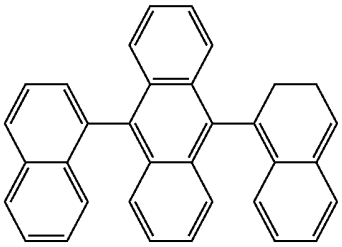
group, a C_1-C_{60} alkoxy group, a phenyl group, a naphthyl group, an anthryl group, a pyrenyl group, a phenanthrenyl group, a fluorenyl group, and



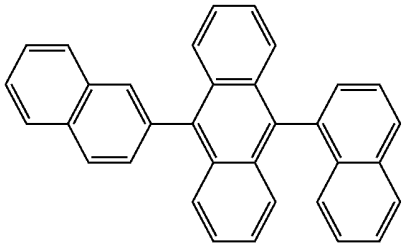
but are not limited thereto.

[0130] For example, the anthracene-based compound represented by Formula 400 may be one of the following compounds, but is not limited thereto:

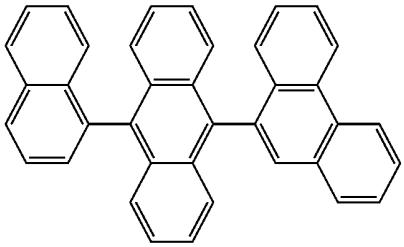
H1



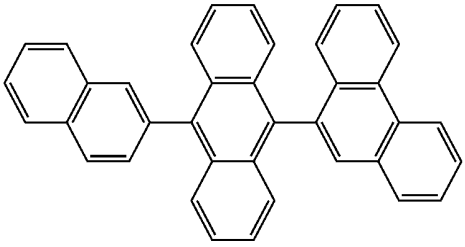
H2



H3

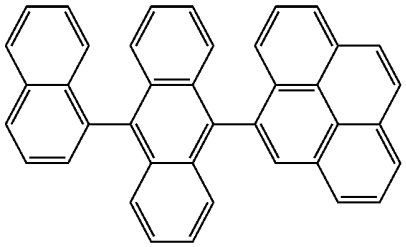


H4

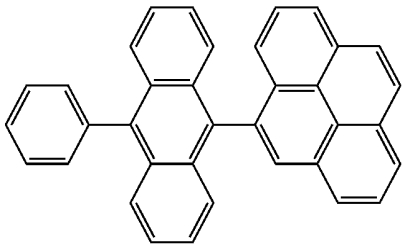


-continued

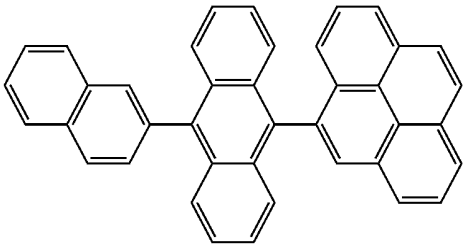
H5



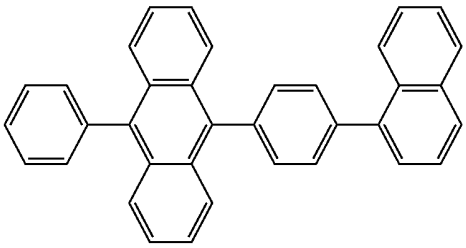
H6



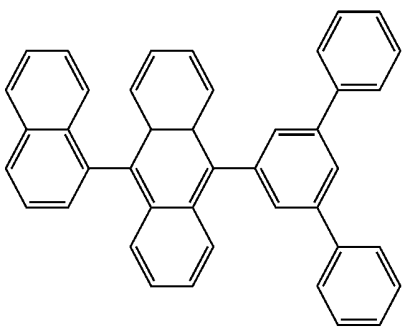
H7



H8

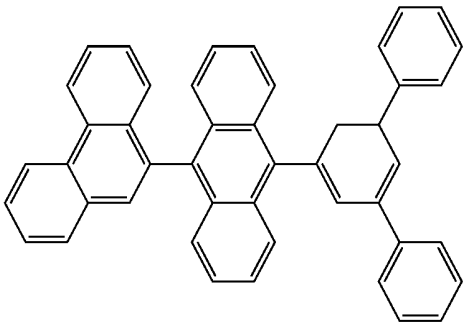


H9

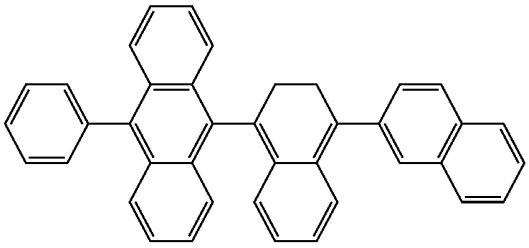


-continued

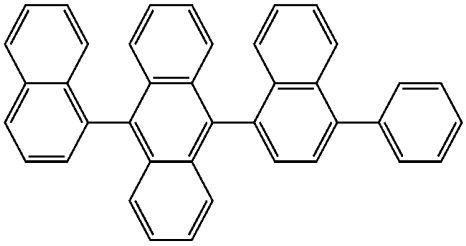
H10



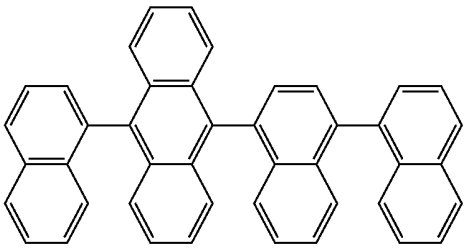
H11



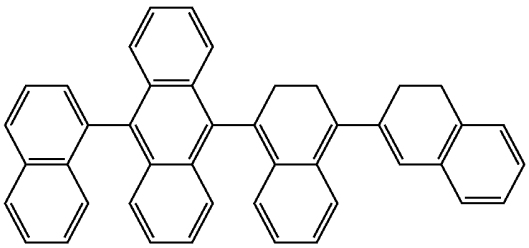
H12



H13

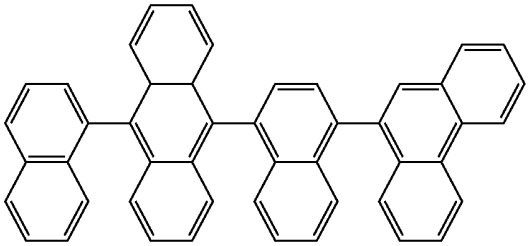


H14

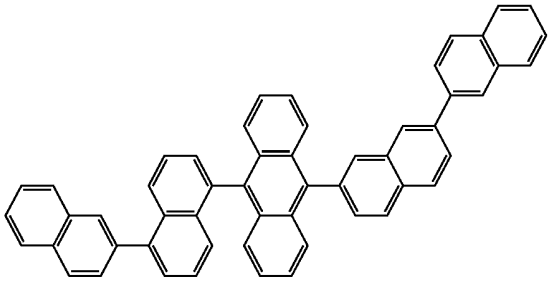


-continued

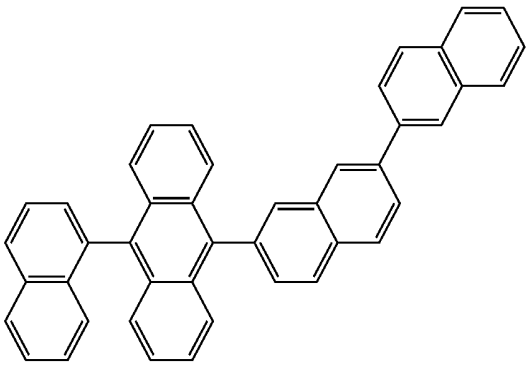
H15



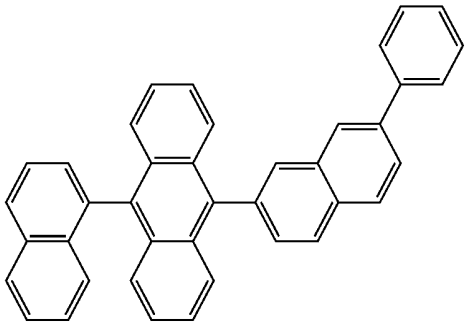
H16



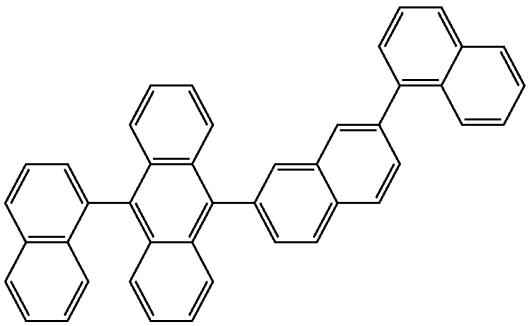
H17



H18

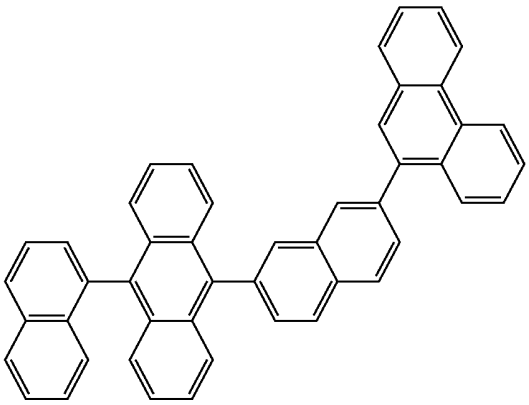


H19

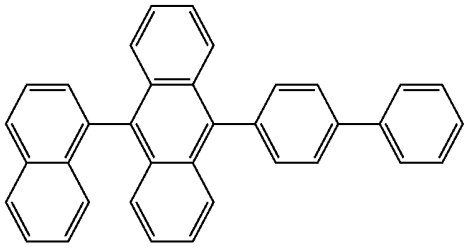


-continued

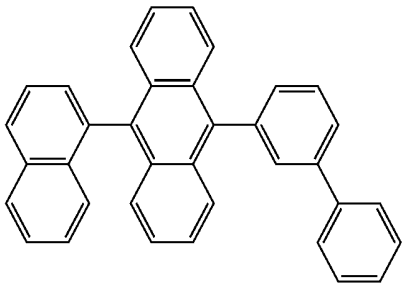
H20



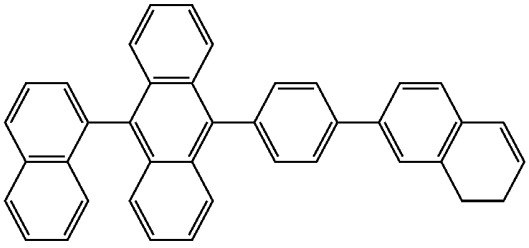
H21



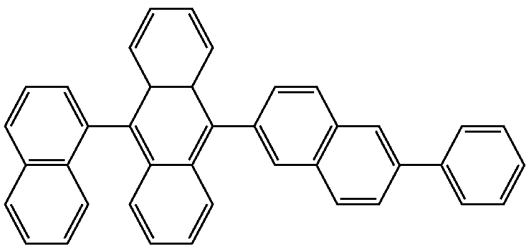
H22



H23

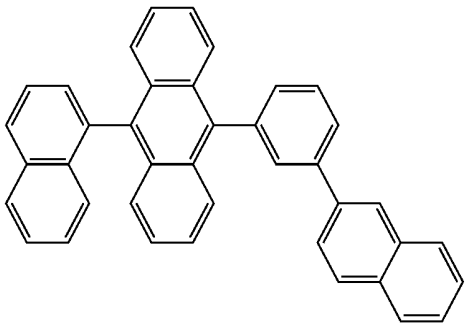


H24

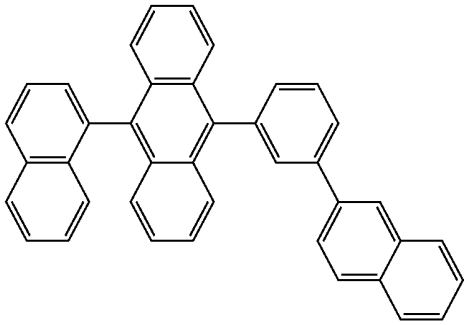


-continued

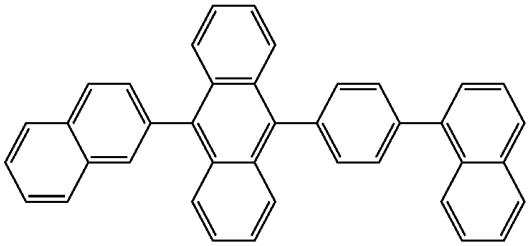
H25



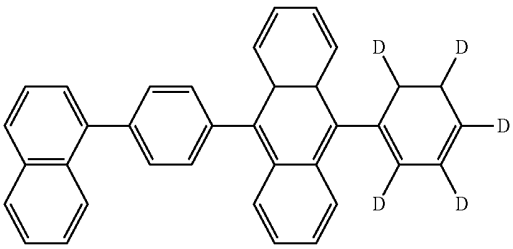
H26



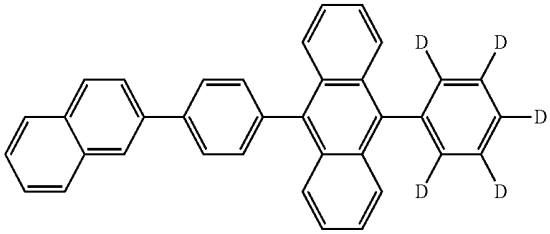
H27



H28

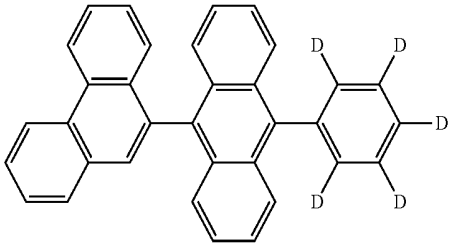


H29

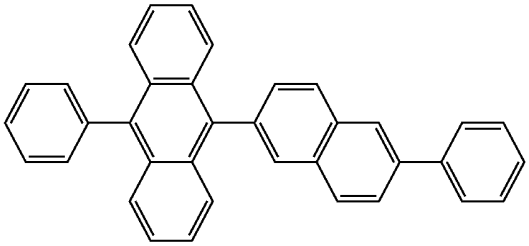


-continued

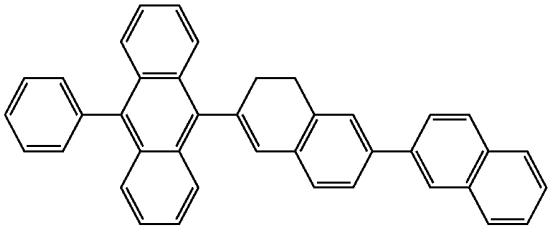
H30



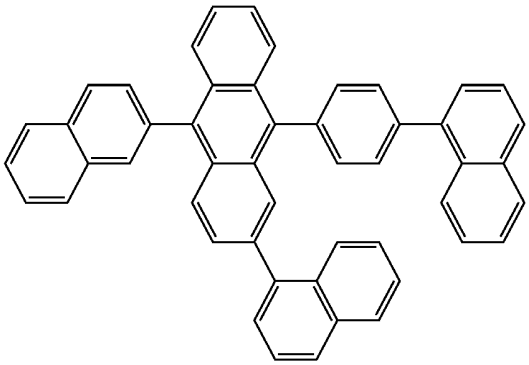
H31



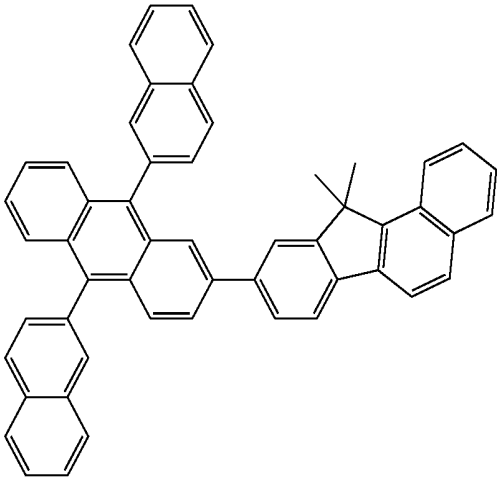
H32



H33

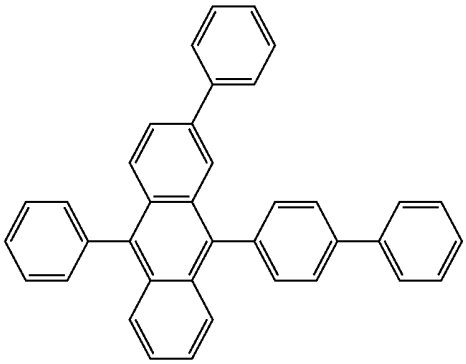


H34

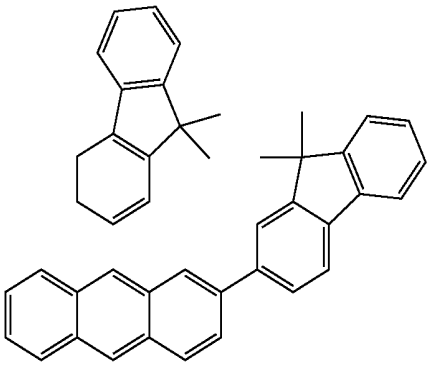


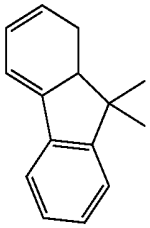
-continued

H35

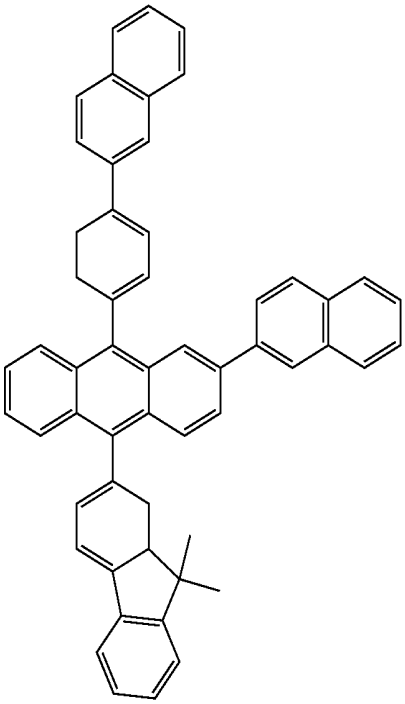


H36



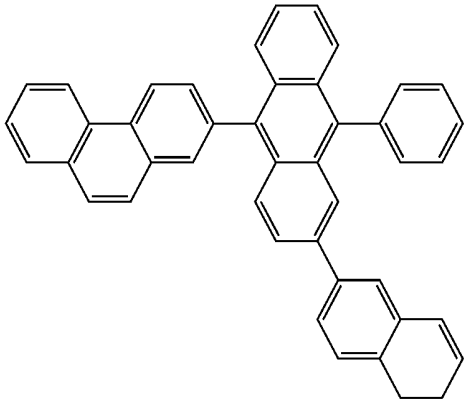


H37

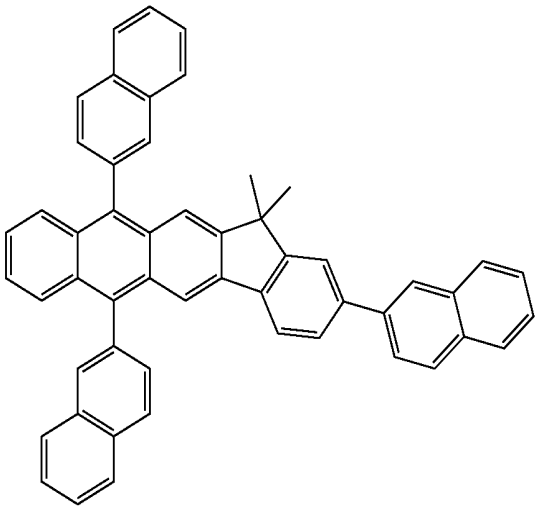


-continued

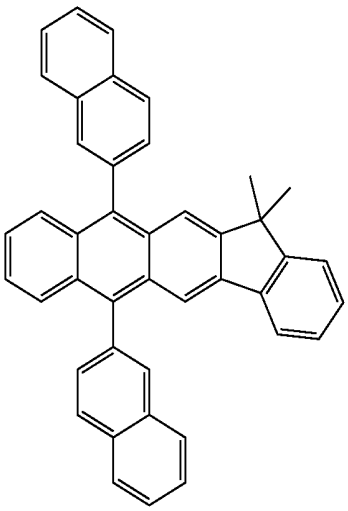
H38



H39

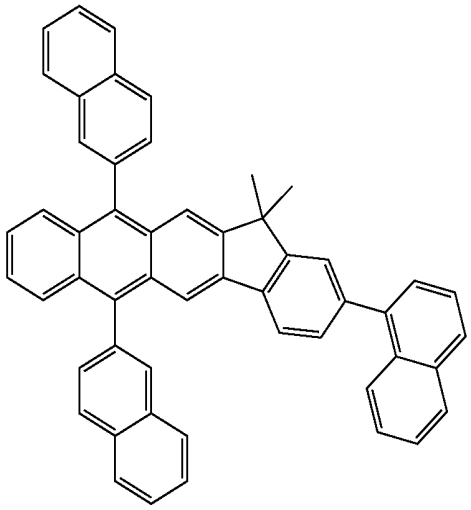


H40

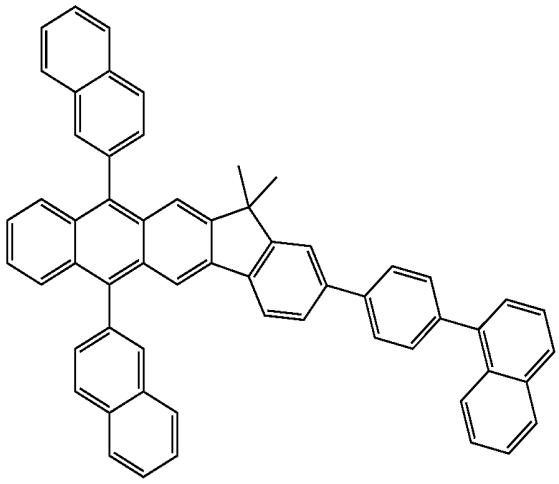


-continued

H41

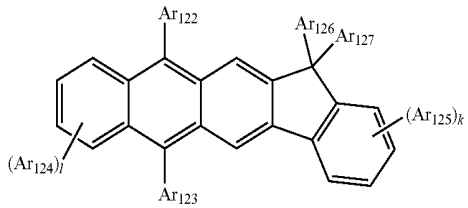


H42



[0131] Also, the host may be an anthracene-based compound represented by Formula 401 below:

Formula 401

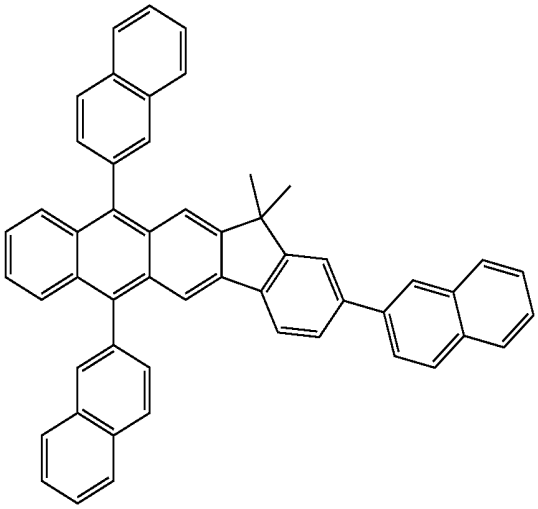


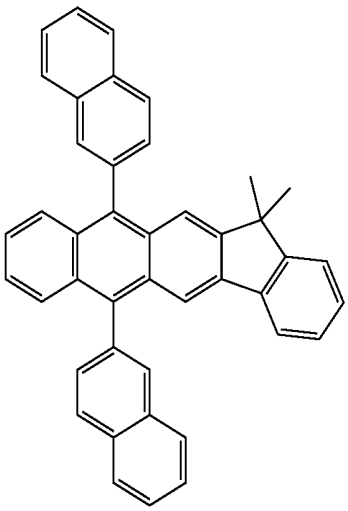
[0132] Ar_{122} to Ar_{125} in Formula 401 are the same as described in detail in connection with Ar_{113} in Formula 400.

[0133] Ar_{126} and Ar_{127} in Formula 401 may be each independently a C_1-C_{10} alkyl group (for example, a methyl group, an ethyl group, or a propyl group).

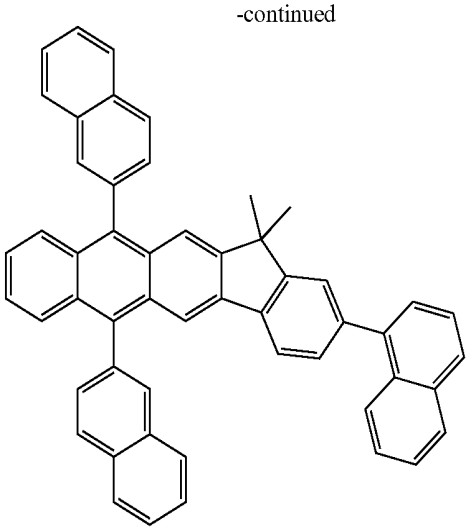
[0134] k and I in Formula 401 may be each independently an integer of 0 to 4. For example, k and I may be each independently 0, 1, or 2.

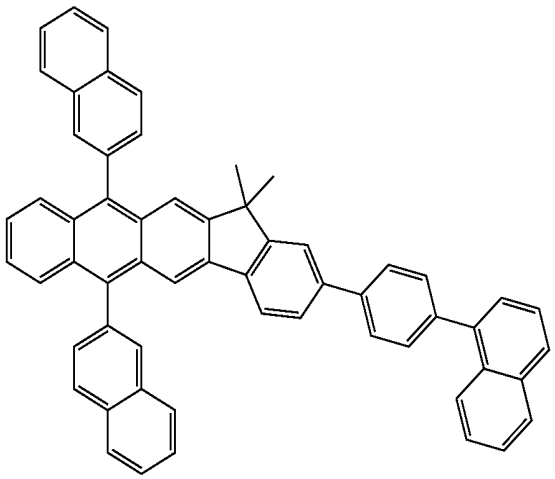
[0135] For example, the anthracene-based compound represented by Formula 401 may be one of the following compounds, but is not limited thereto:





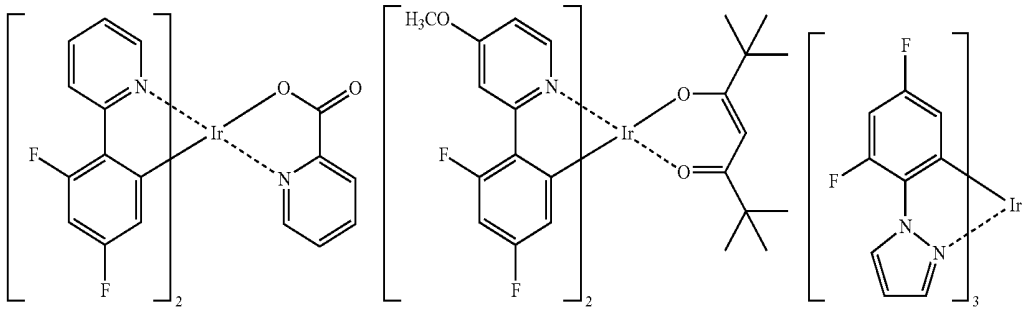
-continued





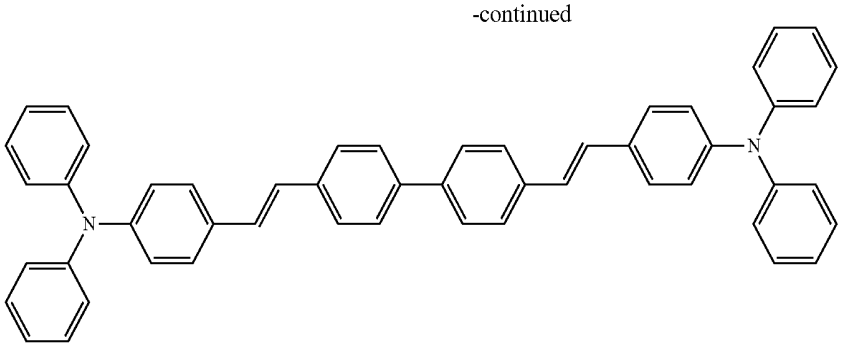
[0136] A dopant material may be any known (or suitable) dopant. The known (or suitable) dopant may be at least one of a fluorescent dopant and a phosphorescent dopant. The phosphorescent dopant may be an organometallic complex including Ir, Pt, Os, Re, Ti, Zr, Hf, or a combination of at least two of these, but is not limited thereto.

[0137] Examples of a known (or suitable) blue dopant are bis[3,5-difluoro-2-(2-pyridyl)phenyl](picolinato)iridium (III) (F2Irpic), $(F_2ppy)_2Ir(tmd)$, $Ir(dfppz)_3$, 4,4'-bis(2,2'-diphenylethen-1-yl)biphenyl (DPVBi), 4,4'-bis[4-(diphenylamino)styryl]biphenyl (DPAVBi), and 2,5,8,11-tetra-tert-butyl perylene (TBPe), which are illustrated below:

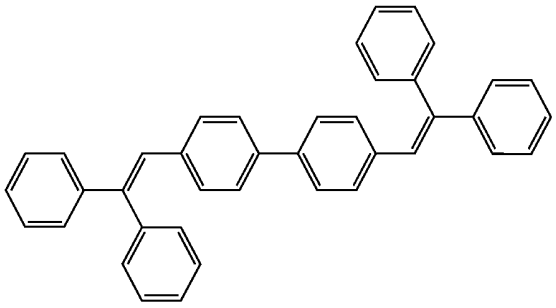


F_2Irpic $(F_2ppy)_2Ir(tmd)$ $Ir(dfppz)_3$

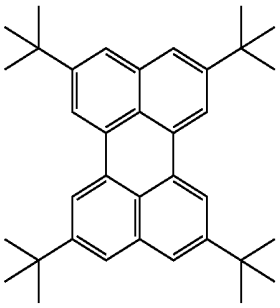
-continued



DPAVBi



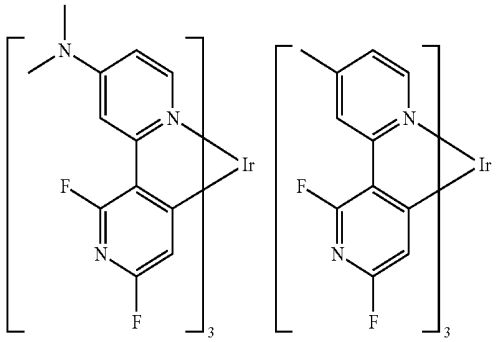
DPABi

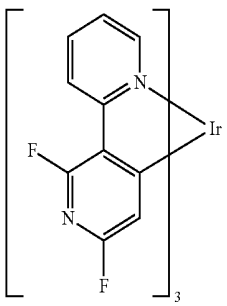


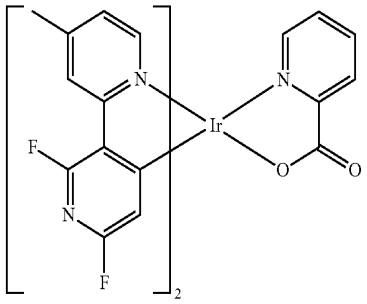
TPBe

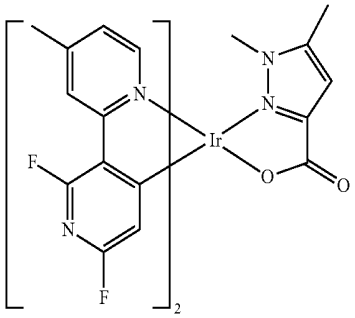
[0138] Examples of a known (or suitable) blue dopant include compounds illustrated below, but are not limited thereto:

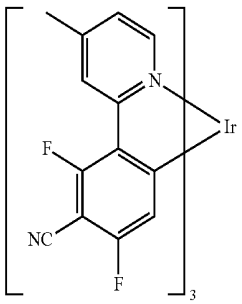
-continued



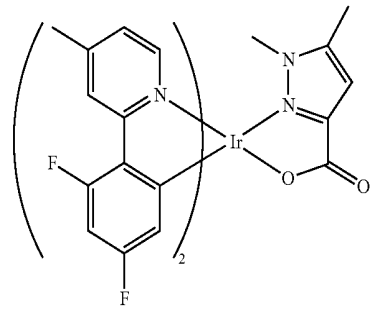


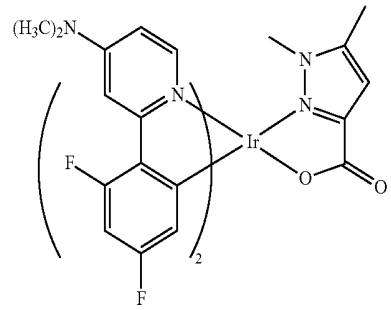


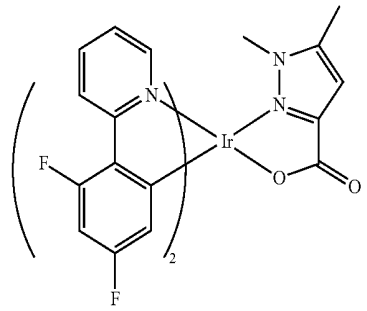




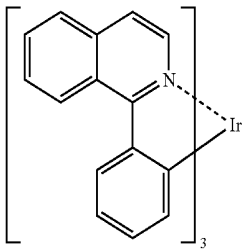
-continued



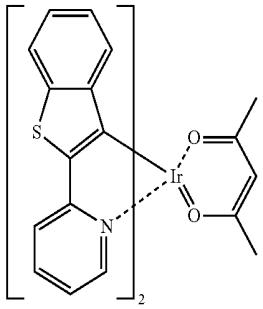




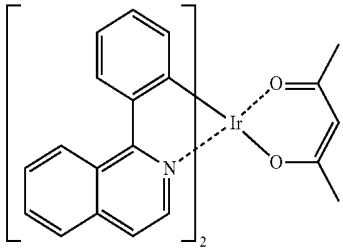
-continued



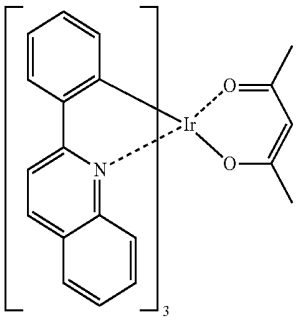
Ir(piq)3



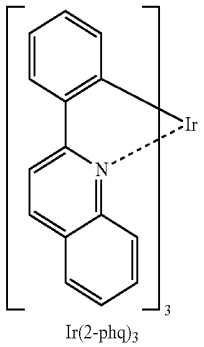
Btp2Ir(acac)



$Ir(piq)_2(acac)$

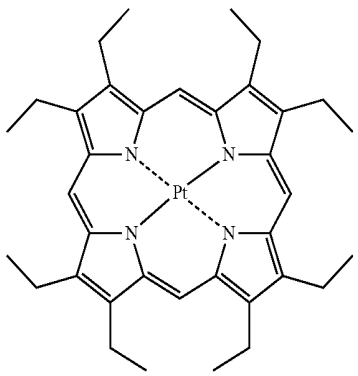


$Ir(2\text{-}phq)_2(acac)$



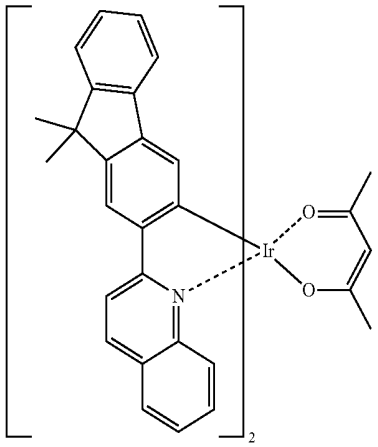
$Ir(2\text{-}phq)_3$

[0139] Examples of a known (or suitable) red dopant include Pt(II) octaethylporphine (PtOEP), tris(2-phenylisoquinoline)iridium (Ir(piq)3), bis(2-(2'-benzothienyl)-pyridinato-N,C3')iridium(acetylacetonate) (Btp2Ir(acac)), 4-(dicyanomethylene)-2-methyl-6-[p-(dimethylamino)styryl]-4H-pyran (DCM), and 4-(dicyanomethylene)-2-tert-butyl-6-(1,1,7,7,-tetramethyljulolidyl-9-enyl)-4H-pyran (DCJTB), but are not limited thereto.

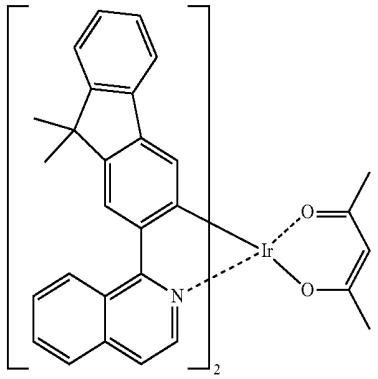


PtOEP

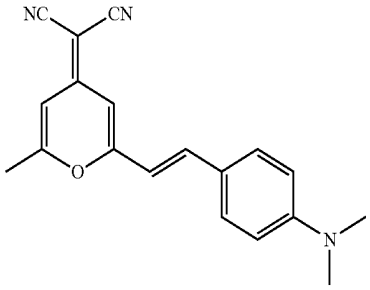
-continued



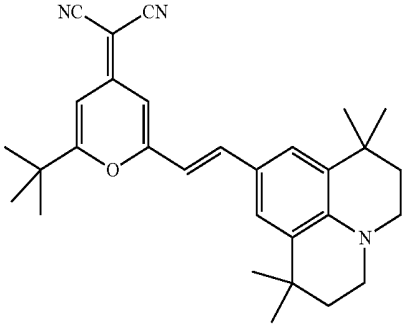
$Ir(flq)_2(acac)$



$Ir(fliq)_2(acac)$

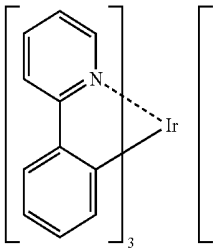


DCM

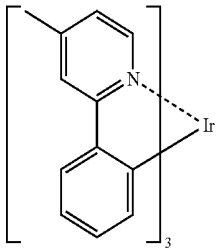


DCJTB

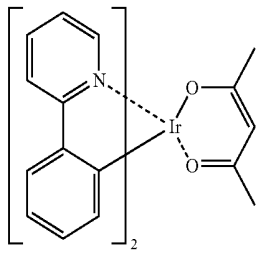
[0140] Examples of a known (or suitable) green dopant include tris(2-phenylpyridine) iridium ($Ir(ppy)_3$), bis(2-phenylpyridine)(acetylacetonato)iridium(III) ($Ir(ppy)_2(acac)$), tris(2-(4-tolyl)phenylpiridine)iridium ($Ir(mppy)_3$), and 10-(2-benzothiazolyl)-1,1,7,7-tetramethyl-2,3,6,7-tetrahydro-1H,5H,11H-[1]benzopyrano[6,7,8-ij]-quinolizin-11-one (C545T), but are not limited thereto.



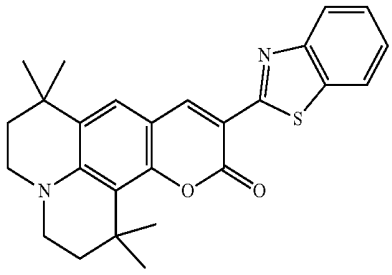
$Ir(ppy)_3$



$Ir(mppy)_3$



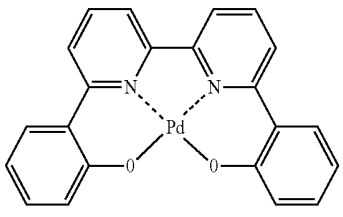
$Ir(ppy)_2(acac)$



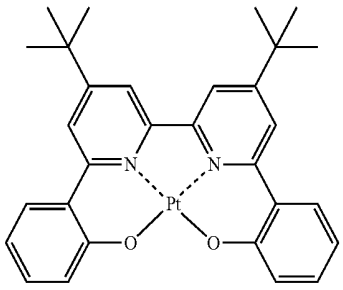
C545T

[0141] Also, the dopant available for use (usage) in the emission layer may be a Pt-complex illustrated below, but is not limited thereto:

D1

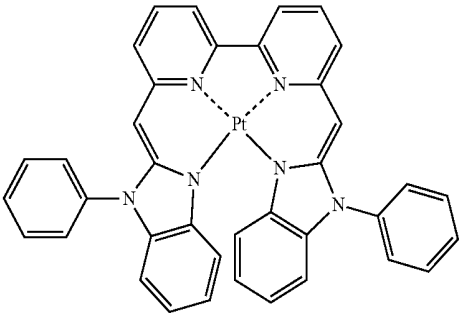


D2

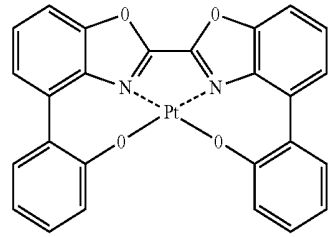


-continued

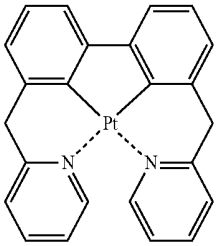
D3



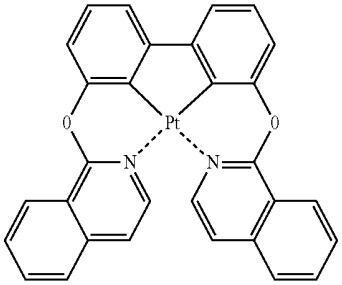
D4



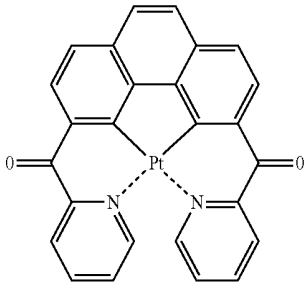
D5



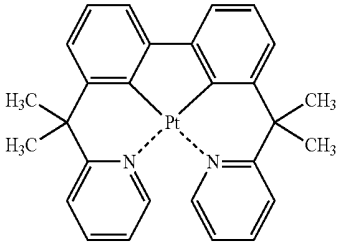
D6



D7

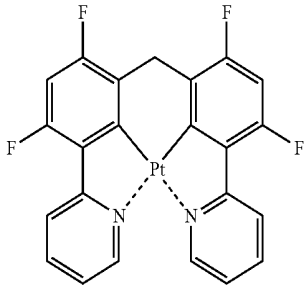


D8

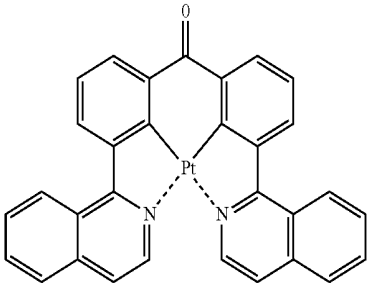


-continued

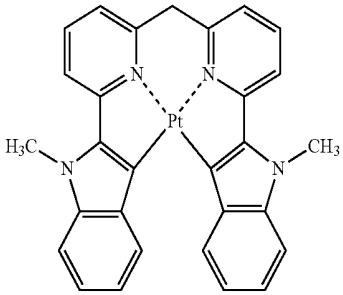
D9



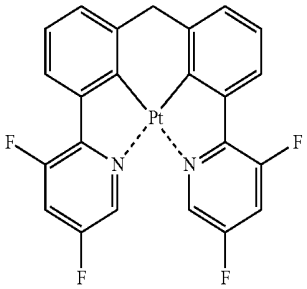
D10



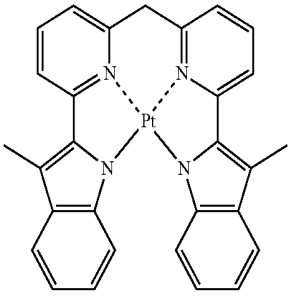
D11



D12

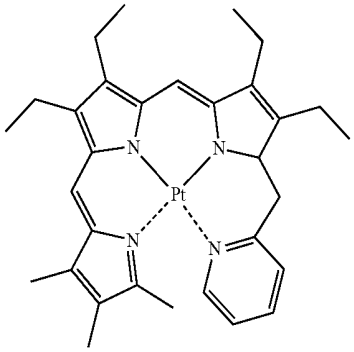


D13

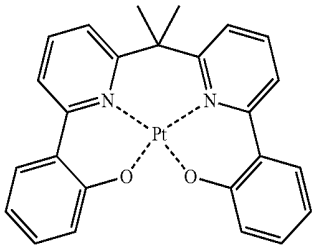


-continued

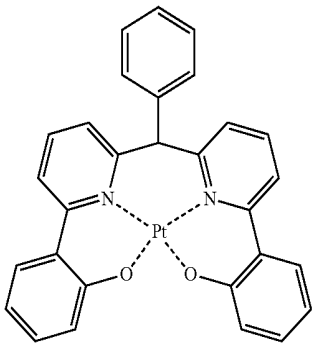
D14



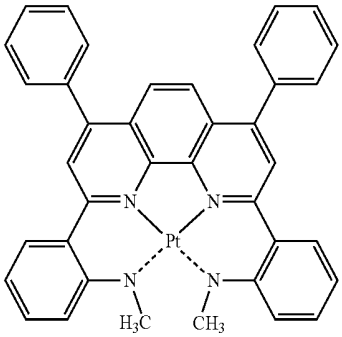
D15



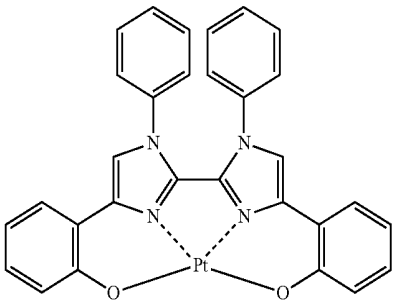
D16



D17

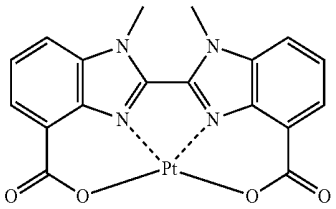


D18

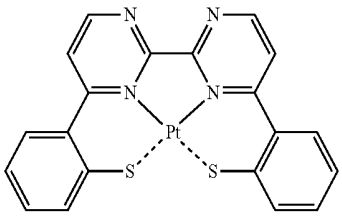


-continued

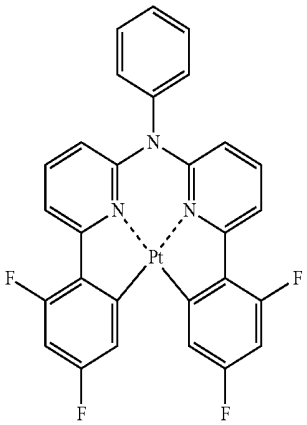
D19



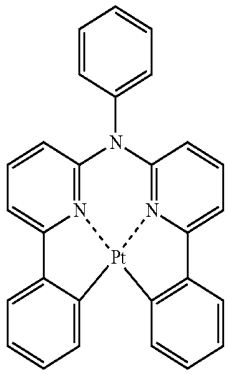
D20



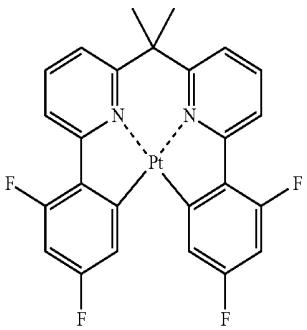
D21



D22

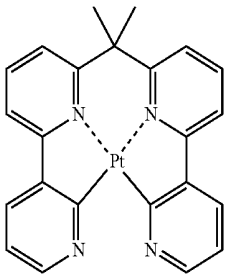


D23

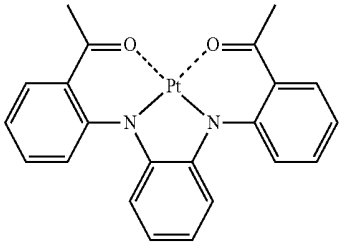


-continued

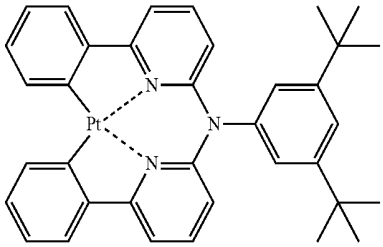
D24



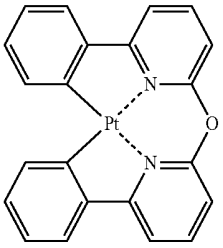
D25



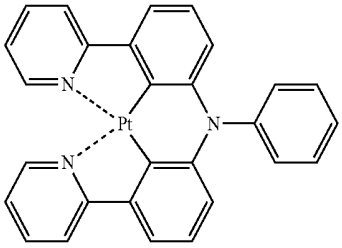
D26



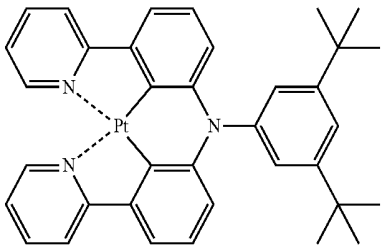
D27



D28

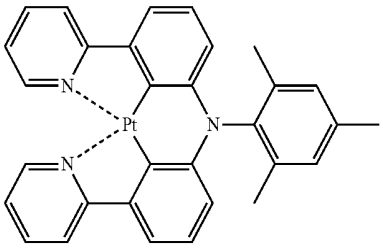


D29

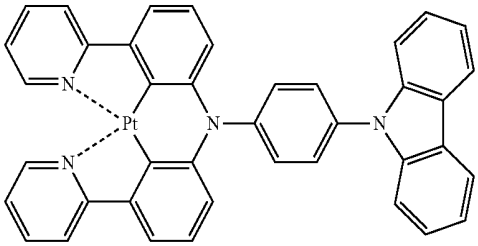


-continued

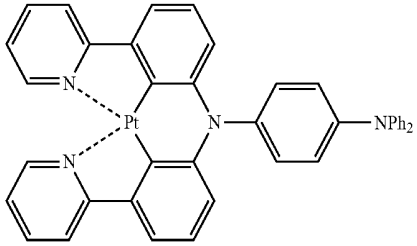
D30



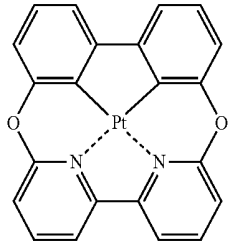
D31



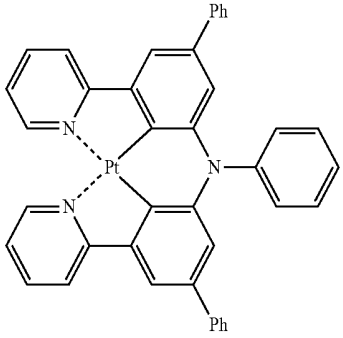
D32



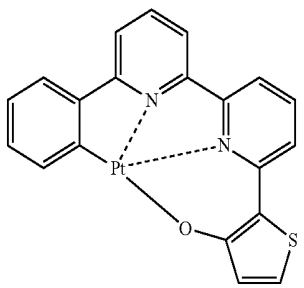
D33



D34

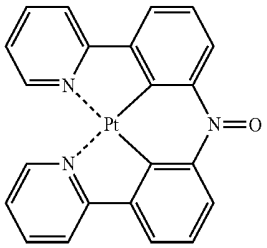


D35

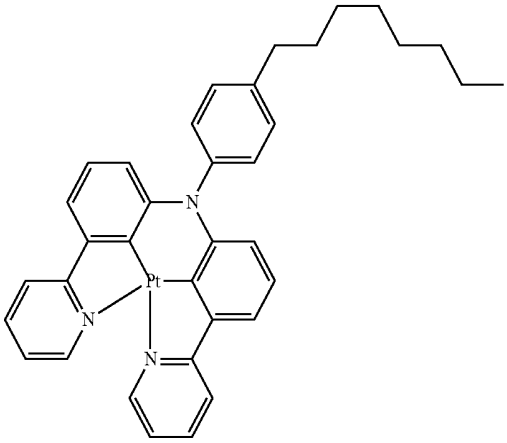


-continued

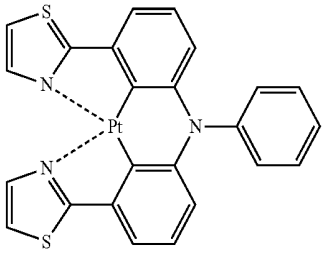
D36



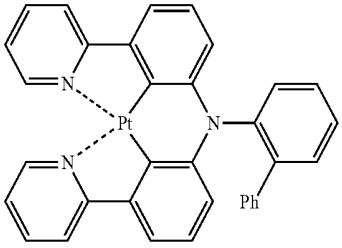
D37



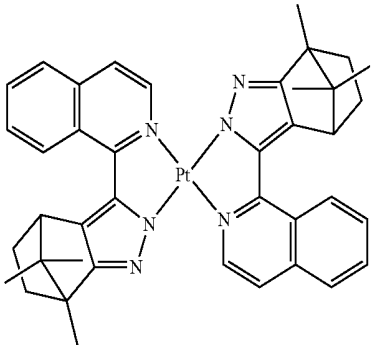
D38



D39

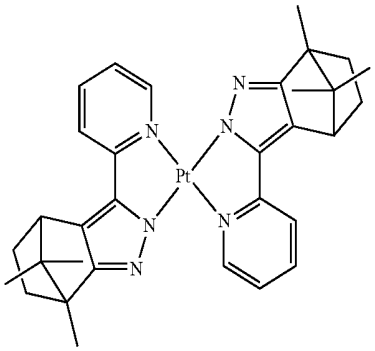


D40

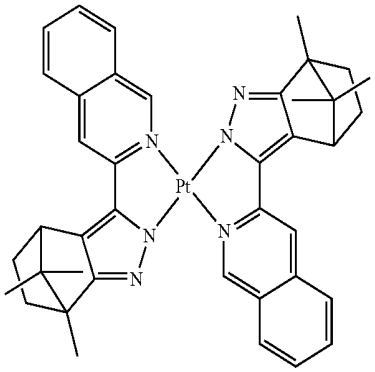


-continued

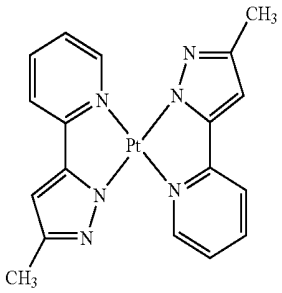
D41



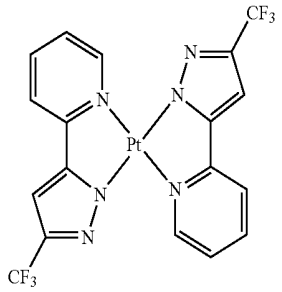
D42



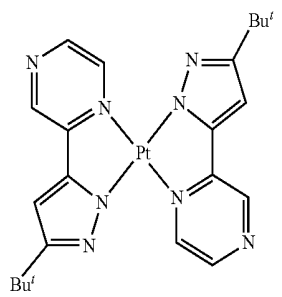
D43



D44

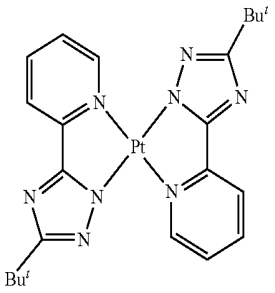


D45

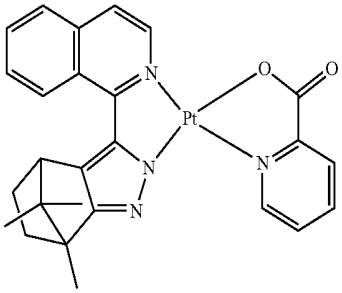


-continued

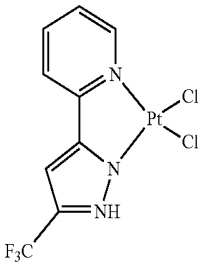
D46



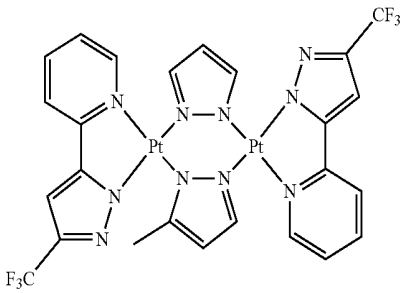
D47



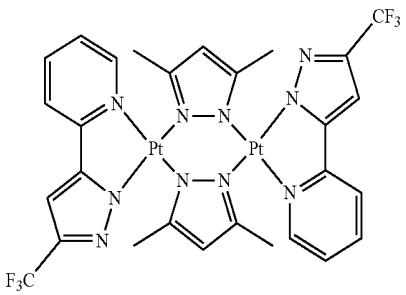
D48



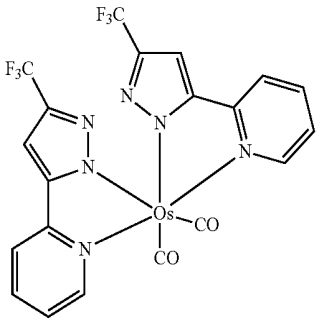
D49



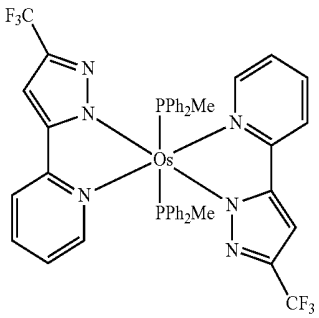
D50



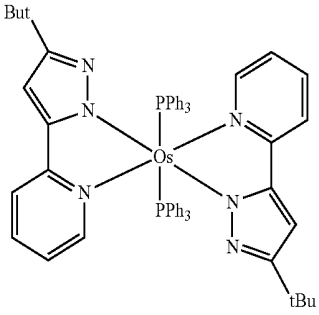
[0142] Also, the dopant available for use (usage) in the emission layer may be an Os-complex illustrated below, but is not limited thereto:



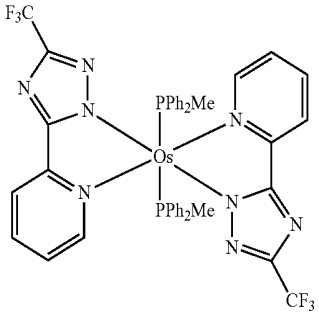
$Os(fppz)_2(CO)_2$



$Os(fppz)_2(PPh_2Me)_2$

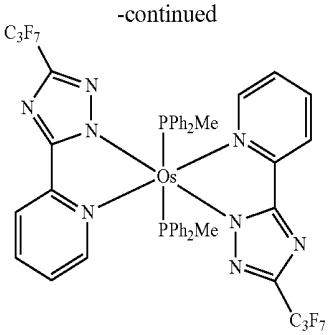


$Os(bppz)_2(PPh_3)_2$



$Os(fptz)_2(PPh_2Me)_2$

-continued



$Os(hptz)_2(PPh_2Me)_2$

[0143] When the emission layer includes a host and a dopant, an amount of the dopant may be in a range of about 0.01 to about 15 parts by weight based on 100 parts by weight of the host, but is not limited thereto.

[0144] 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. In one embodiment, when the thickness of the emission layer is within this range, excellent luminescent characteristics are obtained without a substantial increase in driving voltage.

[0145] In addition, a hole blocking layer (HBL) may be formed between the hole transport layer and the emission layer by vacuum deposition, spin coating, casting, LB deposition, or the like to reduce or prevent diffusion of excitons or holes into an electron transport layer. When the hole blocking layer is formed by vacuum deposition or spin coating, the deposition and coating conditions may be similar to those for the formation of the hole injection layer, though the conditions for deposition and coating may vary according to the material that is used (utilized) to form the hole blocking layer. A hole blocking material may be any one of known (or suitable) hole blocking materials, and examples thereof are an oxadiazole derivative, a triazole derivative, a phenanthroline derivative, and so on. For example, BCP may be used (utilized) to form the hole blocking layer.

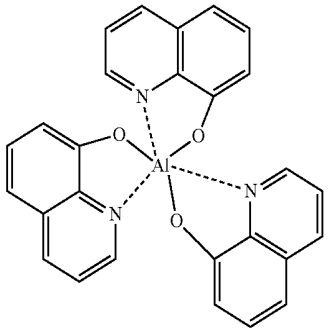
[0146] A thickness of the hole blocking layer may be in a range of about 50 Å to about 1,000 Å, for example, about 100 Å to about 300 Å. In one embodiment, when the thickness of the hole blocking layer is within these ranges, the hole blocking layer has excellent hole blocking characteristics without a substantial increase in driving voltage.

[0147] A buffer layer including the condensed cyclic compound of Formula 1 may be formed on the emission layer by, for example, vacuum deposition, spin coating, or casting. When the buffer layer is formed by vacuum deposition or spin coating, the vacuum deposition and coating conditions may be similar to those for the formation of the hole injection layer, though the conditions for vacuum deposition and coating may vary according to the material that is used (utilized) to form the buffer layer.

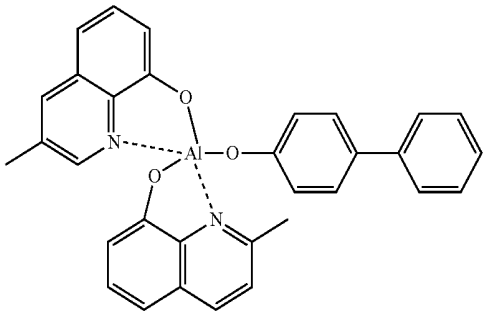
[0148] The buffer layer including the condensed cyclic compound of Formula 1 has excellent energy band matching characteristics with respect to an emission layer, and allows electrons to be easily supplied, thereby improving the color change in a relatively low-gradation region.

[0149] Next, an electron transport layer (ETL) is formed on the emission layer by using (utilizing) various suitable methods, for example, by vacuum deposition, spin coating, casting, or the like. When the electron transport layer is formed by vacuum deposition or spin coating, the vacuum deposition and coating conditions may be similar to those for the formation of the hole injection layer, though the conditions for vacuum deposition and coating may vary according to the material that is used (utilized) to form the electron transport layer. A material for forming the electron transport layer may stably transport electrons injected from an electron injection electrode (cathode), and may be a known (or suitable) electron transportation material.

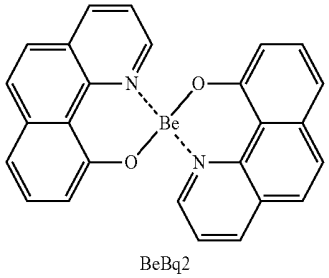
[0150] Examples of the known (or suitable) electron transportation material are a quinoline derivative, such as Alq_3, 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), 3-(4-biphenylyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole (TAZ), 4-(naphthalen-1-yl)-3,5-diphenyl-4H-1,2,4-triazole (NTAZ), 2-(4-biphenylyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole (tBu-PBD), BAlq (illustrated below), beryllium bis (benzoquinolin-10-olate) (Bebq2), 9,10-di(naphthalene-2-yl)anthracene (ADN), Compound 501, and Compound 502, but are not limited thereto.



Alq3

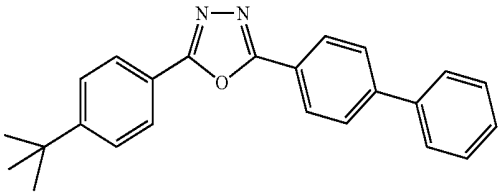


BAlq

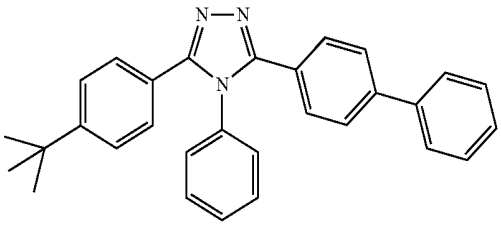


BeBq2

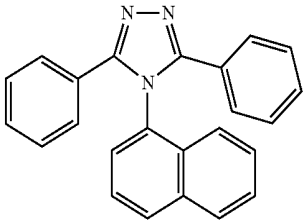
-continued



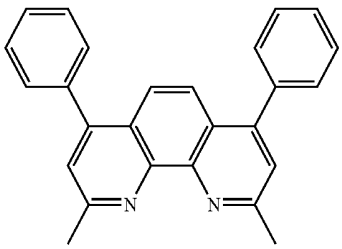
tBu-PBD



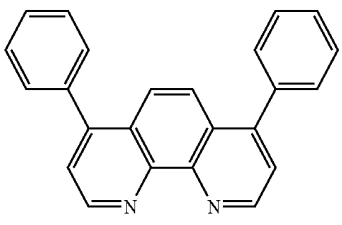
TAZ



NTAZ

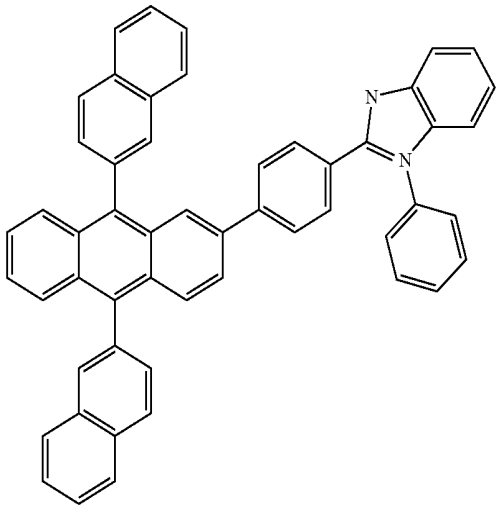


BCP

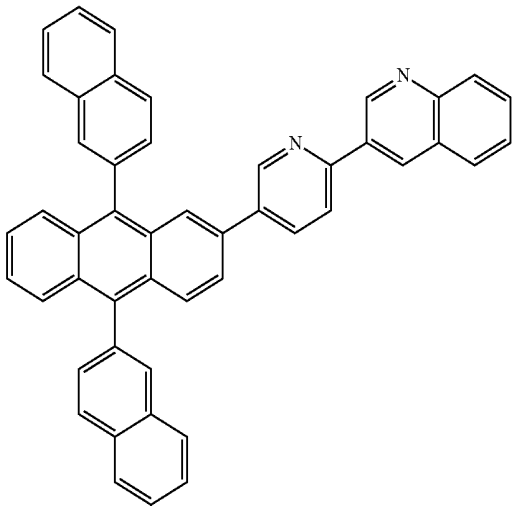


Bphen

-continued



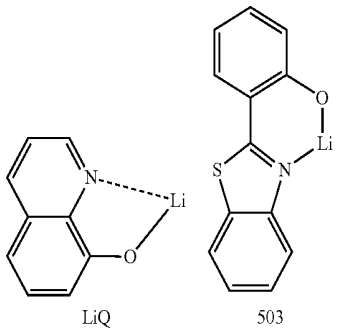
501



502

[0151] 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. In one embodiment, when the thickness of the electron transport layer is within the range described above, the electron transport layer has satisfactory electron transport characteristics without a substantial increase in a driving voltage.

[0152] In some embodiments, the electron transport layer may include an electron transport organic compound and a metal-containing material. The metal-containing material may include a Li complex. Non-limiting examples of the Li complex are lithium quinolate (LiQ) and Compound 503 illustrated below:



LiQ 503

[0153] Then, an electron injection layer (EIL), which facilitates injection of electrons from the cathode, may be formed on the electron transport layer. Any suitable electron injection material may be used (utilized) to form the electron injection layer.

[0154] Non-limiting examples of materials for forming the electron injection layer are LiF, NaCl, CsF, Li_2O, and BaO, which are known in the art. The deposition conditions of the electron injection layer may be similar to those used (utilized) to form the hole injection layer, although the deposition conditions may vary according to the material that is used (utilized) to form the electron injection layer.

[0155] 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. In one embodiment, when the thickness of the electron injection layer is within the range described above, the electron injection layer has satisfactory electron injection characteristics without a substantial increase in a driving voltage.

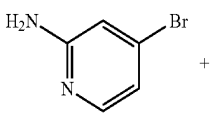
[0156] The second electrode **17** is disposed on the organic layer **15**. The second electrode may be a cathode that is an electron injection electrode, and in this regard, a metal for forming the second electrode may be a material having a low work function, examples thereof are metal, alloy, an electrically conductive compound, and a mixture thereof. For example, lithium (Li), magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), or magnesium-silver (Mg—Ag) may be formed as a thin film for use (usage) as a transmissive electrode. Also, in the case of a top emission light-emitting device, ITO or IZO may be used (utilized) to form a transmissive electrode.

[0157] Hereinafter, an organic light-emitting device according to an embodiment is described in more detail with reference to the Synthesis Examples and Examples. However, the organic light-emitting device is not limited thereto.

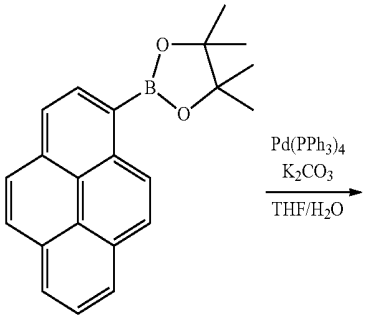
SYNTHESIS EXAMPLE 1

Synthesis of Compound 1

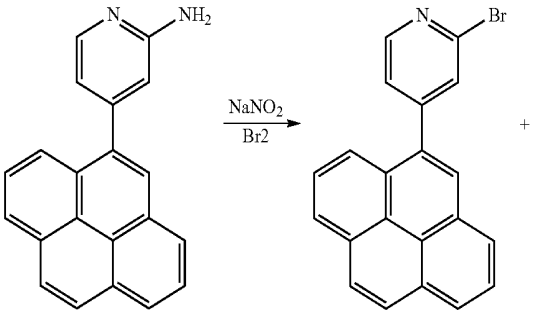
[0158]



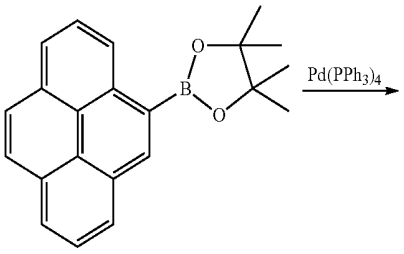
-continued



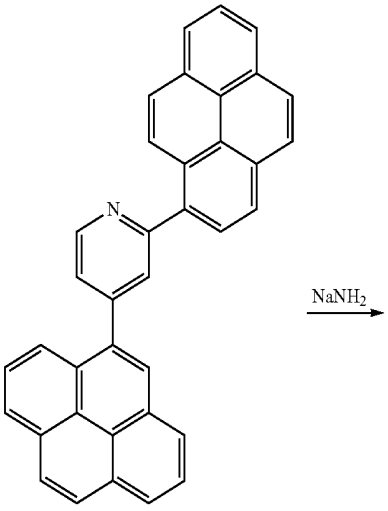
I-1



I-2 I-3

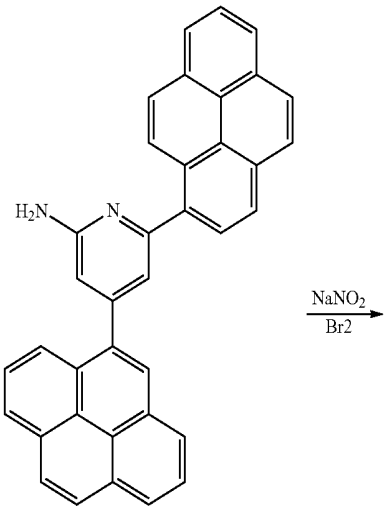


I-4

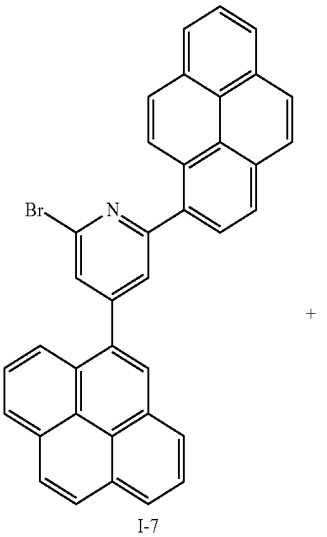


I-5

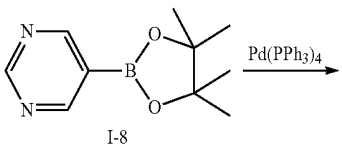
-continued



I-6

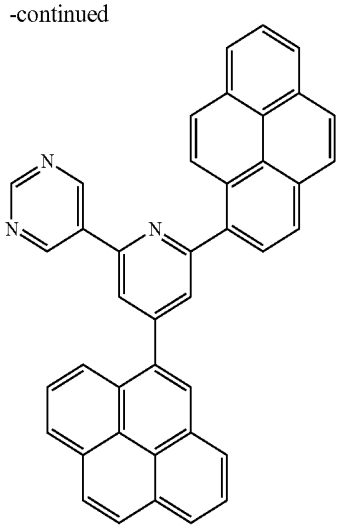


I-7



I-8

-continued



A

Synthesis of Intermediate I-2

[0159] 39.39 g (120.0 mmol) of Intermediate I-1, 10.38 g (60.0 mmol) of 2-amino-4-bromopyridine, 3.47 g (3.0 mmol) of $Pd(PPh_3)_4$, and 24.84 g (180.0 mmol) of K_2CO_3 were dissolved in 75 mL of a THF/H_2O mixed solution (a volumetric ratio of 2/1), and then, at a temperature of 70° C., the resultant solution was stirred for 5 hours. The reaction solution was cooled to room temperature, and then extracted three times with 100 mL of water and 100 mL of diethylether. A collected organic layer was dried by using (utilizing) magnesium sulfate, and then, the residual obtained by evaporating the solvent therefrom was separation-purified by silica gel column chromatography to obtain 18.84 g (yield of 80%) of Intermediate I-2. The obtained compound was identified by LC-MS. ($C_{21}H_{14}N_2$: calc. 294.36, obtained 294.12)

Synthesis of Intermediate I-3

[0160] 22.08 g (75 mmol) of Intermediate I-2 was mixed with 9.6 mL (48%) of a hydrobromic acid (HBr), and then, the temperature was dropped to −2° C., and 3.9 mL (49 mmol) of bromine (Br_2) was added thereto. 2.8 g (41 mmol) of sodium nitrite ($NaNO_2$) was added thereto in a nitrogen atmosphere, and then, 15 mL of 30% sodium hydroxide was added thereto. The mixture was stirred for 20 minutes. 15 minutes after the stirring, extraction was performed three times thereon with 150 mL of ether. A collected organic layer was dried by using (utilizing) sodium sulfate, and then, the residual obtained by evaporating the solvent therefrom was separation-purified by silica gel column chromatography to obtain 17.73 g (yield of 66%) of Intermediate I-3. The obtained compound was identified by LC-MS. ($C_{37}H_{22}N_2$: calc. 358.24, obtained 357.02)

Synthesis of Intermediate I-5

[0161] 26.26 g (80.0 mmol) of Intermediate I-4, 13.13 g (40.0 mmol) of Intermeidate I-3, 2.3 g (2.0 mmol) of $Pd(PPh_3)_4$, and 16.58 g (120.0 mmol) of K_2CO_3 were dissolved in 50 mL of a THF/H_2O (2/1) mixed solution, and then, at a temperature of 70° C., the resultant solution was stirred for 5 hours. The reaction solution was cooled to room temperature, and then extracted three times with 100 mL of water and 100 mL of diethylether. A collected organic layer was

dried by using (utilizing) magnesium sulfate, and then, the residual obtained by evaporating the solvent therefrom was separation-purified by silica gel column chromatography to obtain 15.34 g (yield of 80%) of Intermediate I-5. The obtained compound was identified by LC-MS. ($C_{37}H_{21}N$: calc. 479.58, obtained 479.17)

Synthesis of Intermediate I-6

[0162] 11.99 g (25 mmol) of Intermediate I-5 and 2.4 g of sodium amide were dissolved in 10.5 mL of dimethylaniline, and then, the mixture was stirred in an argon atmosphere at a temperature of 118° C. for 18 hours. The reaction solution was cooled to room temperature, and then, 13 mL of 5% sodium hydroxide solution and 40 mL of water were added thereto, and the result was stirred for 15 minutes. To remove dimethylaniline, extraction was performed thereon with 25 mL of petroleum ether. Sodium hydroxide was added to the resultant mixture, cooled, and then subjected to extraction three times by using (utilizing) 50 mL of benzene to obtain 8.2 g (yield of 66%) of Intermediate I-6. The obtained compound was identified by LC-MS. ($C_{37}H_{22}N_2$: calc. 494.60, obtained 494.18)

Synthesis of Intermediate I-7

[0163] 7.91 g (16 mmol) of Intermediate I-6 was mixed with 9.6 mL (48%) of a hydrobromic acid, and then, the temperature was dropped to −2° C., and 3.9 mL (49 mmol) of bromine was added thereto. 2.8 g (41 mmol) of sodium nitrite ($NaNO_2$) was added thereto in a nitrogen atmosphere, and then, 15 mL of 30% sodium hydroxide was added thereto. The mixture was stirred for 20 minutes. 15 minutes after the stirring, extraction was performed three times thereon with 150 mL of ether. A collected organic layer was dried by using (utilizing) sodium sulfate, and then, the residual obtained by evaporating the solvent therefrom was separation-purified by silica gel column chromatography to obtain 5.58 g (yield of 62%) of Intermediate I-7. The obtained compound was identified by LC-MS. ($C_{37}H_{20}BrN$: calc. 558.48, obtained 557.08)

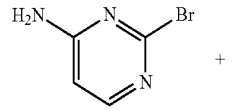
Synthesis of Compound 1 (i.e., Compound A)

[0164] 5.58 g (10.0 mmol) of Intermediate I-7, 2.06 g (10.0 mmol) of Intermeidate I-8, 0.75 g (0.5 mmol) of $Pd(PPh_3)_4$, and 4.15 g (30.0 mmol) of K_2CO_3 were dissolved in 25 mL of a THF/H_2O (2/1) mixed solution, and then, at a temperature of 70° C., the resultant solution was stirred for 5 hours. The reaction solution was cooled to room temperature, and then extracted three times with 25 mL of water and 25 mL of diethylether. A collected organic layer was dried by using (utilizing) magnesium sulfate, and then, the residual obtained by evaporating the solvent therefrom was separation-purified by silica gel column chromatography to obtain 4.46 g (yield of 80%) of Compound 1 (i.e., Compound A). The obtained compound was identified by LC-MS. ($C_{41}H_{23}N_3$: calc. 557.66, obtained 557.19)

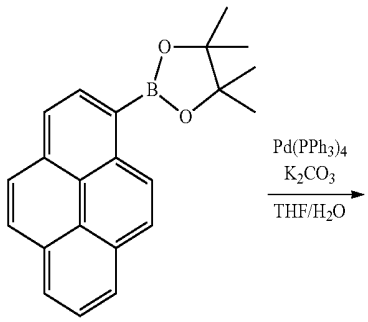
SYNTHESIS EXAMPLE 2

Synthesis of Compound 2 (i.e., Compound B)

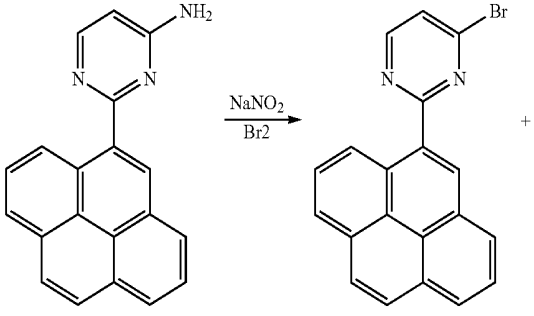
[0165]



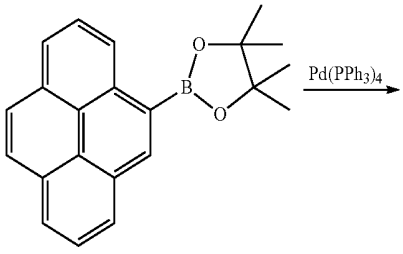
2-bromopyrimidin-4-amine



II-1

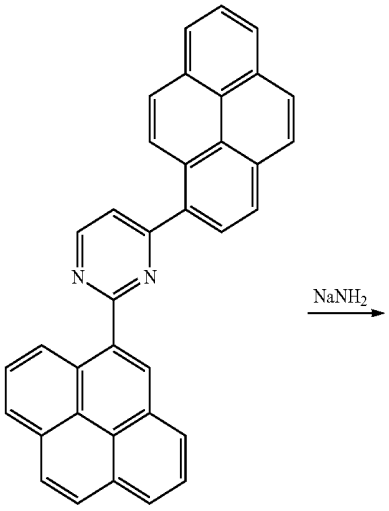


II-2 II-3

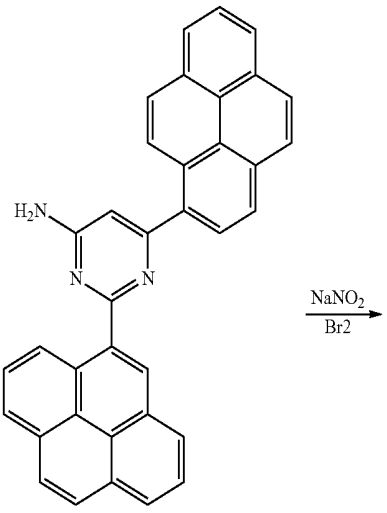


II-4

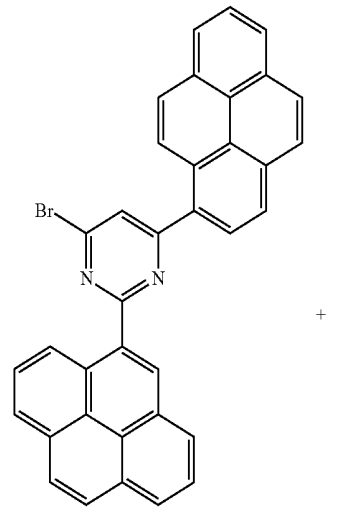
-continued



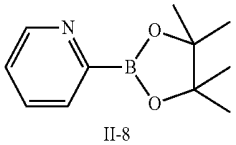
II-5



II-6

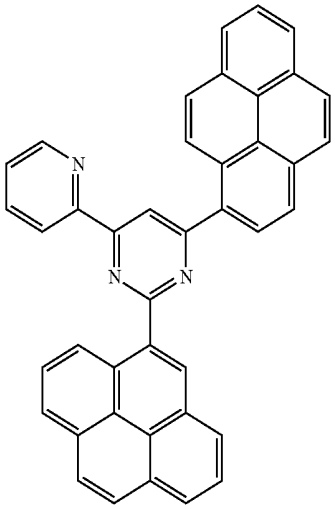


II-7



II-8

-continued



B

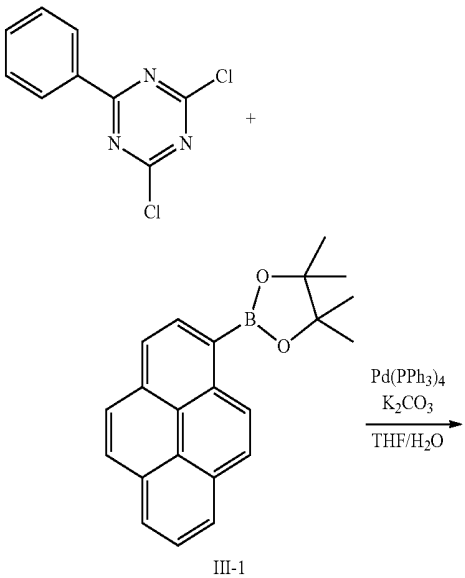
[0166] Intermediate II-2 was synthesized in the same manner as used (utilized) to synthesize Intermediate I-2, except that 6-bromo-4-aminopyrimidine was used (utilized) instead of 2-amino-4-bromopyridine.

[0167] Compound 2 (i.e., Compound B) was obtained in the same manner as used (utilized) to synthesize Compound 1, except that Intermediate II-2 was used (utilized) instead of Intermediate I-2, and Intermediate II-8 was used (utilized) instead of Intermediate I-8. ($C_{41}H_{23}N_3$: calc. 557.66, obtained 557.19)

SYNTHESIS EXAMPLE 3

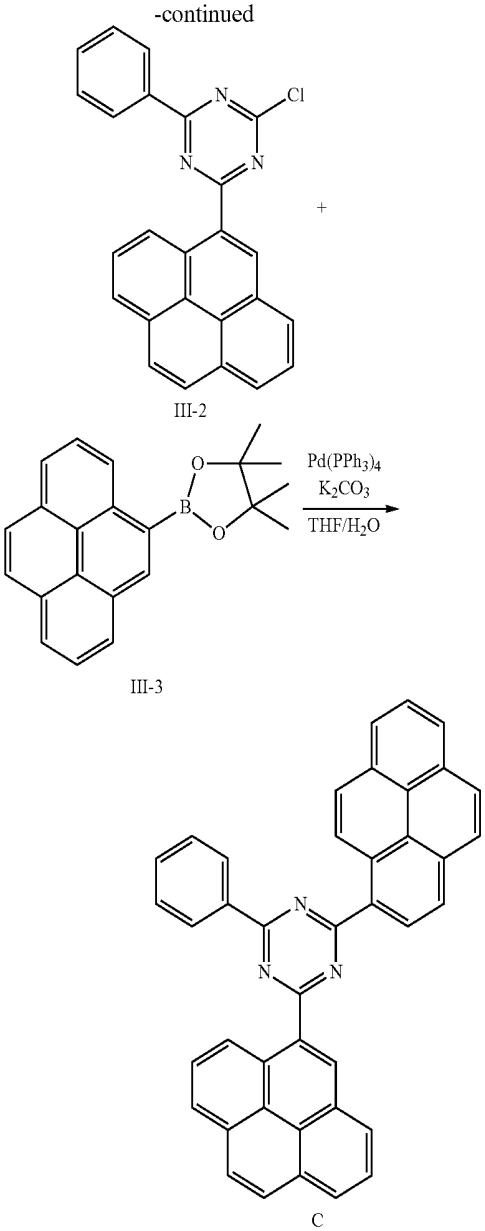
Synthesis of Compound 3 (i.e., Compound C)

[0168]



III-1

-continued



Synthesis of Intermediate III-2

[0169] 19.69 g (60.0 mmol) of Intermediate III-1, 13.56 g (60.0 mmol) of 2,4-dichloro-6-phenyl-1,3,5-triazine, 1.73 g (1.5 mmol) of $Pd(PPh_3)_4$, and 12.44 g (90.0 mmol) of K_2CO_3 were dissolved in 75 mL of a THF/H_2O mixed solution (a volumetric ratio of 2/1), and then, at a temperature of 70° C., the resultant solution was stirred for 5 hours. The reaction solution was cooled to room temperature, and then extracted three times with 100 mL of water and 100 mL of diethylether. A collected organic layer was dried by using (utilizing) magnesium sulfate, and then, the residual obtained by evaporating the solvent therefrom was separation-purified by silica gel column chromatography to obtain 23.51 g (yield of 50%) of Intermediate III-2. The obtained compound was identified by LC-MS. ($C_{21}H_{14}N_2$: calc. 391.86, obtained 391.09)

Synthesis of Compound 3 (i.e., Compound C)

[0170] 19.59 g (50.0 mmol) of Intermediate III-2, 16.41 g (50.0 mmol) of Intermediate III-3, 1.73 g (1.5 mmol) of $Pd(PPh_3)_4$, and 12.44 g (90.0 mmol) of K_2CO_3 were dissolved in 75 mL of a THF/H_2O mixed solution (a volumetric ratio of 2/1), and then, at a temperature of 70° C., the resultant solution was stirred for 5 hours. The reaction solution was cooled to room temperature, and then extracted three times with 100 mL of water and 100 mL of diethylether. A collected organic layer was dried by using (utilizing) magnesium sulfate, and then, the residual obtained by evaporating the solvent therefrom was separation-purified by silica gel column chromatography to obtain 22.30 g (yield of 80%) of Compound 3 (i.e., Compound C). The obtained compound was identified by LC-MS. ($C_{21}H_{14}N_2$: calc. 557.66, obtained 557.19)

EXAMPLE 1

[0171] An anode was manufactured as follows: an ITO glass substrate (a product of Corning Co., Ltd) having an ITO layer having a thickness of 1200 Å and a sheet resistance of 150 Ω/cm^2 was cut to a size of 50 mm×50 mm×0.7 mm, and then, sonicated by using (utilizing) isopropyl alcohol for 5 minuts and pure water for 5 minutes, and cleaned by exposure to ultraviolet rays and ozone for 30 minutes. 2-TNATA was vacuum deposited on the ITO glass substrate to form a hole injection layer having a thickness of 600 Å, and then, NPB was vacuum deposited on the hole injection layer to form a hole transport layer having a thickness of 300 Å. 98 wt % of ADN, which is a blue fluorescent host, and 2 wt % of DPAVBi, which is a blue fluorescent dopant, were used (utilized) to form an emission layer having a a thickness of 300 Å on the hole transport layer. Compound 1 was vacuum deposited on the emission layer to form a buffer layer having a thickness of 40 Å. Alq_3 was vacuum deposited on the buffer layer to form an electron transport layer having a thickness of 320 Å. LiF was vacuum deposited on the electron transport layer to form an electron injection layer having a thickness of 10 Å, and then, Al was vacuum deposited thereon to form a cathode having a thickness of 3,000 Å, thereby completing the manufacturing of an organic light-emitting device.

COMPARATIVE EXAMPLE 1

[0172] An organic light-emitting device was manufactured in the same manner as in Example 1, except that the electron transport layer was formed to have a thickness of 360 Å without utilizing the buffer layer.

EXAMPLE 2

[0173] An organic light-emitting device was manufactured in the same manner as in Example 1, except that as a material for forming the buffer layer, Compound 2 was used (utilized) instead of Compound 1.

EXAMPLE 3

[0174] An organic light-emitting device was manufactured in the same manner as in Example 1, except that as a material for forming the buffer layer, Compound 3 was used (utilized) instead of Compound 1.

EVALUATION EXAMPLE

[0175] The driving voltage, current density, luminance, efficiency, and emission color of the organic light-emitting devices manufactured according to Examples 1 to 3 and Comparative Example 1 were measured in the following manners.

[0176] 1) Change in Current Density According to Voltage

[0177] Regarding the organic light-emitting devices, a current flowing in a unit device was measured by using (utilizing) a current-voltage meter while a voltage was raised, and the measured current value was divided by an area.

[0178] 2) Change in Luminance According to Voltage

[0179] Regarding the organic light-emitting device, luminance was measured by using (utilizing) Minolta Cs-1000A, which is a luminance meter, while a voltage was raised.

[0180] 3) Luminescent Efficiency and Power Efficiency Measurement

[0181] Luminance values, current densities, and voltages (V) which were measured in 1) (change in current density according to voltage) and 2) (change in brightness according to voltage) were used (utilized) to calculate current efficiency and power efficiency, and results are shown in Table 1.

[0182] 4) Lifespan Measurement

[0183] From among current density values according to voltage, a current value corresponding to a reference luminance (blue 720nit) was identified, and then, at a constant current, brightness change was measured according to time by using (utilizing) a lifespan measurement equipment (OLED Life Time System). The lifespan was determined as a time when an emission luminance of a device was dropped to 97% of the initial emission luminance.

TABLE 1

	Driving voltage (V)	Current density (mA/cm^2)	Current efficiency (cd/A)	Power Efficiency (lm/W)	Color coordinate (CIE_x)	Color coordinate (CIE_y)	Lifespan (time @ % L = 97)
Comparative Example 1	4.9	11.7	5.7	3.6	0.138	0.051	400
Example 1	4.9	11.6	5.1	3.3	0.140	0.046	405
Example 2	4.8	12.4	4.5	2.9	0.142	0.042	395
Example 3	4.8	12.0	5.0	3.2	0.141	0.045	402

[0184] Referring to Table 1, the driving voltage, efficiency, and lifespan of the organic light-emitting devices of Examples 1 to 3 are similar to those of the organic light-emitting device of Comparative Example 1.

[0185] FIG. **2** is a graph of current efficiency with respect to luminance of the organic light-emitting devices of Comparative Example 1 and Examples 1 to 3. Referring to FIG. **2**, in the case of Comparative Example 1, the current efficiency was not constant (e.g., in a low luminance region (0 to 30 cd/m^2), a maximum value of the current efficiency is 6.2 Cd/A, while in a high luminance region, the value of the currently efficiency is lower). However, in the case of Examples 1 to 3, the maximum value and the average value of luminance were almost constant (e.g., about the same).

[0186] That is, in organic light-emitting devices according to embodiments of the present invention, electrons are easily provided from a buffer layer into an emission layer, and luminescent efficiency in a relatively low-gradation region is stabilized. Accordingly, the organic light-emitting devices have improved color change.

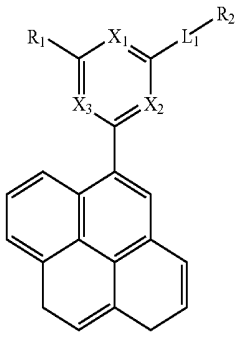
[0187] An organic light-emitting device including the condensed cyclic compound of Formula 1 has excellent performances and improved color change in a relatively low-gradation region.

[0188] It should be understood that the example 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.

[0189] While one or more embodiments of the present invention have been described with reference to the figures, it will be understood by those of ordinary skill in the art that various changes in form and details may be made therein without departing from the spirit and scope of the present invention as defined by the following claims, and equivalents thereof.

What is claimed is:

1. A condensed cyclic compound represented by Formula 1 below:



wherein in Formula 1,

X_1, X_2, and X_3 are each independently N or —CH, and at least one of X_1, X_2, and X_3 is N;

R_1 and R_2 are each independently selected from a hydrogen, a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group; a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, a C_1-C_{40} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group;

a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, and a C_1-C_{40} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a

sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group; and

a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group;

L_1 is selected from a direct bond; a C_6-C_{40} arylene group; a C_2-C_{40} heteroarylene group; and a C_6-C_{40} arylene group and a C_2-C_{40} heteroarylene group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group, —$N(Q_{11})(Q_{12})$, and —$Si(Q_{13})(Q_{14})(Q_{15})$; and

Q_{11} to Q_{15} are each independently selected from a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, a C_1-C_{40} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group;

a C_1-C_{40} alkyl group, a C_2-C_{40} alkenyl group, a C_2-C_{40} alkynyl group, and a C_1-C_{40} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group; and

a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arythio group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group.

2. The condensed cyclic compound of claim **1**, wherein R_1 and R_2 in Formula 1 are each independently selected from:

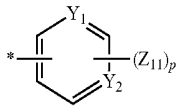
a hydrogen, a deuterium, a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, an indacenyl group, an acenaphthyl group, a biphenyl group, a heptalenyl group, a phenalenyl group, a fluorenyl group, a phenanthrenyl group, an anthryl group, a fluoranthenyl group, a pyrenyl group, a benzofluorenyl group, a naphthacenyl group, a chrysenyl group, a triphenylenyl group, a terphenyl group, a perylenyl group, a picenyl group, a hexacenyl group, a spiro-fluorenyl group, a pyrrolyl group, a furyl group, a pyrazolyl group, an imidazolyl group, an oxazolyl group, an isooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a pyridyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a pyranyl group, a thiophenyl group, a thiazolyl group, an isothiazolyl group, a thiopyran group, an indolyl group, an isoindolyl group, an indolizinyl group, a benzofuryl group, an isobenzofuryl group, an indazolyl group, a benzimidazolyl group, a benzoxazolyl group, a benzisooxazolyl group, an imidazopyridyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a phthalazinyl group, a quinazolinyl group, a quinoxalinyl group, a naphthyridinyl group, a cinnolinyl group, a benzothiophenyl group, a benzothiazolyl group, a carbazolyl group, a pyridoindolyl group, a dibenzofuryl group, a phenanthridinyl group, a benzoquinolyl group, a phenazinyl group, a dibenzosilolyl group, a dibenzothiophenyl group, and a benzocarbazolyl group; and

a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, an inacenyl group, an acenaphthyl group, a biphenyl group, a heptalenyl group, a phenalenyl group, a fluorenyl group, a phenanthrenyl group, an anthryl group, a fluoranthenyl group, a pyrenyl group, a benzofluorenyl group, a naphthacenyl group, a chrysenyl group, a triphenylenyl group, a terphenyl group, a perylenyl group, a picenyl group, a hexacenyl group, a spiro-fluorenyl group, a pyrrolyl group, a furyl group, a pyrazolyl group, an imidazolyl group, an oxazolyl group, an isooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a pyridyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a pyranyl group, a thiophenyl group, a thiazolyl group, an isothiazolyl group, a thiopyran group, an indolyl group, an isoindolyl

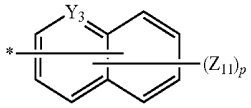
group, an indolizinyl group, a benzofuryl group, an isobenzofuryl group, an indazolyl group, a benzimidazolyl group, a benzoxazolyl group, a benzisooxazolyl group, an imidazopyridyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a phthalazinyl group, a quinazolinyl group, a quinoxalinyl group, a naphthyridinyl group, a cinnolinyl group, a benzothiophenyl group, a benzothiazolyl group, a carbazolyl group, a pyridoindolyl group, a dibenzofuryl group, a phenanthridinyl group, a benzoquinolyl group, a phenazinyl group, a dibenzosilolyl group, a dibenzothiophenyl group and a benzocarbazolyl group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group.

3. The condensed cyclic compound of claim **1**, wherein R_1 and R_2 are each independently represented by any one of Formulae 2A to 2D below:

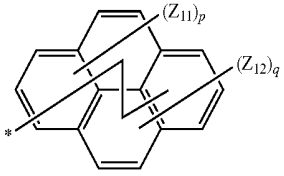
Formula 2A



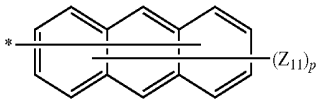
Formula 2B



Formula 2C



Formula 2D



in Formulae 2A to 2D,

Y_1, Y_2, and Y_3 are each independently N or —CH;

Z_{11} and Z_{12} are each independently selected from a hydrogen, a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a C_6-C_{20} aryl group, and a C_2-C_{20} heteroaryl group;

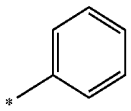
a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof; and

a C_6-C_{20} aryl group and a C_2-C_{20} heteroaryl group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a C_6-C_{20} aryl group, and a C_2-C_{20} heteroaryl group;

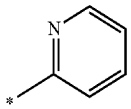
p is an integer of 3 to 9; q is 4 or 5; and * indicates a binding site.

4. The condensed cyclic compound of claim **1**, wherein R_1 and R_2 are each independently represented by any one of Formulae 3A to 3J below:

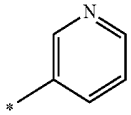
Formula 3A



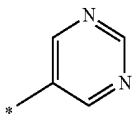
Formula 3B



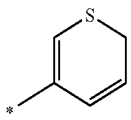
Formula 3C



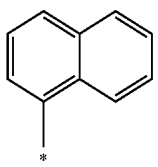
Formula 3D



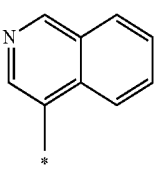
Formula 3E



Formula 3F

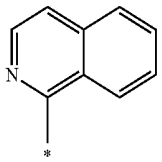


Formula 3G

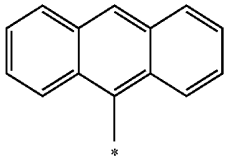


-continued

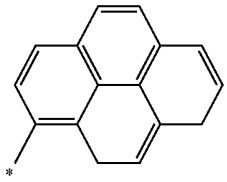
Formula 3H



Formula 3I



Formula 3J



in the formulae above, * indicates a binding site.

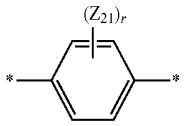
5. The condensed cyclic compound of claim **1**, wherein L_1 is selected from:

a direct bond, a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, an indacenylene group, an acenaphthylene group, a biphenylene group, a heptalenylene group, a phenalenylene group, a fluorenylene group, a phenanthrenylene group, an anthrylene group, a fluoranthenylene group, a pyrenylene group, a benzofluorenylene group, a naphthacenylene group, a chrysenylene group, and a triphenylenylene group; and

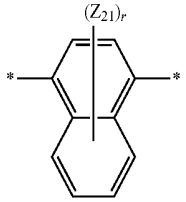
a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, an indacenylene group, an acenaphthylene group, a biphenylene group, a heptalenylene group, a phenalenylene group, a fluorenylene group, a phenanthrenylene group, an anthrylene group, a fluoranthenylene group, a pyrenylene group, a benzofluorenylene group, a naphthacenylene group, a chrysenylene group, and a triphenylenylene group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_2-C_{20} alkenyl group, a C_2-C_{20} alkynyl group, a C_1-C_{20} alkoxy group, a C_3-C_{10} cycloalkyl group, a C_3-C_{10} heterocycloalkyl group, a C_3-C_{10} cycloalkenyl group, a C_3-C_{10} heterocycloalkenyl group, a C_6-C_{40} aryl group, a C_2-C_{40} heteroaryl group, a C_6-C_{40} aryloxy group, and a C_6-C_{40} arylthio group.

6. The condensed cyclic compound of claim **1**, wherein L_1 is a direct bond or any one represented by Formulae 4A and 4B:

Formula 4A



Formula 4B



wherein in Formulae 4A and 4B,

Z_{21} is independently selected from a hydrogen, a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_2-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a C_6-C_{20} aryl group, and a C_2-C_{20} heteroaryl group;

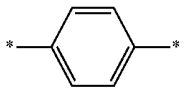
a C_1-C_{20} alkyl group and a C_1-C_{20} alkoxy group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, and a phosphoric acid group or a salt thereof; and

a C_6-C_{20} aryl group and a C_2-C_{20} heteroaryl group, each substituted with at least one of a deuterium, a halogen atom, a hydroxyl group, a cyano group, a nitro group, an amino group, an amidino group, a hydrazine group, a hydrazone group, a carboxylic acid group or a salt thereof, a sulfonic acid group or a salt thereof, a phosphoric acid group or a salt thereof, a C_1-C_{20} alkyl group, a C_1-C_{20} alkoxy group, a C_6-C_{20} aryl group, and a C_2-C_{20} heteroaryl group;

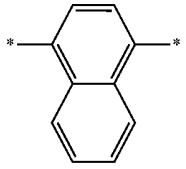
r is an integer of 4 to 6; and * indicates a binding site.

7. The condensed cyclic compound of claim **1**, wherein L_1 is a direct bond or any one represented by Formulae 5A and 5B:

Formula 5A



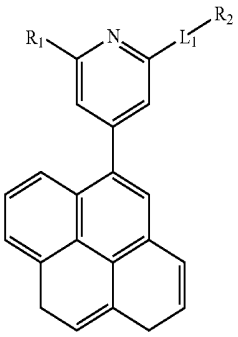
Formula 5B



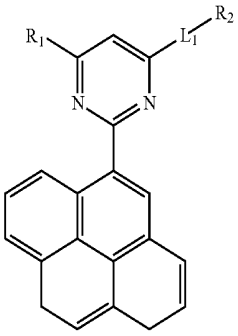
in Formulae 5A and 5B, * indicates a binding site.

8. The condensed cyclic compound of claim **1**, wherein the condensed cyclic compound is represented by any one of Formulae 1A to 1C:

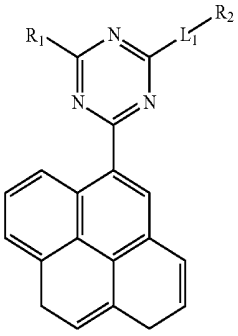
Formula 1A



Formula 1B



Formula 1C



in Formulae 1A to 1C,

R_1 and R_2 are each independently selected from a C_6-C_{40} aryl group and a C_2-C_{40} heteroaryl group; and

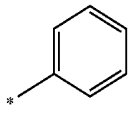
L_1 is selected from a direct bond, a C_6-C_{40} arylene group, and a C_2-C_{40} heteroarylene group.

9. The condensed cyclic compound of claim **8**, wherein R_1 and R_2 are each independently selected from:

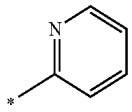
a phenyl group, a pentalenyl group, an indenyl group, a naphthyl group, an azulenyl group, an indacenyl group, an acenaphthyl group, a biphenyl group, a heptalenyl group, a phenalenyl group, a fluorenyl group, a phenanthrenyl group, an anthryl group, a fluoranthenyl group, a pyrenyl group, a benzofluorenyl group, a naphthacenyl group, a chrysenyl group, a triphenylenyl group, a terphenyl group, a perylenyl group, a picenyl group, a hexacenyl group, a spiro-fluorenyl group, a pyrrolyl group, a furyl group, a pyrazolyl group, an imidazolyl group, an oxazolyl group, an isooxazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a pyridyl group, a pyrimidinyl group, a pyrazinyl group, a pyridazinyl group, a triazinyl group, a pyranyl group, a thiophenyl group, a thiazolyl group, an isothiazolyl group, a thiopyran group, an indolyl group, an isoindolyl group, an indolizinyl group, a benzofuryl group, an isobenzofuryl group, an indazolyl group, a benzimidazolyl group, a benzoxazolyl group, a benzisooxazolyl group, an imidazopyridyl group, a purinyl group, a quinolyl group, an isoquinolyl group, a phthalazinyl group, a quinazolinyl group, a quinoxalinyl group, a naphthyridinyl group, a cinnolinyl group, a benzothiophenyl group, a benzothiazolyl group, a carbazolyl group, a pyridoindolyl group, a dibenzofuryl group, a phenanthridinyl group, a benzoquinolyl group, a phenazinyl group, a dibenzosilolyl group, a dibenzothiophenyl group, and a benzocarbazolyl group.

10. The condensed cyclic compound of claim **8**, wherein R_1 and R_2 are each independently represented by any one of Formulae 3A to 3J below:

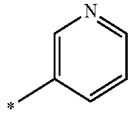
Formula 3A



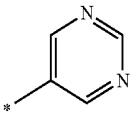
Formula 3B



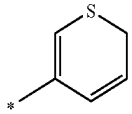
Formula 3C



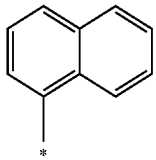
Formula 3D



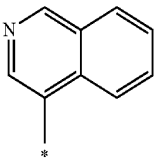
Formula 3E



Formula 3F

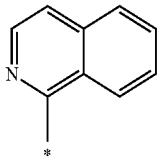


Formula 3G

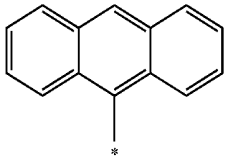


-continued

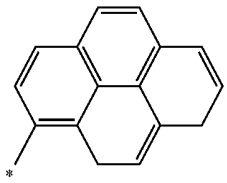
Formula 3H



Formula 3I



Formula 3J



in the formulae above, * indicates a binding site.

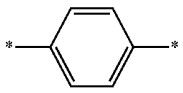
11. The condensed cyclic compound of claim **10**, wherein R_2 is represented by any one of Formulae 3A, 3F, 3I, and 3J.

12. The condensed cyclic compound of claim **8**, wherein L_1 is selected from:

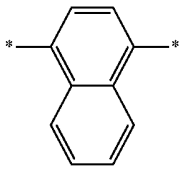
a direct bond, a phenylene group, a pentalenylene group, an indenylene group, a naphthylene group, an azulenylene group, an indacenylene group, an acenaphthylene group, a biphenylene group, a heptalenylene group, a phenalenylene group, a fluorenylene group, a phenanthrenylene group, an anthrylene group, a fluoranthenylene group, a pyrenylene group, a benzofluorenylene group, a naphthacenylene group, a chrysenylene group, and a triphenylenylene group.

13. The condensed cyclic compound of claim **8**, wherein L_1 is a direct bond or any one represented by Formulae 5A and 5B:

Formula 5A



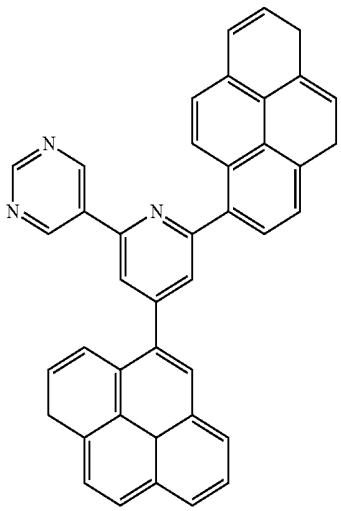
Formula 5B



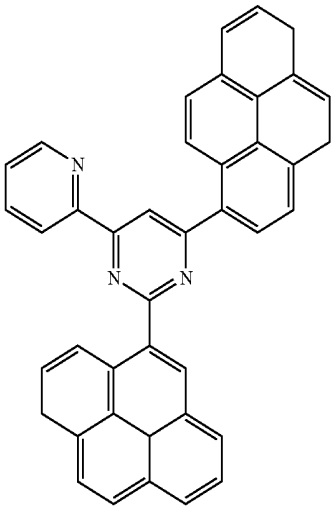
in Formulae 5A and 5B, * indicates a binding site.

14. The condensed cyclic compound of claim **1**, wherein the condensed cyclic compound is one of Compounds 1 to 18 below:

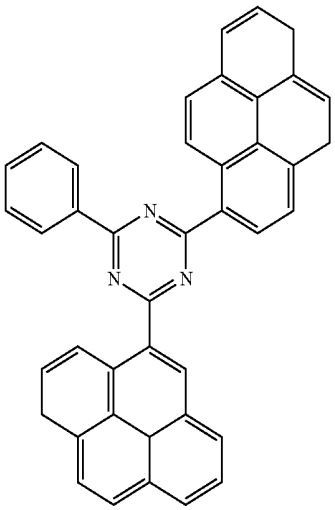
1



2

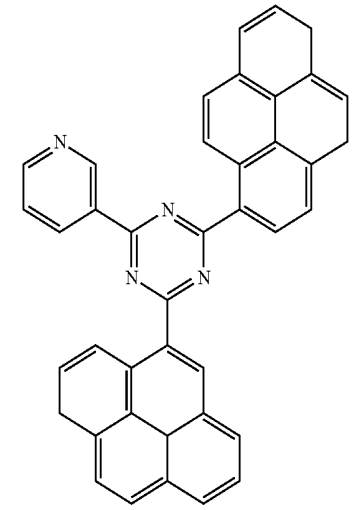


3

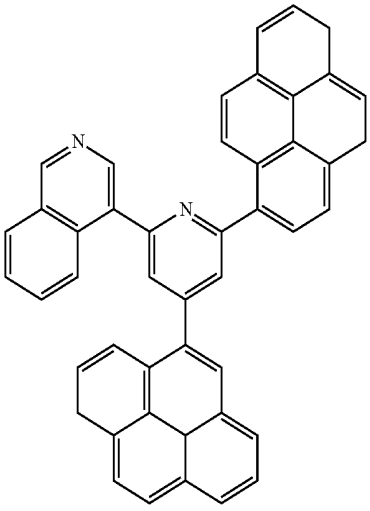


-continued

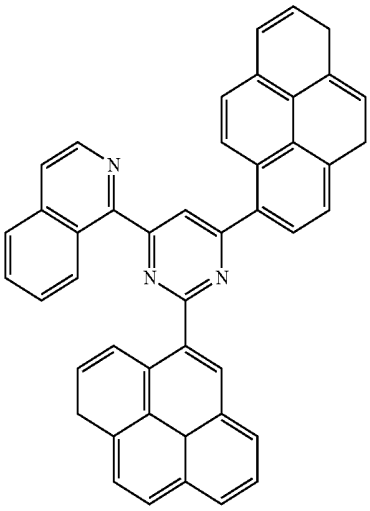
4



5

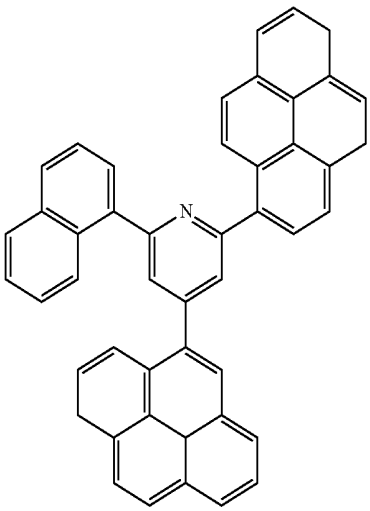


6

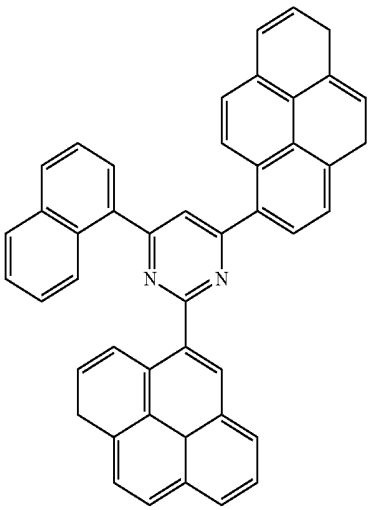


-continued

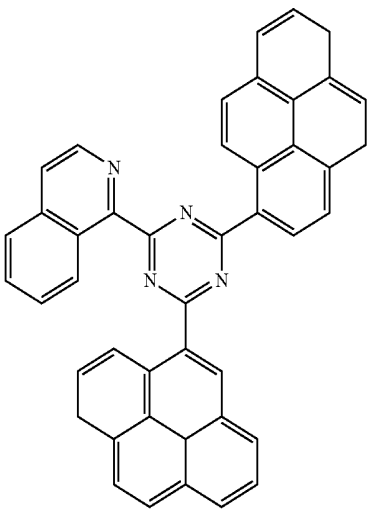
7



8

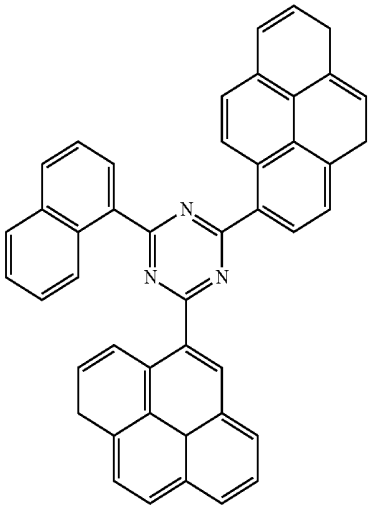


9

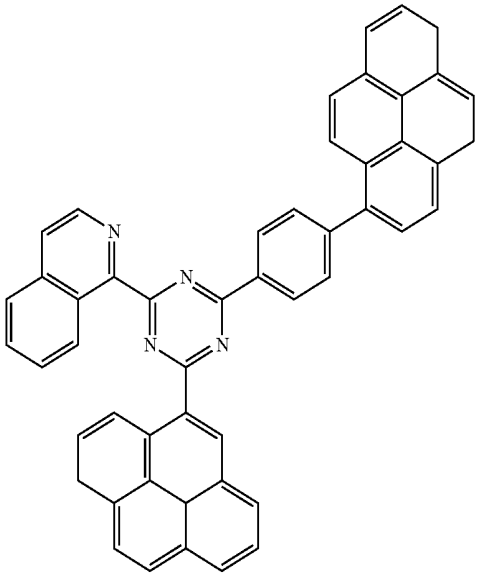


-continued

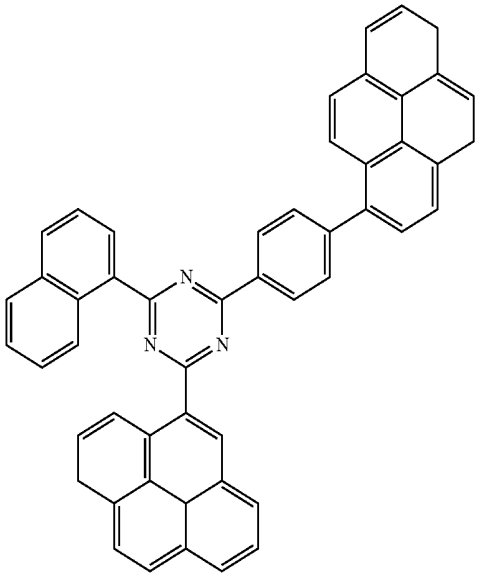
10



11

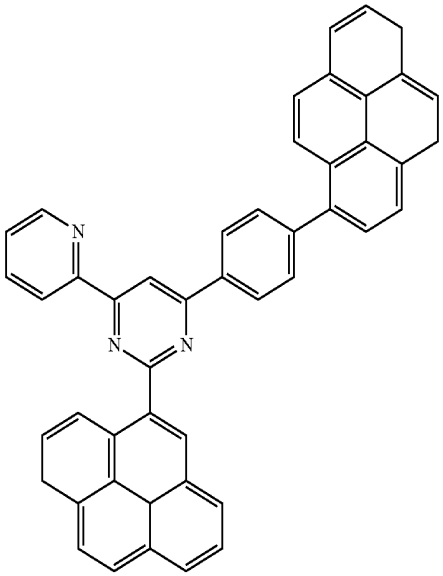


12

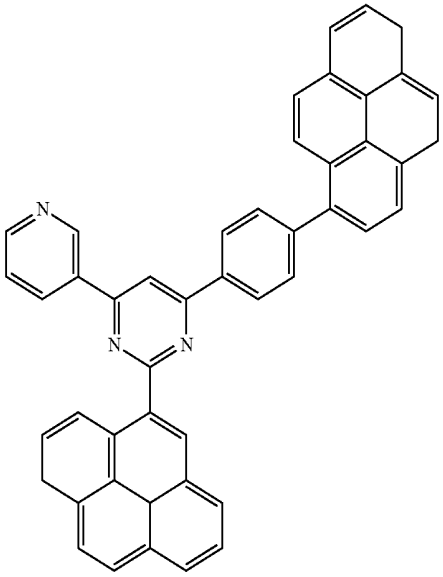


-continued

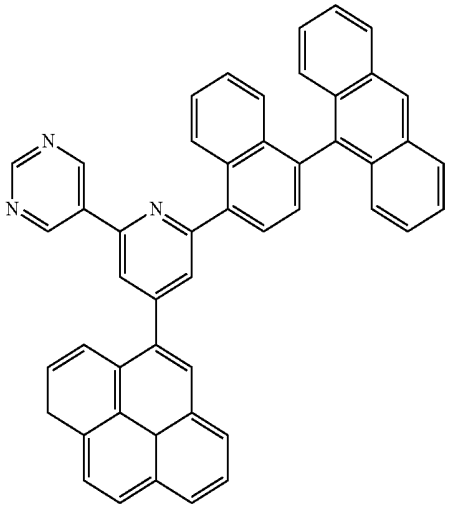
13



14

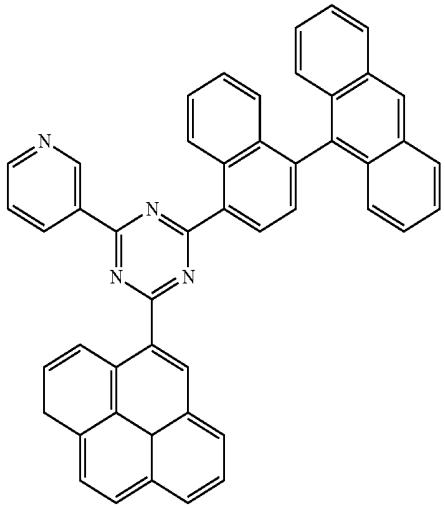


15

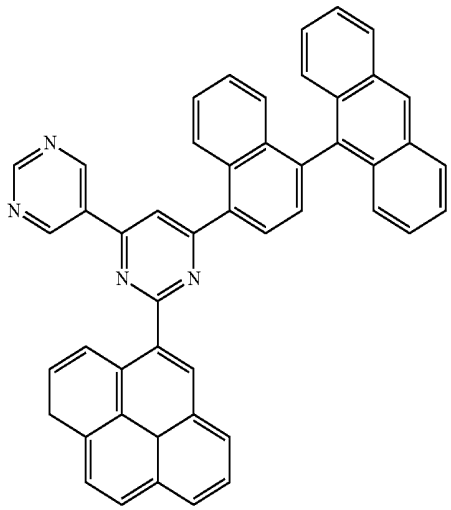


-continued

16

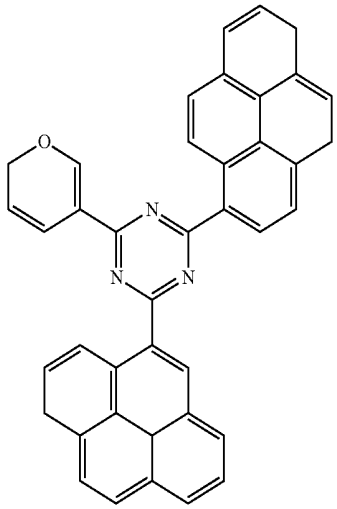


17



-continued

18



15. 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,
wherein the organic layer comprises at least one of the condensed cyclic compounds of claim **1**.

16. The organic light-emitting device of claim **15**, wherein the organic layer comprises:
an emission layer;
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,
wherein the electron transport region comprises at least one of the condensed cyclic compounds.

17. The organic light-emitting device of claim **16**, wherein the electron transport region comprises an electron transport layer, and a buffer layer between the emission layer and the electron transport layer,
wherein the buffer layer comprises at least one of the condensed cyclic compounds.

18. The organic light-emitting device of claim **17**, wherein the electron transport region further comprises an electron injection layer between the electron transport layer and the second electrode.

19. The organic light-emitting device of claim **16**, wherein the hole transport region comprises at least one selected from a hole injection layer, a hole transport layer, and an electron blocking layer.

20. The organic light-emitting device of claim **16**, wherein the first electrode is an anode and the second electrode is a cathode.

* * * * *

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	US20150263290A1	公开(公告)日	2015-09-17
申请号	US14/340442	申请日	2014-07-24
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	CHO SE JIN LEE CHANG MIN		
发明人	CHO, SE-JIN LEE, CHANG-MIN		
IPC分类号	H01L51/00		
CPC分类号	H01L51/0058 H01L51/0067 H01L51/0072 H01L51/5012 H01L51/5092 H01L51/5072 H01L51/5056 H01L51/0065 H01L51/0054 H01L51/0081 H01L51/508		
优先权	1020140028599 2014-03-11 KR		
外部链接	Espacenet USPTO		

摘要(译)

式1表示稠合环状化合物，有机发光装置含有缩合环状化合物。 在式1中，X1，X2，X3，L1，R1和R2。包括具有稠环化合物的有机层的有机发光装置在相对低灰度区域中具有改善的颜色变化。