US 20110084256A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2011/0084256 A1**

(43) **Pub. Date: Apr. 14, 2011**

Kim et al.

(54) **CONDENSED-CYCLIC COMPOUND AND ORGANIC LIGHT EMITTING DIODE INCLUDING ORGANIC LAYER CONTAINING THE CONDENSED-CYCLIC COMPOUND**

(75) Inventors: **Hee-Yeon Kim**, Yongin-City (KR); **Seung-Gak Yang**, Yongin-City (KR); **Kwan-Hee Lee**, Yongin-City (KR)

(73) Assignee: **Samsung Mobile Display Co., Ltd.**, Yongin-City (KR)

(21) Appl. No.: **12/895,732**

(22) Filed: **Sep. 30, 2010**

(30) **Foreign Application Priority Data**

Oct. 9, 2009 (KR) 10-2009-0096393

Publication Classification

(51) **Int. Cl.**

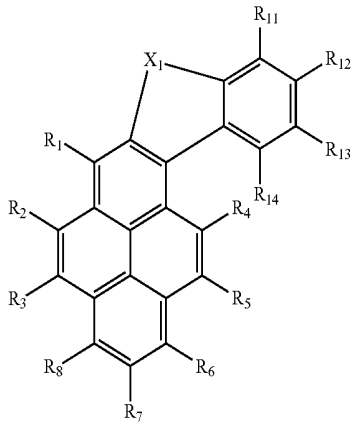
H01L 51/50	(2006.01)
C07C 25/22	(2006.01)
C07D 401/04	(2006.01)
C07D 401/10	(2006.01)
C07C 211/61	(2006.01)
C07D 403/12	(2006.01)
C07C 13/615	(2006.01)

(52) **U.S. Cl.** **257/40**; 570/183; 546/167; 546/255; 564/426; 548/442; 585/22; 257/E51.018

(57) **ABSTRACT**

A condensed-cyclic compound represented by Formula 1 below and an organic light emitting diode including the condensed-cyclic compound:

Formula 1



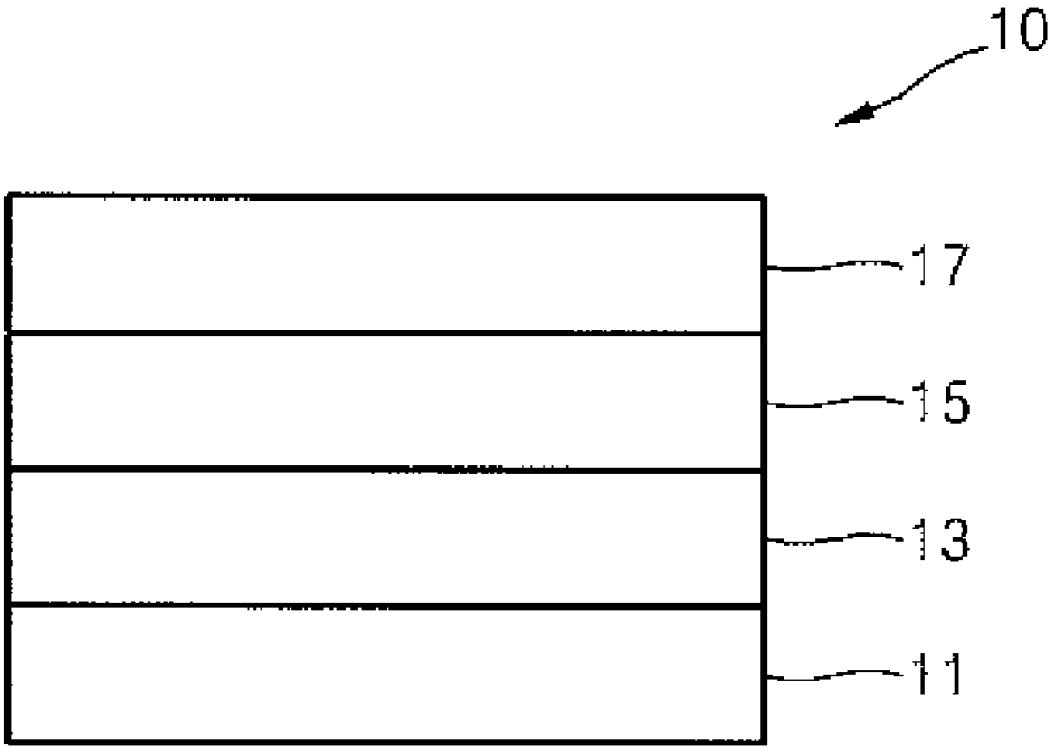
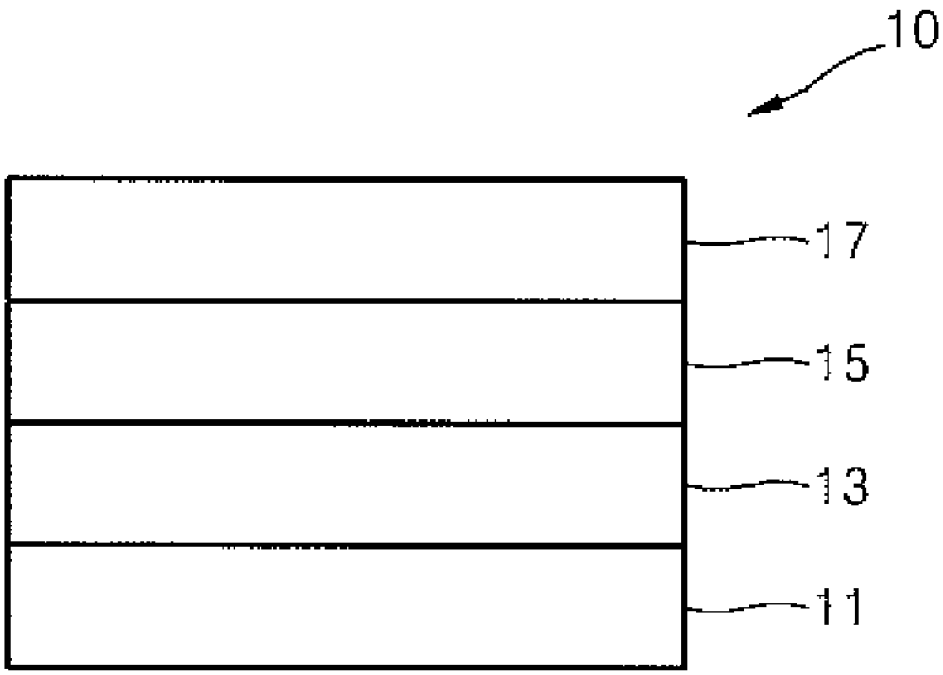


FIG. 1



CONDENSED-CYCLIC COMPOUND AND ORGANIC LIGHT EMITTING DIODE INCLUDING ORGANIC LAYER CONTAINING THE CONDENSED-CYCLIC COMPOUND

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Korean Patent Application No. 10-2009-0096393, filed on Oct. 9, 2009, in the Korean Intellectual Property Office, the disclosure of which is incorporated herein in its entirety by reference.

BACKGROUND

[0002] 1. Field

[0003] A condensed-cyclic compound, and an organic light emitting diode including an organic layer containing the condensed-cyclic compound are provided.

[0004] 2. Description of the Related Technology

[0005] Organic light-emitting diodes (OLEDs), which are self-emitting devices, have advantages such as a wide viewing angle, excellent contrast, quick response, high brightness, excellent driving voltage characteristics, and can provide multicolored images.

[0006] A typical OLED has a structure including a substrate, and an anode, a hole transport layer (HTL), an emissive layer (EML), an electron transport layer (ETL), and a cathode which are sequentially stacked on the substrate in the order stated. In this regard, the HTL, the EML, and the ETL are organic thin films formed of organic compounds.

[0007] An operating principle of an OLED having the above-described structure is as follows.

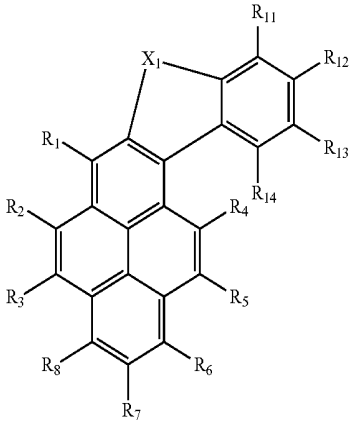
[0008] When a voltage is applied to the anode and the cathode, holes injected from the anode move to the EML via the HTL, and electrons injected from the cathode move to the EML via the ETL. The holes and electrons recombine in the EML to generate excitons. When the excitons drop from an excited state to a ground state, light is emitted.

SUMMARY OF CERTAIN INVENTIVE ASPECTS

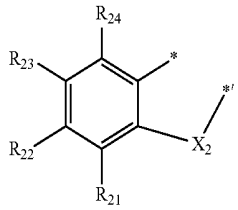
[0009] A compound for providing an organic light emitting diode having high efficiency and long durability is provided.

[0010] According to an aspect of the present embodiments, there is provided a condensed-cyclic compound represented by Formula 1 below:

Formula 1



[0011] where R_8 and R_7 are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a group represented by $—(Ar_1)_a—Ar_{11}$, and a group represented by $—N[—(Ar_2)_b—Ar_{12}][—(Ar_3)_c—Ar_{13}]$; or R_8 is connected to * of Formula 2 represented by



and R_7 is connected to *' of Formula 2; R_1 through R_6, R_{11} through R_{14}, and R_{21} through R_{24} are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a group represented by $—(Ar_4)_d—Ar_{14}$, and a group represented by $—N[—(Ar_5)_e—Ar_{15}][—(Ar_6)_f—Ar_{16}]$; Ar_1 through Ar_6 are each independently selected from the group consisting of a substituted or unsubstituted C_1-C_{30} alkylene group, a substituted or unsubstituted C_2-C_{30} alkenylene group, a substituted or unsubstituted C_5-C_{30} arylene group, and a substituted or unsubstituted C_4-C_{30} heteroarylene group; Ar_{11} through Ar_{16} are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a substituted or unsubstituted C_5-C_{30} aryl group, and a substituted or unsubstituted C_4-C_{30} heteroaryl group; a through f are each independently an integer from 0 to 10; a Ar_1s in the group represented by $—(Ar_1)_a—Ar_{11}$ are identical to or different from each other, b Ar_2s in the group represented by $—(Ar_2)_b—Ar_{12}$ are identical to or different from each other, c Ar_3s in the group represented by $—(Ar_3)_c—Ar_{13}$ are identical to or different from each other, d Ar_4s in the group represented by $—(Ar_4)_d—Ar_{14}$ are identical to or different from each other, e Ar_5s in the group represented by $—(Ar_5)_e—Ar_{15}$ are identical to or different from each other, and f Ar_6s in the group represented by $[—(Ar_6)_f—Ar_{16}]$ are identical to or different from each other; X_1 and X_2 are each independently a divalent linking group selected from the group consisting of $—C(Q_1)(Q_2)-$ and $—N(Q_3)-$; and Q_1 through Q_3 are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a substituted or unsubstituted C_5-C_{30} aryl group, and a substituted or unsubstituted C_4-C_{30} heteroaryl group.

[0012] R_1 through R_3 and R_4 through R_7 may be hydrogen; R_8 may be selected from the group consisting of hydrogen, a substituted or unsubstituted C_1-C_{10} alkyl group, a substituted or unsubstituted C_2-C_{10} alkenyl group, a substituted or unsubstituted C_2-C_{10} alkynyl group, a substituted or unsubstituted C_1-C_{10} alkoxy group, a group represented by $—(Ar_1)_a—Ar_{11}$, and a group represented by $—N[—(Ar_2)_b—Ar_{12}][—(Ar_3)_c—Ar_{13}]$; R_{11} through R_{14} may be each independently selected from the group consisting of hydrogen, a substituted or unsubstituted C_1-C_{10} alkyl group, a substituted or unsubstituted C_2-C_{10} alkenyl group, a substituted or unsubstituted C_2-C_{10} alkynyl group, a substituted or unsubstituted C_1-C_{10} alkoxy group, a group represented by $—(Ar_4)_d—Ar_{14}$, and a group represented by $—N[—(Ar_5)_e—Ar_{15}][—(Ar_6)_f—Ar_{16}]$; Ar_1 through Ar_6 may be each independently selected from the group consisting of a substituted or unsubstituted C_1-C_{30} alkylene group, a substituted or unsubstituted C_2-C_{30} alkenylene group, a substituted or unsubstituted C_5-C_{30} arylene group, and a substituted or unsubstituted C_4-C_{30} heteroarylene group; and Ar_{11} and Ar_{16} may be each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a substituted or unsubstituted C_5-C_{30} aryl group, and a substituted or unsubstituted C_4-C_{30} heteroaryl group.

BRIEF DESCRIPTION OF THE DRAWING

[0013] The above and other features and advantages of the present embodiments will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawing in which:

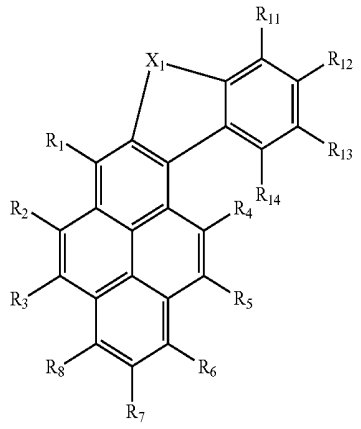
[0014] FIG. **1** is a diagram schematically illustrating a structure of an organic light emitting diode (OLED) according to an embodiment.

DETAILED DESCRIPTION OF CERTAIN INVENTIVE EMBODIMENTS

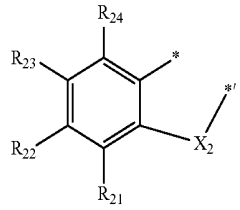
[0015] Hereinafter, the present embodiments will be described more fully with reference to the accompanying drawings, in which exemplary embodiments are shown.

[0016] A condensed-cyclic compound represented by Formula 1 below is provided:

Formula 1



[0017] In Formula 1, R_8 and R_7 may be each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a group represented by $—(Ar_1)_a—Ar_{11}$, and a group represented by $—N[—(Ar_2)_b—Ar_{12}][—(Ar_3)_c—Ar_{13}]$; or R_8 may be connected to * of Formula 2 represented by



and R_7 may be connected to *' of Formula 2; and R_1 through R_6, R_{11} through R_{14}, and R_{21} through R_{24} may be each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a group represented by $—(Ar_4)_d—Ar_{14}$, and a group represented by $—N[—(Ar_5)_e—Ar_{15}][—(Ar_6)_f—Ar_{16}]$.

[0018] For example, in Formula 1, R_5 and R_7 may be each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a group represented by $—(Ar_1)_a—Ar_{11}$, and a group represented by $—N[—(Ar_2)_b—Ar_{12}][—(Ar_3)_c—Ar_{13}]$, and R_1 through R_6 and R_{11} through R_{14} may be each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a group represented by $—(Ar_4)_d—Ar_{14}$, and a group represented by $—N[—(Ar_5)_e—Ar_{15}][—(Ar_6)_f—Ar_{16}]$.

[0019] For example, in Formula 1, R_1 through R_3 and R_4 through R_7 may be hydrogen; R_8 may be selected from the group consisting of hydrogen, a substituted or unsubstituted C_1-C_{10} alkyl group, a substituted or unsubstituted C_2-C_{10} alkenyl group, a substituted or unsubstituted C_2-C_{10} alkynyl group, a substituted or unsubstituted C_1-C_{10} alkoxy group, a group represented by $—(Ar_1)_a—Ar_{11}$, and a group represented by $—N[—(Ar_2)_b—Ar_{12}][—(Ar_3)_c—Ar_{13}]$; R_{11} through R_{14} may be each independently selected from the group consisting of hydrogen, a substituted or unsubstituted C_1-C_{10} alkyl group, a substituted or unsubstituted C_2-C_{10} alkenyl group, a substituted or unsubstituted C_2-C_{10} alkynyl group, a substituted or unsubstituted C_1-C_{10} alkoxy group, a group represented by $—(Ar_4)_d—Ar_{14}$, and a group represented by $—N[—(Ar_5)_e—Ar_{15}][—(Ar_6)_f—Ar_{16}]$.

[0020] Ar_1 through Ar_6 may be each independently selected from the group consisting of a substituted or unsubstituted C_1-C_{30} alkylene group, a substituted or unsubstituted C_2-C_{30}

alkenylene group, an unsubstituted C_5-C_{30} arylene group, and a substituted or unsubstituted C_4-C_{30} heteroarylene group.

[0021] For example, Ar_1 through Ar_6 may be each independently selected from the group consisting of a substituted or unsubstituted C_1-C_{10} alkylene group, a substituted or unsubstituted C_2-C_{10} alkenylene group, a substituted or unsubstituted C_5-C_{14} arylene group, and a substituted or unsubstituted C_4-C_{14} heteroarylene group.

[0022] Ar_1 through Ar_6 may be each independently selected from the group consisting of a substituted or unsubstituted ethylene group, a substituted or unsubstituted phenylene group, a substituted or unsubstituted pentalenylene group, a substituted or unsubstituted indenylene group, a substituted or unsubstituted naphthylene group, a substituted or unsubstituted azulenylene group, a substituted or unsubstituted heptalenylene group, a substituted or unsubstituted indacenylene group, a substituted or unsubstituted acenaphthylene group, a substituted or unsubstituted fluorenylene group, a substituted or unsubstituted phenalenylene group, a substituted or unsubstituted phenanthrenylene group, a substituted or unsubstituted anthracenylene group, a substituted or unsubstituted fluoranthenylene group, a substituted or unsubstituted triphenylenylene group, a substituted or unsubstituted pyrenylenylene group, a substituted or unsubstituted chrysenylene group, a substituted or unsubstituted naphthacenylene group, a substituted or unsubstituted phenylene group, a substituted or unsubstituted perylenylene group, a substituted or unsubstituted pentaphenylene group, a substituted or unsubstituted hexacenylene group, a substituted or unsubstituted pyrrolylene group, a substituted or unsubstituted pyrazolylene group, a substituted or unsubstituted imidazolylene group, a substituted or unsubstituted imidazolinylene group, a substituted or unsubstituted imidazopyridinylene group, a substituted or unsubstituted imidazopyrimidinylene group, a substituted or unsubstituted pyridinylene group, a substituted or unsubstituted pyrazinylene group, a substituted or unsubstituted pyrimidinylene group, a substituted or unsubstituted indolylene group, a substituted or unsubstituted purinylene group, a substituted or unsubstituted quinolinylene group, a substituted or unsubstituted phthalazinylene group, a substituted or unsubstituted indolizinylene group, a substituted or unsubstituted naphthyridinylene group, a substituted or unsubstituted quinazolinylene group, a substituted or unsubstituted cinnolinylene group, a substituted or unsubstituted indazolylene group, a substituted or unsubstituted carbazolylene group, a substituted or unsubstituted phenazinylene group, a substituted or unsubstituted phenanthridinylene group, a substituted or unsubstituted pyranylene group, a substituted or unsubstituted chromenylene group, a substituted or unsubstituted benzofuranylene group, a substituted or unsubstituted thiophenylene group, a substituted or unsubstituted benzothiophenylene group, a substituted or unsubstituted isothiazolylene group, a substituted or unsubstituted benzimidazolylene group, and a substituted or unsubstituted isoxazolylene group, but are not limited thereto.

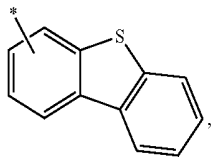
[0023] Ar_{11} through Ar_{16} may be each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a substituted or unsubstituted C_5-C_{30} aryl group, and a substituted or unsubstituted C_4-C_{30} heteroaryl group.

[0024] Ar_{11} through Ar_{16} may be each independently selected from the group consisting of a substituted or unsubstituted C_1-C_{10} alkyl group, a substituted or unsubstituted C_1-C_{10} alkoxy group, a substituted or unsubstituted phenyl group, a substituted or unsubstituted pentalenyl group, a substituted or unsubstituted indenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted azulenyl group, a substituted or unsubstituted heptalenyl group, a substituted or unsubstituted indacenyl group, a substituted or unsubstituted acenaphthyl group, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted phenalenyl group, a substituted or unsubstituted phenantlenyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted fluoranthenyl group, a substituted or unsubstituted triphenylenyl group, a substituted or unsubstituted pyrenyl group, a substituted or unsubstituted chrysenyl group, a substituted or unsubstituted naphthacenyl group, a substituted or unsubstituted picenyl group, a substituted or unsubstituted perylenyl group, a substituted or unsubstituted pentacenyl group, a substituted or unsubstituted hexacenyl group, a substituted or unsubstituted pyrrolyl group, a substituted or unsubstituted pyrazolyl group, a substituted or unsubstituted imidazolyl group, a substituted or unsubstituted imidazolinyl group, a substituted or unsubstituted imidazopyridinyl group, a substituted or unsubstituted imidazopyrimidinyl group, a substituted or unsubstituted pyridinyl group, a substituted or unsubstituted pyrazinyl group, a substituted or unsubstituted pyrimidinyl group, a substituted or unsubstituted indolyl group, a substituted or unsubstituted furinyl group, a substituted or unsubstituted quinolinyl group, a substituted or unsubstituted phthalazinyl group, a substituted or unsubstituted indolizinyl group, a substituted or unsubstituted naphthyridinyl group, a substituted or unsubstituted quinazolinyl group, a substituted or unsubstituted cinolinyl group, a substituted or unsubstituted indazolyl group, a substituted or unsubstituted carbazolyl group, a substituted or unsubstituted phenazinyl group, a substituted or unsubstituted phenanthridinyl group, a substituted or unsubstituted pyranylene group, a substituted or unsubstituted chromenyl group, a substituted or unsubstituted benzofuranyl group, a substituted or unsubstituted thiophenyl group, a substituted or unsubstituted benzothiophenyl group, a substituted or unsubstituted isothiazolyl group, a substituted or unsubstituted benzimidazolyl group, and a substituted or unsubstituted isoxazolyl group, but are not limited thereto.

[0025] For example, Ar_1 through Ar_6 may be each independently selected from the group consisting of a pyridinylene group, a quinolinylene group, a benzimidazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, a phenylene group, a C_1-C_{10} alkyl phenylene group, a carbazolylene group, a phenylcarbazolylene group, a fluorenylene group, a C_1-C_{10} alkyl fluorenylene group, a di(C_1-C_{10} alkyl)fluorenylene group, an ethylene group, and a naphthylene group, but are not limited thereto.

[0026] Also, for example, Ar_{11} through Ar_{16} may be each independently selected from the group consisting of a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pyridinyl group, a quinolinyl group, a benzimidazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl

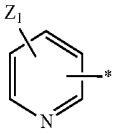
group, a phenyl group, a carbazolyl group, a fluorenyl group, a di(C_1-C_{10} alkyl)fluorenyl group, a naphthyl group, and a functional group represented by the formula



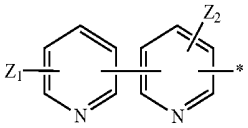
but are not limited thereto.

[0027] R_8 and R_{11} through R_{14} may be each independently selected from the group consisting of functional groups represented by Formulae 3A through 3O below, but are not limited thereto:

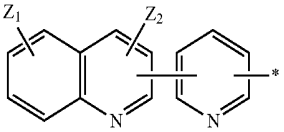
Formula 3A



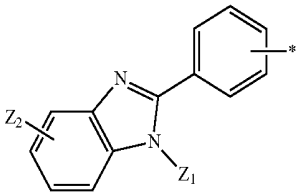
Formula 3B



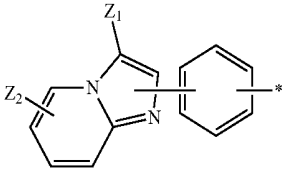
Formula 3C



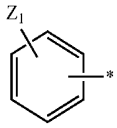
Formula 3D



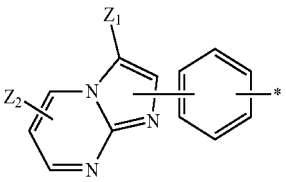
Formula 3E



Formula 3F

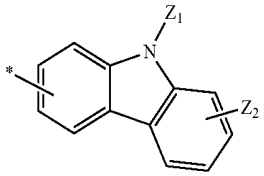


Formula 3G

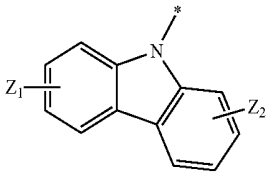


-continued

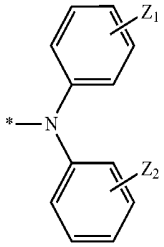
Formula 3H



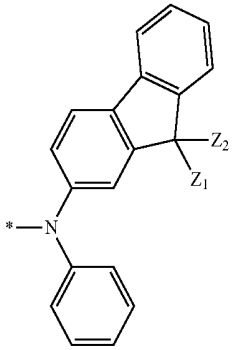
Formula 3I



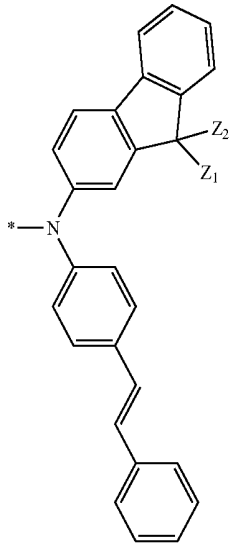
Formula 3J



Formula 3K

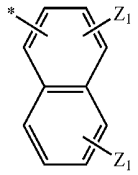


Formula 3L

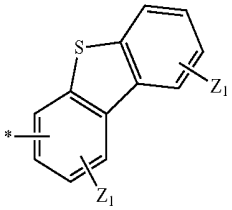


-continued

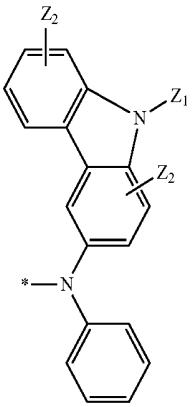
Formula 3M



Formula 3N



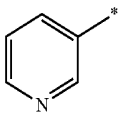
Formula 3O



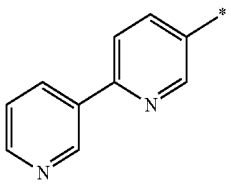
[0028] In Formulae 3A through 3O, Z_1 and Z_2 are each independently selected from the group consisting of hydrogen, a hydroxyl group, a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, and a naphthyl group.

[0029] R_8 and R_{11} through R_{14} may be each independently selected from the group consisting of compounds represented by Formulae 4A through 4R below, but are not limited thereto:

Formula 4A

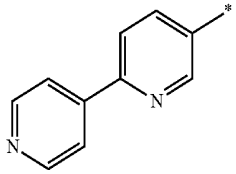


Formula 4B

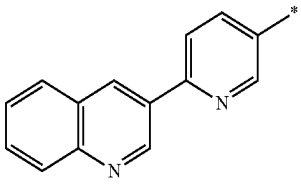


-continued

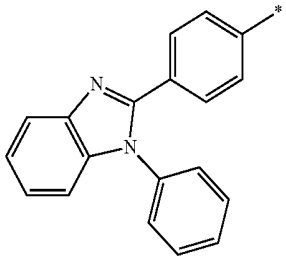
Formula 4C



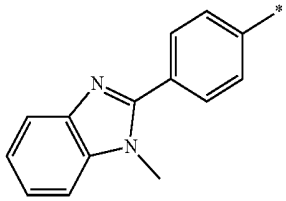
Formula 4D



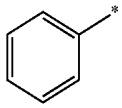
Formula 4E



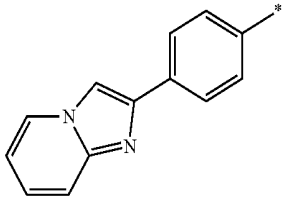
Formula 4F



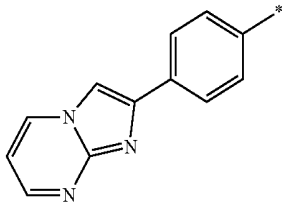
Formula 4G



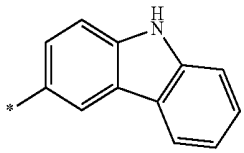
Formula 4H



Formula 4I

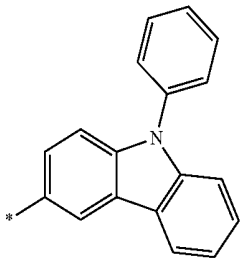


Formula 4J

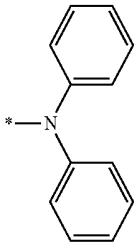


-continued

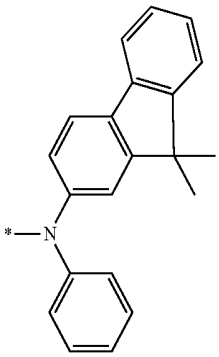
Formula 4K



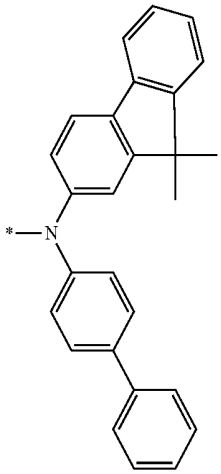
Formula 4L



Formula 4M

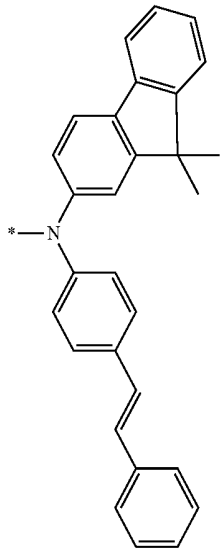


Formula 4N

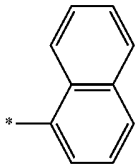


-continued

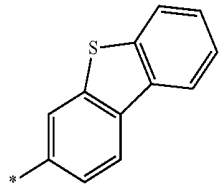
Formula 4O



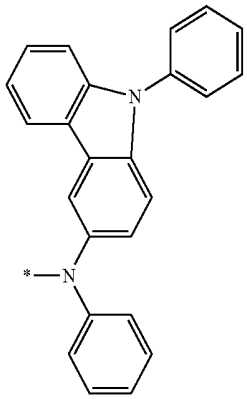
Formula 4P



Formula 4Q



Formula 4R



[0030] In Formula 1, a through f may be each independently an integer from 0 to 10. For example, a through f may be each independently 0, 1, or 2, but are not limited thereto.

[0031] In Formula 1, a Ar_1s in the group represented by $—(Ar_1)_a—Ar_{11}$ may be identical to or different from each other, b Ar_2s in the group represented by $—(Ar_2)_b—A_{12}$ may be identical to or different from each other, c Ar_3s in the group represented by $—(Ar_3)_c—Ar_{13}$ may be identical to or different from each other, d Ar_4s in the group represented by $—(Ar_4)_d—Ar_{14}$ may be identical to or different from each other, e Ar_5s in the group represented by $—(Ar_5)_e—Ar_{15}$ may

be identical to or different from each other, and f Ar_6s in the group represented by [—$(Ar_6)_f$—Ar_{16}] may be identical to or different from each other.

[0032] For example, in the group represented by —$(Ar_1)_a$—Ar_{11}, when a is 2, the two Ar_1s may be both phenylene groups, or one of the two may be a phenylene group and the other may be a benzimidazolylene group.

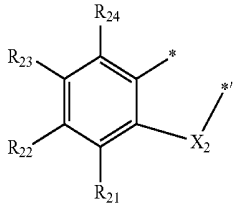
[0033] In Formula 1, Q_1 through Q_3 may be each independently selected from the group consisting of hydrogen, a C_1-C_{30} alkyl group, a C_1-C_{30} alkoxy group, a C_5-C_{14} aryl group, and a C_4-C_{14} heteroaryl group. For example, Q_1 through Q_3 may be each independently selected from the group consisting of hydrogen, a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, and a naphthyl group, but are not limited thereto. For example, Q_1 through Q_3 may be each independently hydrogen, a methyl group, or a phenyl group.

[0034] In Formula 1, X_1 may be selected from the group consisting of —CH_2—, —$CH(CH_3)$—, —$C(CH_3)_2$—, —CH(Ph)—, —NH—, and —N(Ph)—, wherein Ph denotes a phenyl group, but is not limited thereto.

[0035] Accordingly, the condensed-cyclic compound of Formula 1 has high thermal stability. Also, since the condensed-cyclic compound has a wide band gap, the condensed-cyclic compound may be used for various layers, such as a hole transport layer (HTL), an emissive layer (EML), and/or an electron transport layer (ETL), of an organic light emitting diode (OLED), according to substituents, such as R_8 and R_{11} through R_{14}.

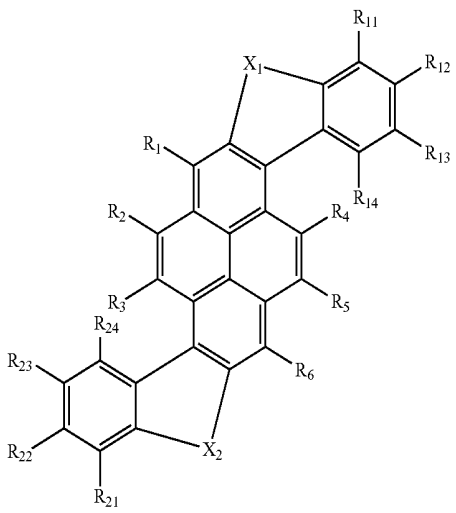
[0036] In Formula 1, R_8 may be connected to * of Formula 2 below and R_7 may be connected to *' of Formula 2.

Formula 2



[0037] Accordingly, the condensed-cyclic compound represented by Formula 1 may be represented by Formula 1A below:

Formula 1A



[0038] In Formula 1A, R_1 through R_6 and R_{11} through R_{14} are as described above, and R_{21} through R_{24} are as described in connection with R_{11} through R_{14}.

[0039] For example, in Formula 1A, R_1 through R_6 may be hydrogen; R_{11} through R_{14} and R_{21} through R_{24} may each independently hydrogen, a substituted or unsubstituted C_1-C_{10} alkyl group, a substituted or unsubstituted C_2-C_{10} alkenyl group, a substituted or unsubstituted C_2-C_{10} alkynyl group, a substituted or unsubstituted C_1-C_{10} alkoxy group, a group represented by —$(Ar_4)_d$—Ar_{14}, and a group represented by —N[—$(Ar_5)_e$—Ar_{15}][—$(Ar_6)_f$—Ar_{16}].

[0040] Here, Ar_4 through Ar_6, A_{14} through Ar_{16}, and d through f are as described above.

[0041] In Formula 1A, R_{11} through R_{14} and R_{21} through R_{24} may be each independently selected from the group consisting of the compounds represented by Formulae 3A through 3O, but are not limited thereto.

[0042] In Formula 1A, R_{11} through R_{14} and R_{21} through R_{24} may be each independently selected from the group consisting of the functional groups represented by Formulae 4A through 4R, but are not limited thereto.

[0043] In Formula 1A, Q_1 through Q_3 and X_1 are as described above, and X_2 is as described above in connection with X_1.

[0044] Since the condensed-cyclic compound of Formula 1 may be represented by Formula 1A, the condensed-cyclic compound has high thermal stability. Also, since the condensed-cyclic compound has a wide band gap, the condensed-cyclic compound may be used for various layers, such as a HTL, an EML, and/or an ETL, of an OLED, according to substituents, such as R_8 and R_{11} through R_{14}.

[0045] According to an embodiment, in Formula 1, R_1 through R_3 and R_4 through R_7 may be hydrogen; R_8 and R_{11} through R_{14} may be each independently selected from the group consisting of hydrogen and functional groups represented by Formulae 3A through 3O; and X_1 may be a divalent linking group selected from the group consisting of —$C(Q_1)(Q_2)$- and —$N(Q_3)$-, wherein Q_1 through Q_3 may be each independently selected from the group consisting of hydrogen, a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, and a naphthyl group.

[0046] According to another embodiment, in Formula 1, R_1 through R_3, R_4 through R_7, R_{11}, R_{13}, and R_{14} may be hydrogen; R_8 and R_{12} may be each independently selected from the group consisting of hydrogen and the functional groups represented by Formulae 3A through 3O; and X_1 may be a divalent linking group selected from the group consisting of —$C(Q_1)(Q_2)$- and —$N(Q_3)$-, wherein Q_1 through Q_3 may be each independently selected from the group consisting of hydrogen, a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, and a naphthyl group.

[0047] According to another embodiment, in Formula 1, R_1 through R_3, R_4 through R_7, R_{11}, R_{13}, and R_{14} may be hydrogen; R_8 and R_{12} may be each independently selected from the group consisting of hydrogen and the functional groups represented by Formulae 4A through 4R; and X_1 may be selected from the group consisting of —CH_2—, —$CH(CH_3)$—, —$C(CH_3)_2$—, —CH(Ph)-, —NH—, and —N(Ph)-, wherein Ph denotes a phenyl group.

[0048] According to another embodiment, in Formula 1, R_1 through R_3, R_4 through R_7, R_{11}, R_{13}, and R_{14} may be hydrogen; R_8 and R_{12} may be each independently selected from the group consisting of hydrogen and the functional groups represented by Formulae 4A through 4R; and X_1 may be selected from the group consisting of —CH_2—, —$CH(CH_3)$—, —$C(CH_3)_2$—, and —CH(Ph)-, wherein Ph denotes a phenyl group.

[0049] According to an embodiment, in Formula 1, R_8 may be connected to * of Formula 2, R_7 may be connected to *' of Formula 2 (that is, Formula 1 is represented by Formula 1A), R_1 through R_6 may be hydrogen; R_{11} through R_{14} and R_{21} through R_{24} may be each independently selected from the group consisting of hydrogen and the functional groups represented by Formulae 3A through 3O; and X_1 and X_2 may be each independently a divalent linking group selected from the group consisting of —$C(Q_1)(Q_2)$- and —$N(Q_3)$-, wherein Q_1 through Q_3 may be each independently selected form the group consisting of hydrogen, a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, and a naphthyl group.

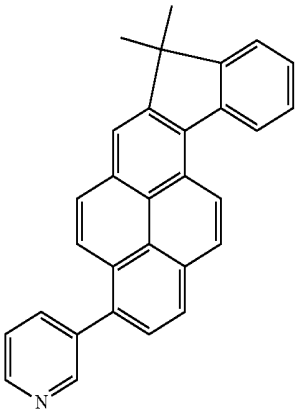
[0050] According to another embodiment, in Formula 1, R_8 may be connected to * of Formula 2, R_7 may be connected to *' of Formula 2 (that is, Formula 1 is represented by Formula 1A), R_1 through R_6, R_{11}, R_{13}, R_{14}, R_{21}, R_{23}, and R_{24} may be hydrogen; R_{12} and R_{22} may be each independently selected from the group consisting of hydrogen and the functional groups represented by Formulae 3A through 3O; and X_1 and X_2 may be each independently a divalent linking group selected from the group consisting of —$C(Q_1)(Q_2)$- and —$N(Q_3)$-, wherein Q_1 through Q_3 may be each independently selected from the group consisting of hydrogen, a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, and a naphthyl group.

[0051] According to another embodiment, in Formula 1, R_8 may be connected to * of Formula 2, R_7 may be connected to *' of Formula 2 (that is, Formula 1 is represented by Formula 1A); R_1 through R_6, R_{11}, R_{13}, R_{14}, R_{21}, R_{23}, and R_{24} may be hydrogen; R_{12} and R_{22} may be each independently selected from the group consisting of hydrogen and the functional groups represented by Formulae 4A through 4R; and X_1 and X_2 may be each independently selected from the group consisting of —CH_2—, —$CH(CH_3)$—, —$C(CH_3)_2$—, —CH(Ph)-, —NH—, and —N(Ph)-, wherein Ph denotes a phenyl group.

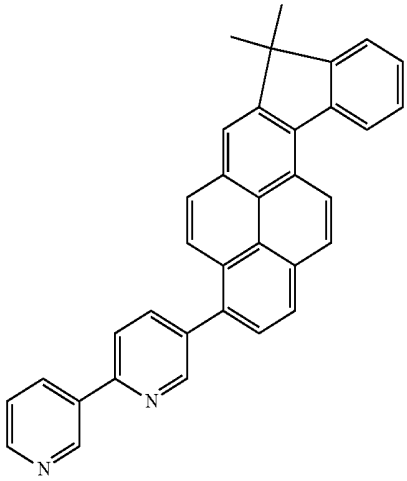
[0052] According to another embodiment, in Formula 1, R_8 may be connected to * of Formula 2, R_7 may be connected to *' of Formula 2 (that is, Formula 1 is represented by Formula 1A); R_1 through R_6, R_{11}, R_{13}, R_{14}, R_{21}, R_{23}, and R_{24} are hydrogen; R_{12} and R_{22} may be each independently selected from the group consisting of hydrogen and the functional groups represented by Formulae 4A through 4R; and X_1 and X_2 may be each independently selected from the group consisting of —CH_2—, —$CH(CH_3)$—, —$C(CH_3)_2$—, and —CH(Ph)-.

[0053] According to another embodiment, the condensed-cyclic compound represented by Formula 1 may be one of Compounds 1 to 43 below, but is not limited thereto.

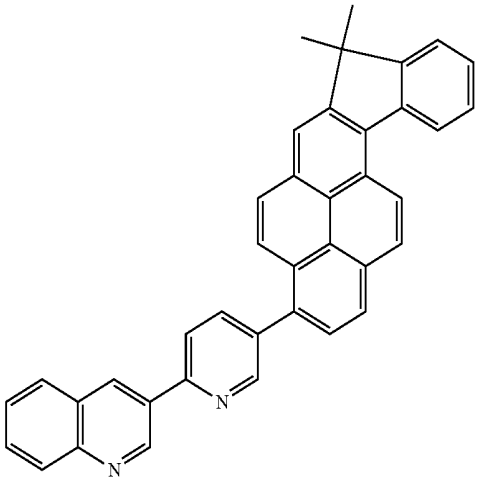
Compound 1



Compound 2

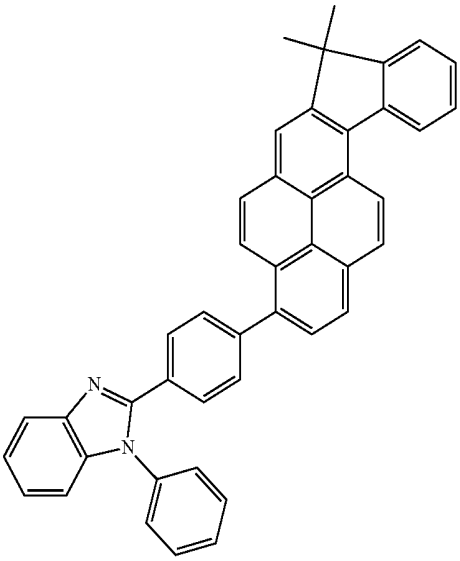


Compound 3

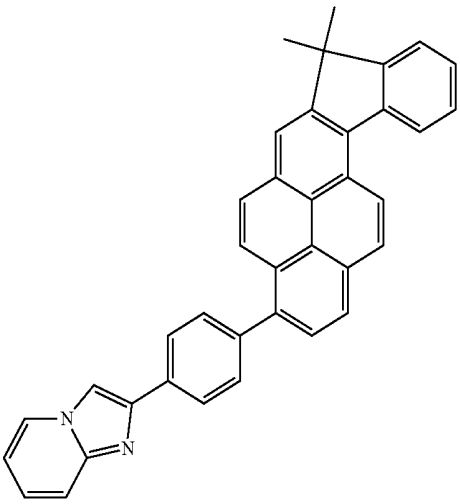


-continued

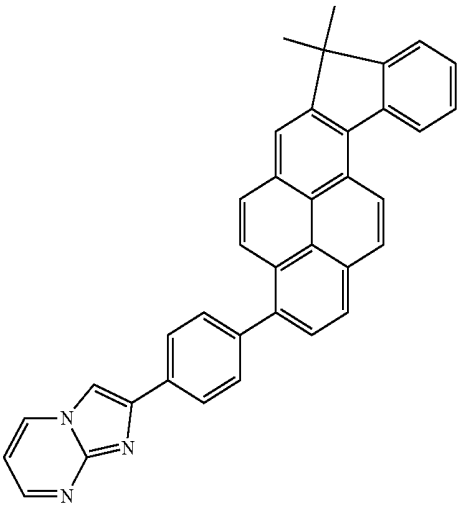
Compound 4



Compound 5

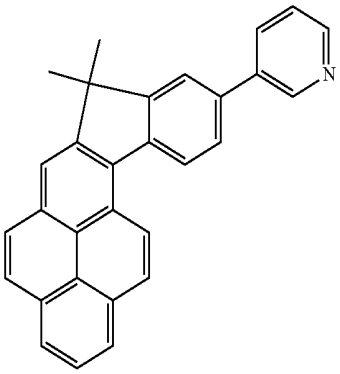


Compound 6

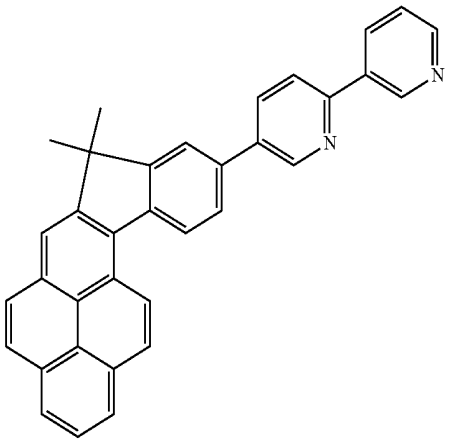


-continued

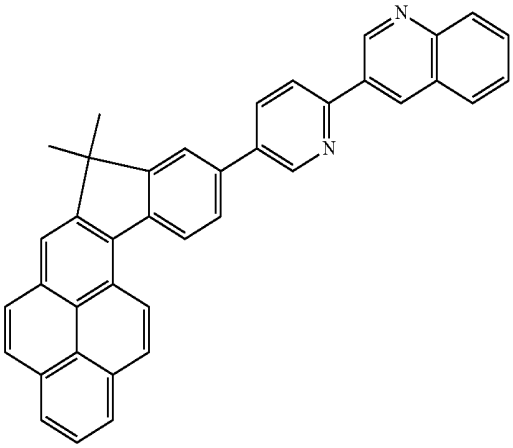
Compound 7



Compound 8

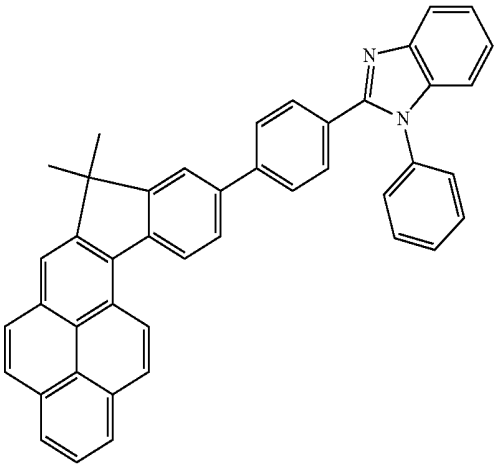


Compound 9

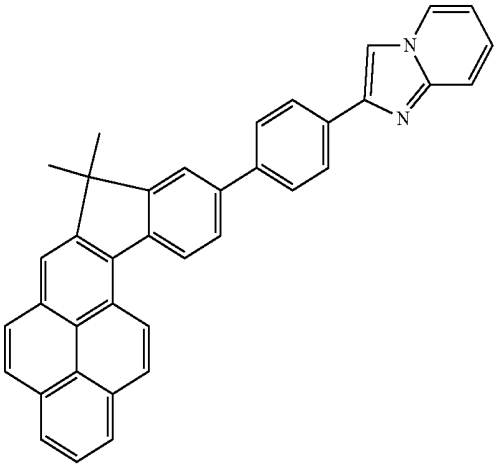


-continued

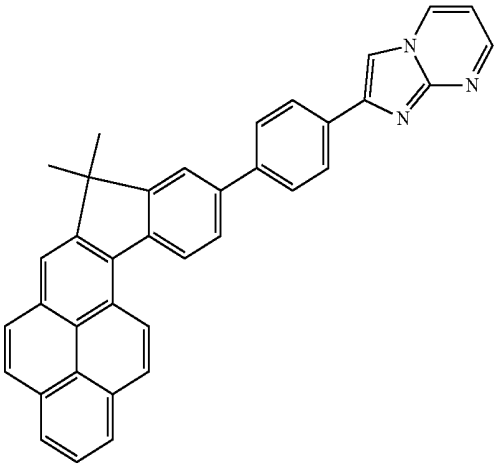
Compound 10



Compound 11

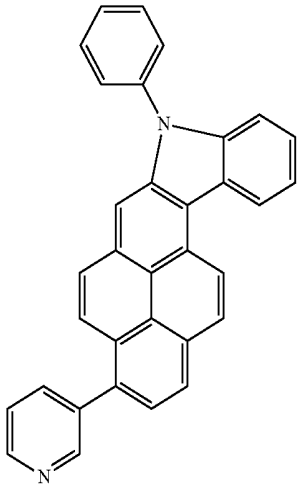


Compound 12

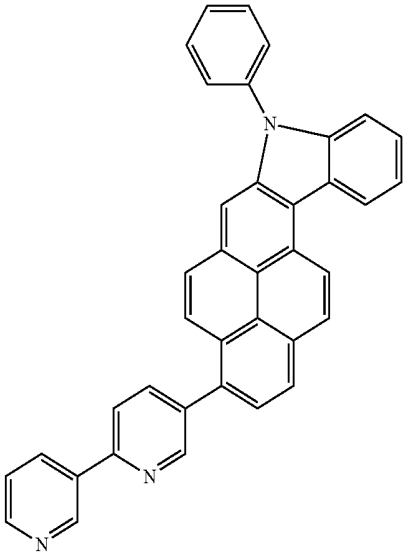


-continued

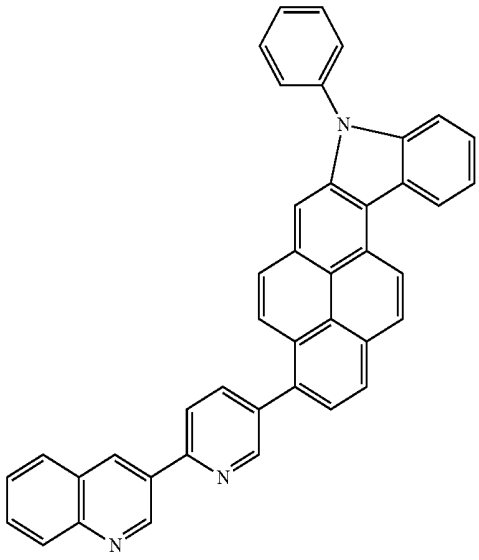
Compound 13



Compound 14

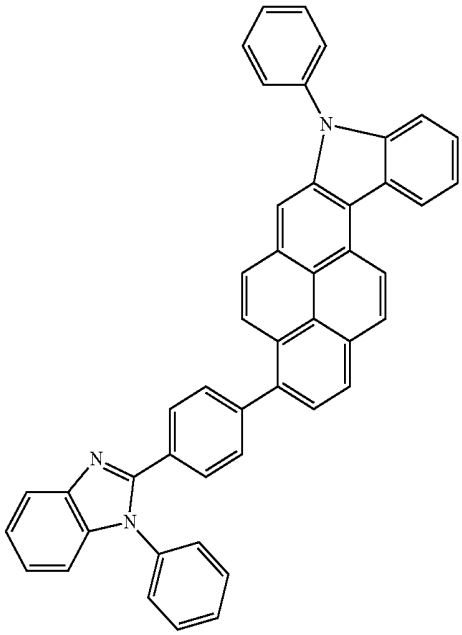


Compound 15

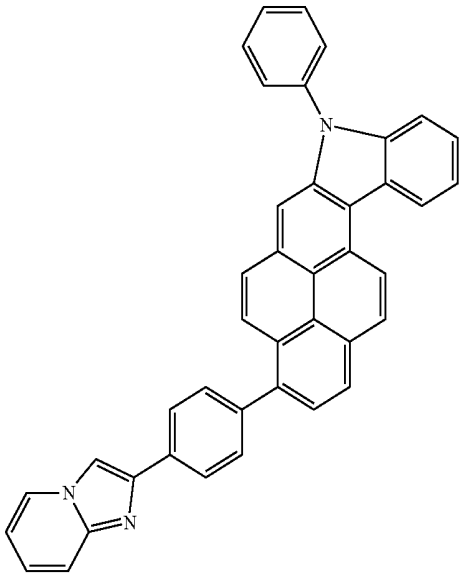


-continued

Compound 16

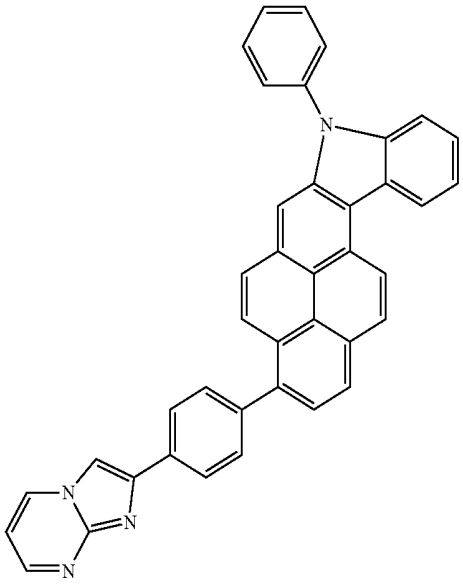


Compound 17

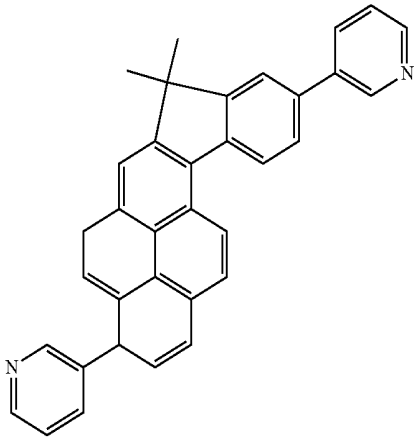


-continued

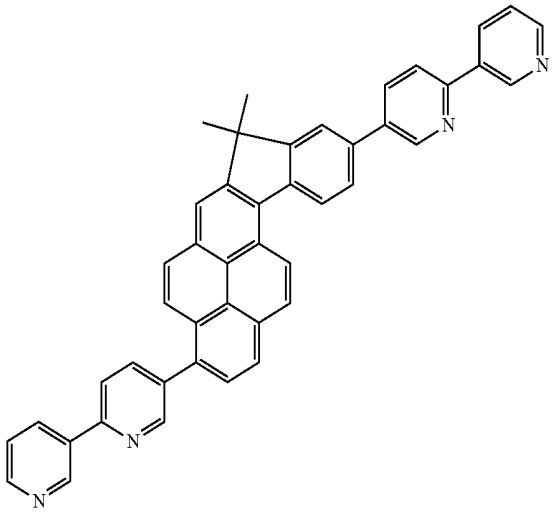
Compound 18



Compound 19

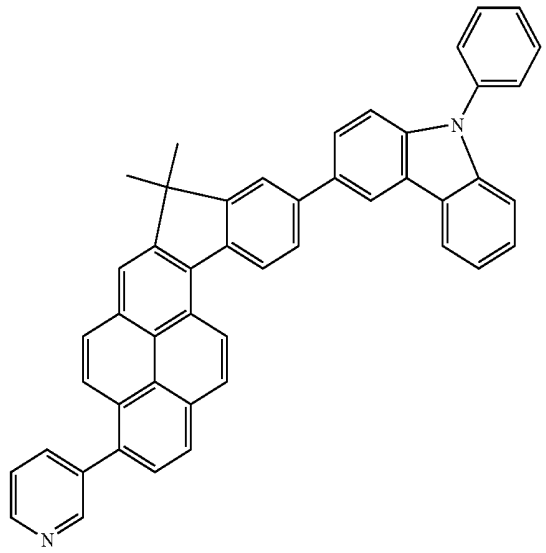


Compound 20

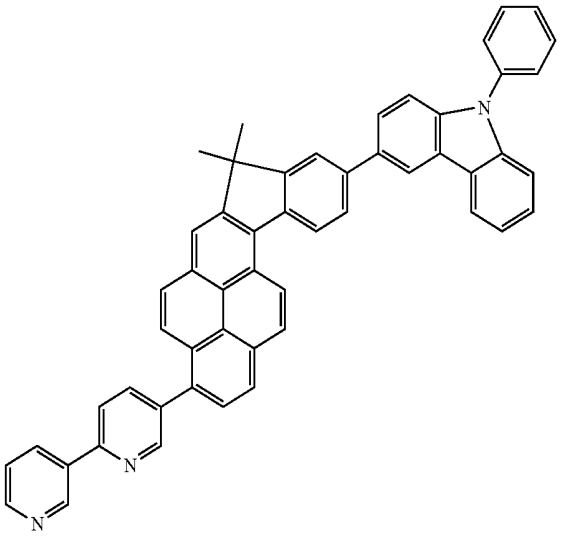


-continued

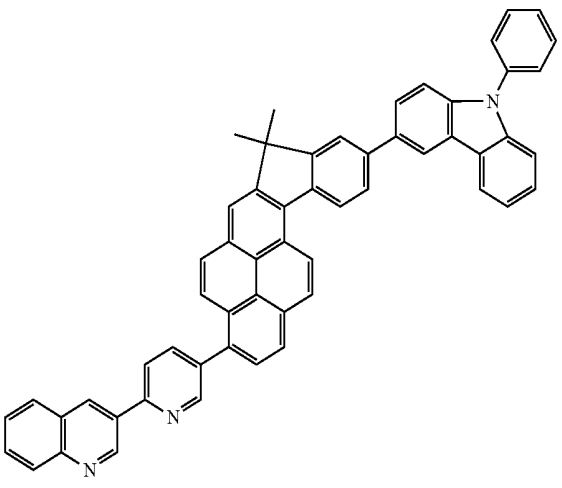
Compound 21



Compound 22

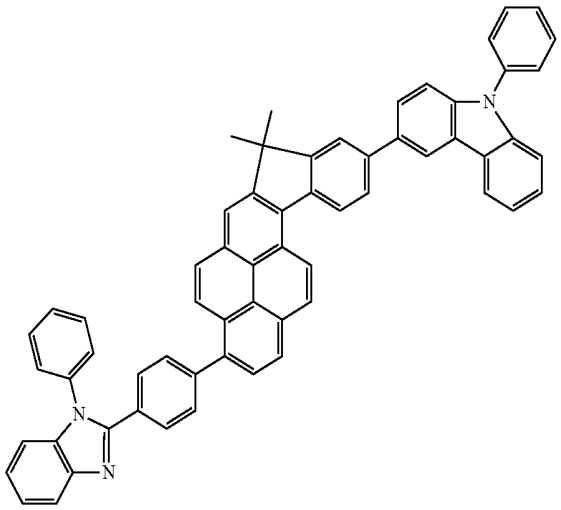


Compound 23

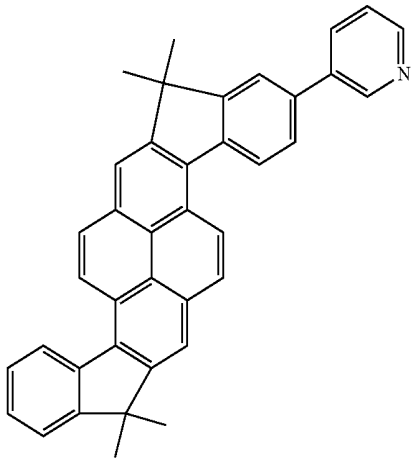


-continued

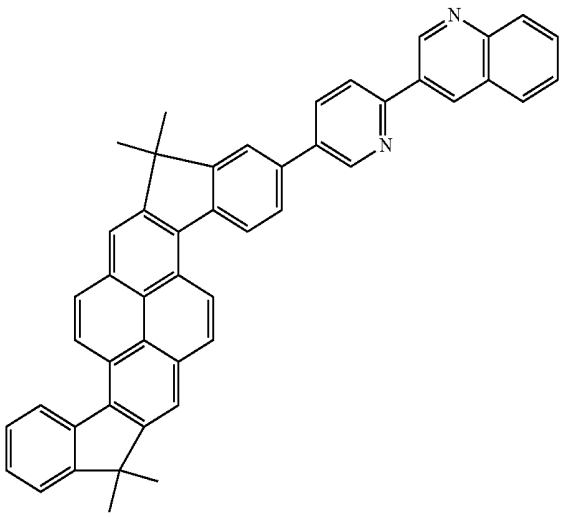
Compound 24



Compound 25

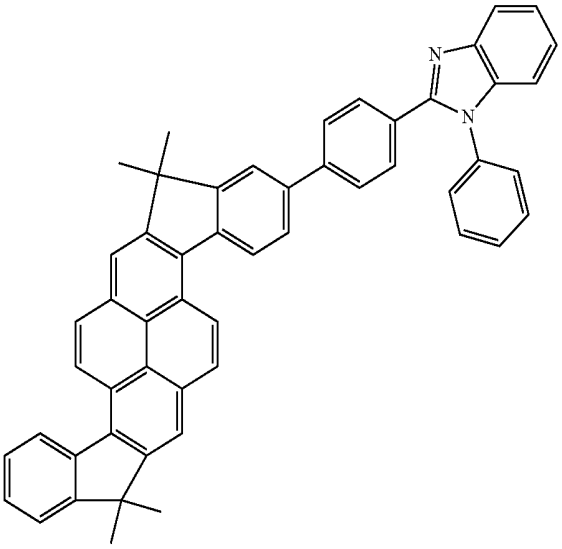


Compound 26

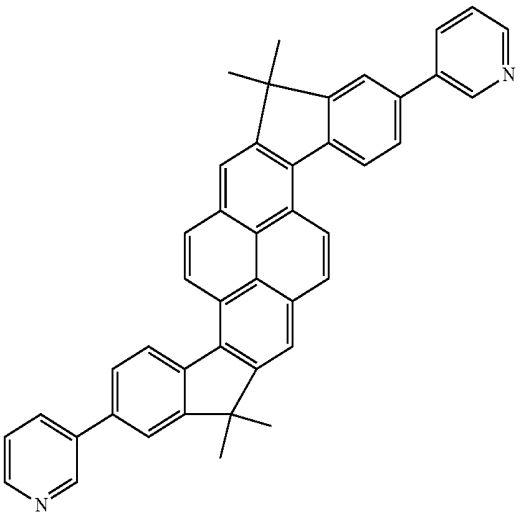


-continued

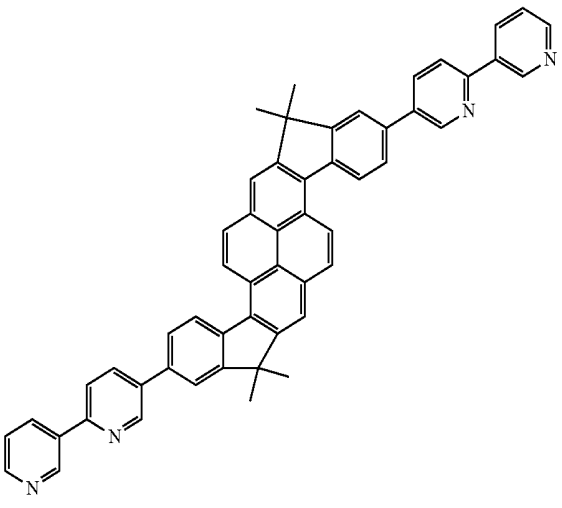
Compound 27



Compound 28

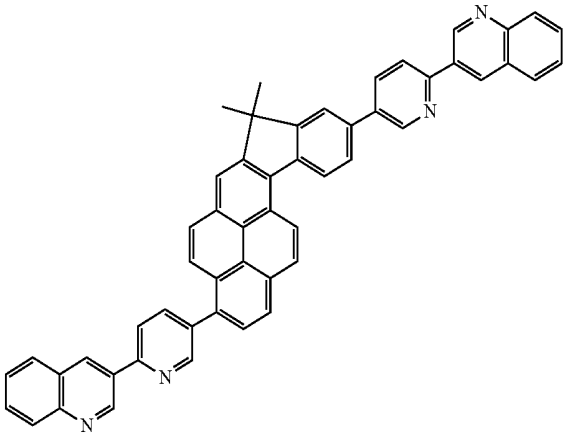


Compound 29

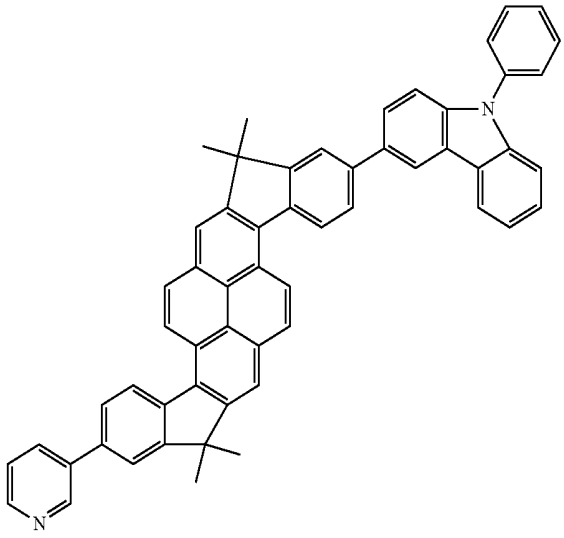


-continued

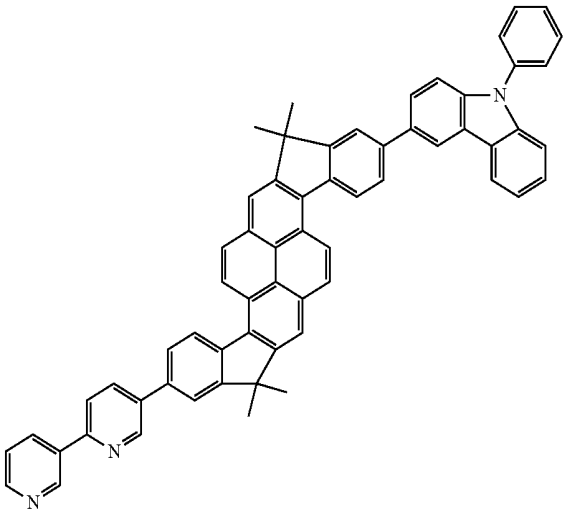
Compound 30



Compound 31

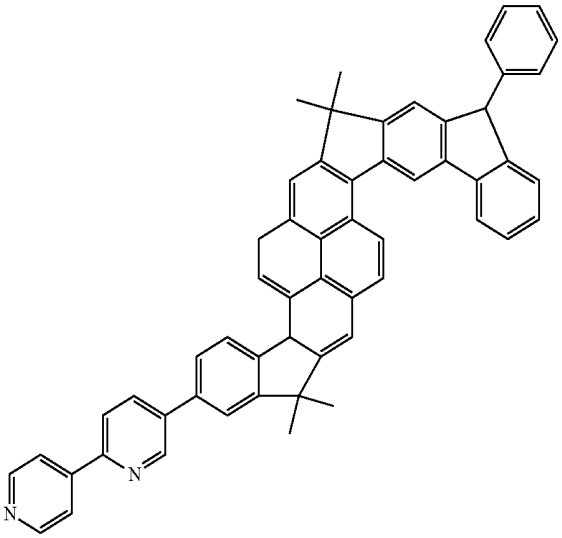


Compound 32

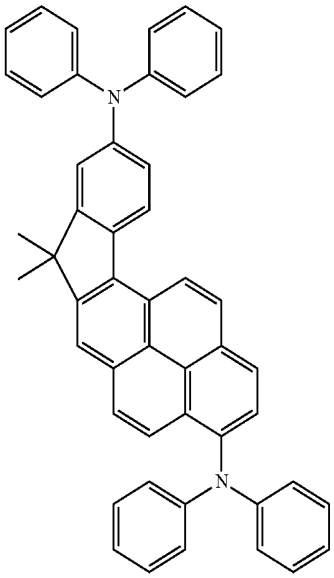


-continued

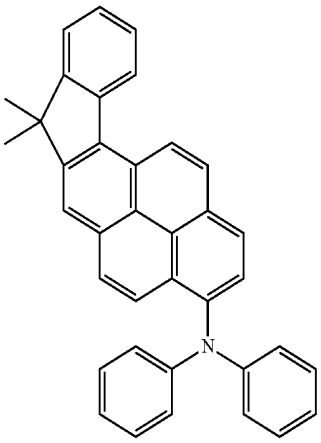
Compound 33



Compound 34

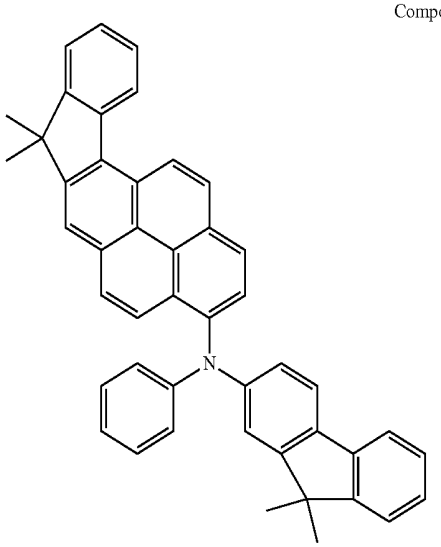


Compound 35

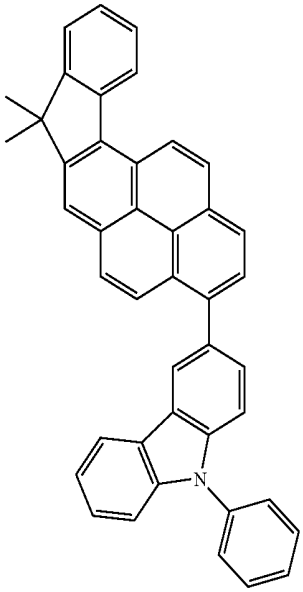


-continued

Compound 36

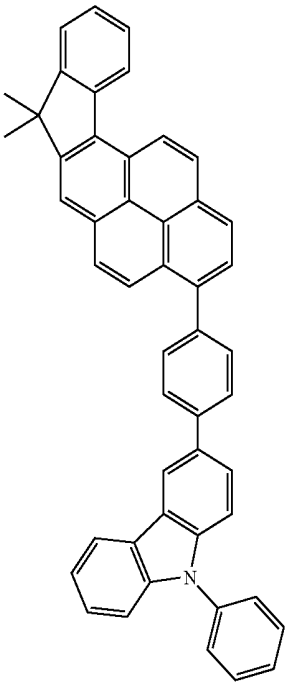


Compound 37

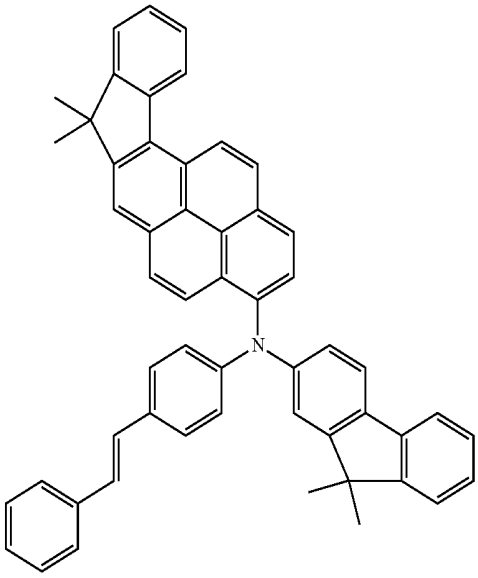


-continued

Compound 38

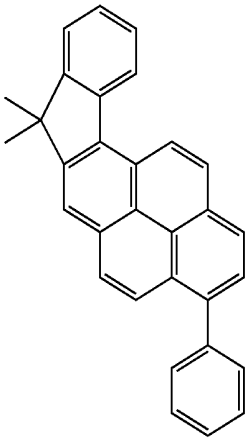


Compound 39

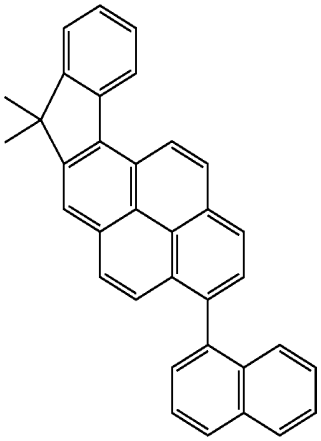


-continued

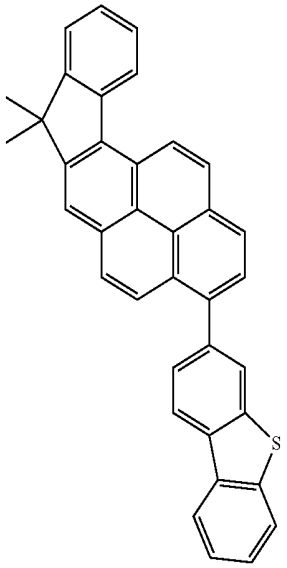
Compound 40



Compound 41

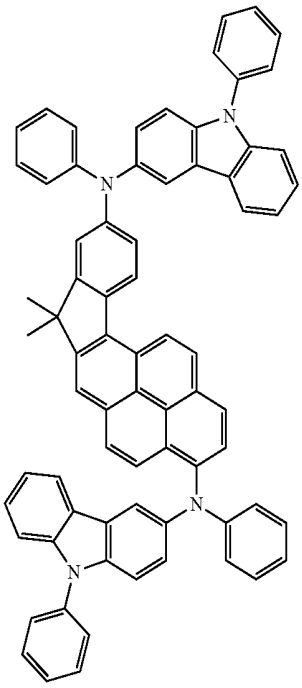


Compound 42



-continued

Compound 43



[0054] Examples of the unsubstituted C_1-C_{30} alkyl group or the C_1-C_{30} alkyl group used herein include methyl, ethyl, propyl, isobutyl, sec-butyl, pentyl, iso-amyl, hexyl, and the like. In the substituted C_1-C_{30} alkyl group, at least one hydrogen atom of the unsubstituted C_1-C_{30} alkyl group may be substituted with a halogen atom, a hydroxyl group, a nitro group, a cyano group, an amino group, an amidino group, hydrazine, hydrazone, a carboxyl group or salts thereof, a sulfonic acid group or salts thereof, a phosphoric acid or salts thereof, a C_1-C_{30} alkyl group, a C_1-C_{30} alkenyl group, a C_1-C_{30} alkynyl group, a C_6-C_{30} aryl group, or a C_2-C_{20} heteroaryl group. The substituted or unsubstituted C_1-C_{30} alkylene group has the same structure as the substituted or unsubstituted C_1-C_{30} alkyl group as described above, but is a divalent linking group.

[0055] The unsubstituted C_1-C_{30} alkoxy group or the C_1-C_{30} alkoxy group may be a group represented by —OA, wherein A is the unsubstituted C_1-C_{30} alkyl group, and examples of the unsubstituted C_1-C_{30} alkoxy group are methoxy, ethoxy, and isopropyloxy. At least one hydrogen atom in the unsubstituted C_1-C_{30} alkoxy group may be substituted with the substituents described with reference to the substituted C_1-C_{30} alkyl group.

[0056] The unsubstituted C_2-C_{30} alkenyl group or the C_2-C_{30} alkenyl group has at least one carbon-carbon double bond in the center or at one end of the unsubstituted C_2-C_{30} alkyl group structure. Examples of the unsubstituted alkenyl group include ethenyl, propenyl, and butenyl. At least one hydrogen atom in the unsubstituted C_2-C_{30} alkenyl group may be substituted with the substituents described with reference to the substituted C_1-C_{30} alkyl group. The substituted or unsubstituted C_2-C_{30} alkenylene group has the same structure as the substituted or unsubstituted C_2-C_{30} alkenyl group described above, but is a divalent linking group.

[0057] The unsubstituted C_2-C_{30} alkynyl group or the C_2-C_{30} alkynyl group has a carbon-carbon triple bond in the center or at one end of the C_2-C_{30} alkyl group structure. Examples of the unsubstituted C_2-C_{30} alkynyl group and acetylene, propylene, isopropylacetylene, and t-butylacetylene. At least one hydrogen atom in the alkynyl group may be substituted with the substituents described with reference to the substituted C_1-C_{30} alkyl group.

[0058] The unsubstituted C_5-C_{30} aryl group is a monovalent group having a carbocyclic aromatic system having 5 to 30 carbon atoms including at least one aromatic ring. The unsubstituted C_5-C_{30} arylene group is a divalent group having a carbocyclic aromatic system having 5 to 30 carbon atoms including at least one aromatic ring. When the aryl group and the arylene group have at least two rings, the at least two rings may be fused to each other. At least one hydrogen atom in the aryl group and the arylene group may be substituted with the substituents described with reference to the substituted C_1-C_{30} alkyl group.

[0059] Examples of the substituted or unsubstituted C_5-C_{30} aryl group are a phenyl group, a C_1-C_{10} alkylphenyl group (e.g., an ethylphenyl group), a C_1-C_{10} alkylbiphenyl group (e.g., an ethylbiphenyl group), a halophenyl group (e.g., an o-, m- or p-fluorophenyl group and a dichlorophenyl group), a dicyanophenyl group, a trifluoromethoxyphenyl group, an o-, m- or p-tolyl 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'-diphenyl)aminophenyl group, a pentalenyl group, an indenyl group, a naphthyl group, a halonaphthyl group (e.g., a fluoronaphthyl group), a C_1-C_{10} alkylnaphthyl group (e.g., a methylnaphthyl group), a C_1-C_{10} alkoxynaphthyl group (e.g., 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 ethyl-chrysenyl group, a picenyl group, a perylenyl group, a chloroperylenyl group, a pentaphenyl group, a pentacenyl group, a tetraphenylenyl group, a hexaphenyl group, hexacenyl group, a rubicenyl group, a coronenyl group, a trinaphthylenyl group, a heptaphenyl group, a heptacenyl group, a pyranthrenyl group, and an ovalenyl group. Examples of the substituted or unsubstituted C_5-C_{30} arylene group may be easily derived from examples of the substituted or unsubstituted C_5-C_{30} aryl group.

[0060] The unsubstituted C_4-C_{30} heteroaryl group is a monovalent group having at least one aromatic ring having at least one of the hetero atoms selected from the group consisting of N, O, P, and S. The unsubstituted C_2-C_{30} heteroarylene group is a divalent group having at least one aromatic ring having at least one of the hetero atoms selected from the group consisting of N, O, P, and S. In this regard, when the heteroaryl group and the heteroarylene group have at least two rings, the at least two rings may be fused with each other. At least one hydrogen atom in the heteroaryl group and the heteroarylene group may be substituted with the substituents described with reference to the substituted C_1-C_{30} alkyl group.

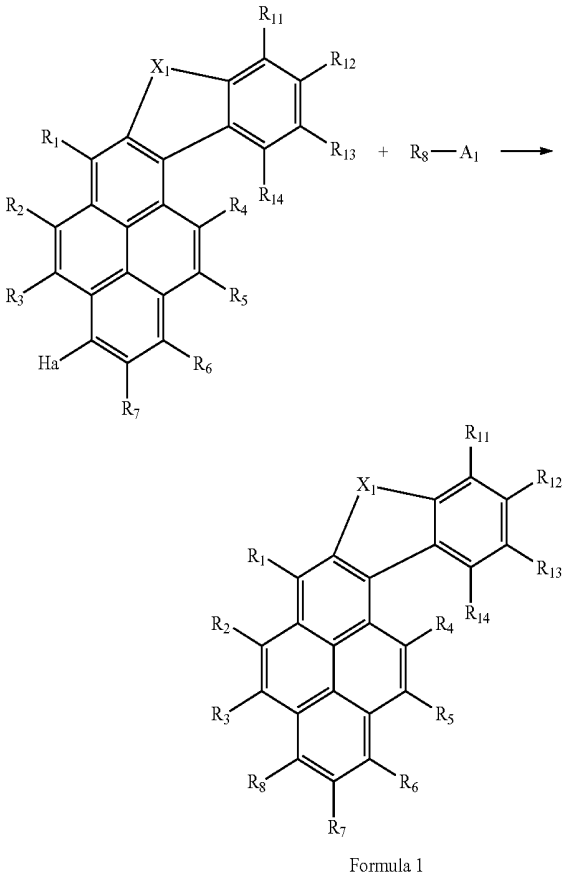
[0061] Examples of the unsubstituted C_4-C_{30} heteroaryl group include a pyrazolyl group, an imidazolyl group, an oxazolyl group, a thiazolyl group, a triazolyl group, a tetrazolyl group, an oxadiazolyl group, a pyridinyl group, a pyridazinyl group, a pyrimidinyl group, a triazinyl group, a carbazolyl group, an indolyl group, a quinolinyl group, an isoquinolinyl group, a benzimidazolyl group, an imidazopy-

ridinyl group and an imidazopyrimidinyl group. Examples of the substituted and unsubstituted C_4-C_{30} heteroarylene group may be easily derived from examples of the substituted or unsubstituted C_4-C_{30} arylene group.

[0062] The condensed-cyclic compound of Formula 1 may be synthesized using an organic synthesis method. A method of synthesizing the condensed-cyclic compound may be referred to embodiments that will be described later.

[0063] For example, Reaction Scheme 1A below is a reaction scheme for synthesizing the condensed-cyclic compound of Formula 1:

Reaction Scheme 1A

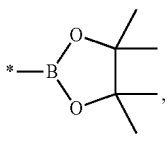


Formula 1

[0064] In Reaction Scheme 1A, R1 through R8, R11 through R14, and X1 are defined as described above.

[0065] In Reaction Scheme 1A, Ha denotes a halogen atom, and may be —F, —Cl, —Br, or —I.

[0066] In Reaction Scheme 1A, A1 may be a hydrogen atom,



or —B(OH)2, but is not limited thereto and may be selected from well known various moiety according to selected R8.

[0067] Reaction Scheme 1A is an example of a method of synthesizing the condensed-cyclic compound of Formula 1, and one of ordinary skill in the art may synthesize the condensed-cyclic compound of Formula 1 by using a well-known organic synthesis method by referring to Reaction Scheme 1A and the structure of the compound of Formula 1.

[0068] The condensed-cyclic compound of Formula 1 may be used in an organic layer of an OLED. An embodiment provides an OLED including a first electrode, a second electrode, and an organic layer disposed between the first electrode and the second electrode, wherein the organic layer includes the condensed-cyclic compound of Formula 1 described above.

[0069] Here, the organic layer may be an EML, a HTL, or an ETL, but is not limited thereto. When the condensed-cyclic compound of Formula 1 is used as an EML, the condensed-cyclic compound may be used as a host or a dopant.

[0070] FIG. **1** is a diagram schematically illustrating a structure of an OLED **10** according to an embodiment. Hereinafter, a structure of the OLED **10** and a method of manufacturing the OLED **10** according to an embodiment will now be described with reference to FIG. **1**.

[0071] The OLED **10** includes a substrate **11**, a first electrode **13**, an organic layer **15**, and a second electrode **17**, which are sequentially stacked in this order.

[0072] The substrate **11**, which may be any substrate that is used in conventional OLEDs, may be a glass substrate or a transparent plastic substrate with excellent mechanical strength, thermal stability, transparency, surface smoothness, ease of handling, and waterproofness.

[0073] The first electrode **13** may be formed by depositing or sputtering a material that is used to form the first electrode **13** on the substrate. When the first electrode **13** constitutes an anode, the material used to form the first electrode **13** may be a high work-function material so as to facilitate hole injection. The first electrode **13** may be a reflective electrode or a transparent electrode. Transparent and conductive materials such as indium tin oxide (ITO), indium zinc oxide (IZO), tin dioxide (SnO2), and zinc oxide (ZnO) may be used to form the first electrode **13**. Alternatively, the first electrode **13** may be formed by using magnesium (Mg), aluminum (Al), aluminum-lithium (Al—Li), calcium (Ca), magnesium-indium (Mg—In), magnesium-silver (Mg—Ag), or the like.

[0074] The organic layer **15** may be disposed on the first electrode **13**. The term "organic layer" used herein indicates any layer interposed between the first electrode **13** and the second electrode **17**. The organic layer **15** may not be formed of pure organic materials, and may also include a metal complex.

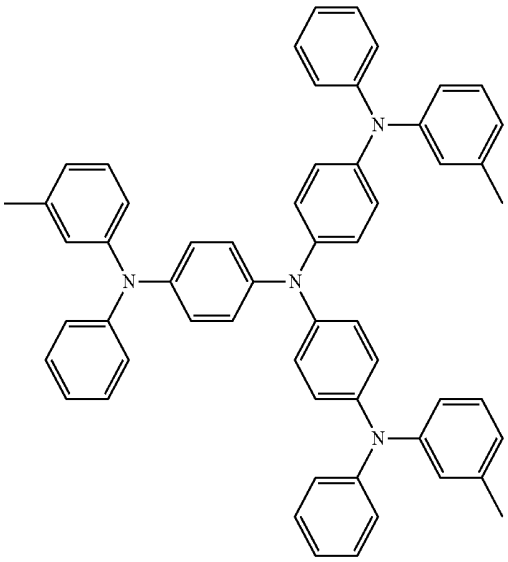
[0075] The organic layer **15** may include at least one of a hole injection layer (HIL), a HTL, an EML, a hole blocking layer (HBL), an ETL and an electron injection layer (EIL).

[0076] The HIL may be formed on the first electrode **13** by using a vacuum deposition method, a spin coating method, a casting method, a Langmuir-Blodgett (LB) method, or the like.

[0077] When the HIL is formed by using a vacuum deposition method, vacuum deposition conditions may vary according to a compound that is used to form the HIL, and the desired structure and thermal properties of the HIL to be formed. In general, however, the vacuum deposition method may be performed at a deposition temperature of about 100° C. to about 500° C., under a pressure of about 10-8 torr to about 10-3 torr, and at a deposition rate of about 0.01 to about 100 Å/sec.

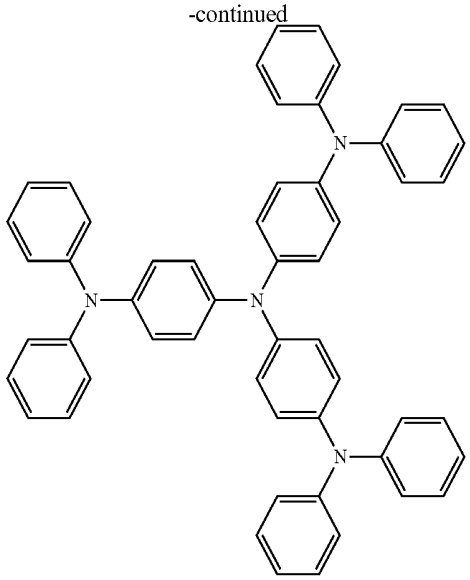
[0078] When the HIL is formed by using a spin coating method, the coating conditions may vary according to a compound that is used to form the HIL, and the desired structure and thermal properties of the HIL to be formed. In general, however, conditions for the spin coating method may include a coating rate of about 2,000 rpm to about 5,000 rpm and a heat treatment temperature of about 80° C. to about 200° C., wherein the heat treatment is performed to remove a solvent after coating.

[0079] The HIL may be formed of any well known hole injecting material. Examples of the hole injecting material include N,N'-diphenyl-N,N'-bis-[4-(phenyl-m-tolyl-amino)-phenyl]-biphenyl-4,4'-diamine (DNTPD), a phthalocyanine compound such as copperphthalocyanine, 4,4',4"-tris(3-methylphenylphenylamino)triphenylamine (m-MTDATA), TDATA, 2T-NATA, polyaniline/dodecylbenzenesulfonic acid (Pani/DBSA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/camphor sulfonicacid (Pani/CSA), and (polyaniline)/poly(4-styrenesulfonate) (PANI/PSS), but are not limited thereto.

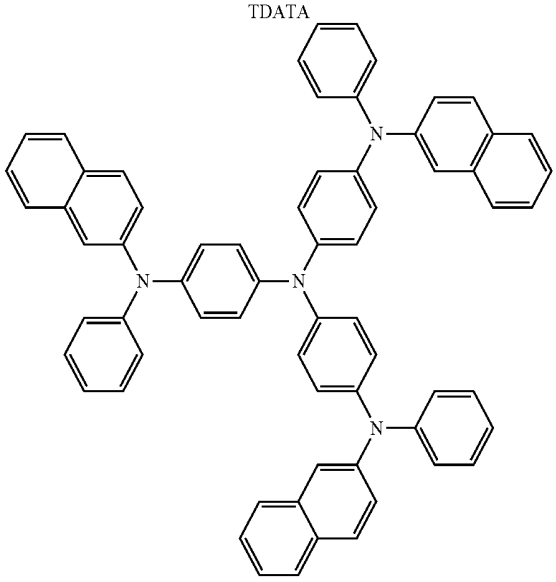


m-MTDATA

-continued



TDATA



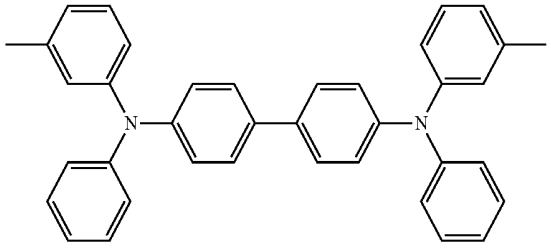
2T-NATA

[0080] The thickness of the HIL may be about 100 Å to about 10000 Å, and for example, about 100 Å to about 1000 Å. When the thickness of the HIL is within this range, the HIL may have excellent hole injecting ability without a substantial increase in driving voltage.

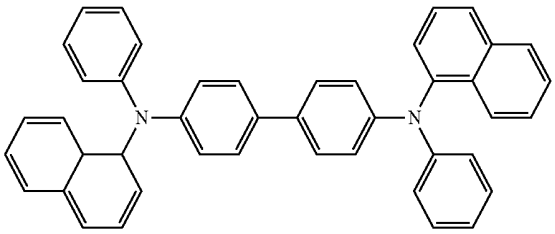
[0081] Then, the HTL may be formed on the HIL by using a vacuum deposition method, a spin coating method, a casting method, a LB method, or the like. When the HTL is formed by using a vacuum deposition method or a spin coating method, the conditions for deposition and coating may be similar to those for the formation of the HIL, although the conditions for the deposition and coating may vary according to the material that is used to form the HTL.

[0082] A HTL material may include the condensed-cyclic compound of Formula 1 described above. Alternatively, the HTL may be formed of any material that is commonly used to form a HTL. Examples of the material that is used to form the HTL include: a carbazole derivative such as N-phenylcarbazole and polyvinylcarbazole; an amine derivative having an

aromatic condensation ring such as N,N'-bis(3-methylphenyl)-N,N'-diphenyl-[1,1-biphenyl]-4,4'-diamine (TPD), and N,N'-di(naphthalene-1-yl)-N,N'-diphenyl benzydine (α-NPD); and a triphenylamine-based material such as 4,4',4"-tris(N-carbazolyl)triphenylamine (TCTA). Among these materials, TCTA may not only transport holes but also inhibit excitons from being diffused into the EML.



TPD

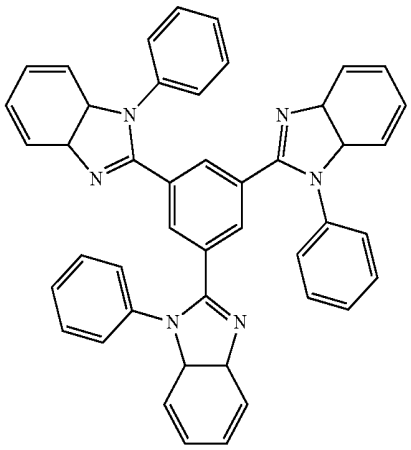


α-NPD

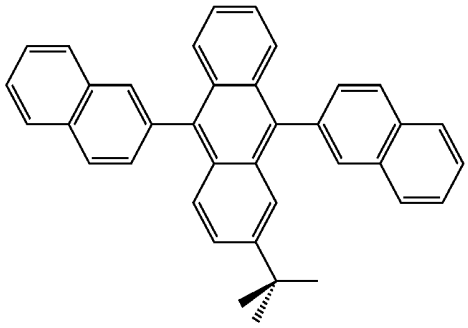
[0083] The thickness of the HTL may be about 50 Å to about 1000 Å, and for example, about 100 Å to about 800 Å. When the thickness of the HTL is within the range described above, the HTL may have excellent hole transporting ability without a substantial increase in driving voltage.

[0084] Then, an EML may be formed on the HTL by using a vacuum deposition method, a spin coating method, a casting method, an LB method, or the like. When the EML is formed using a vacuum deposition method or a spin coating method, the conditions for deposition and coating may be similar to those for the formation of the HIL, although the conditions for deposition and coating may vary according to the material that is used to form the EML.

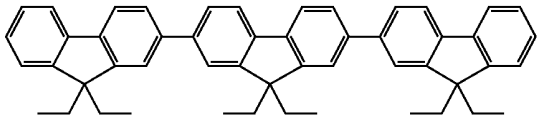
[0085] The EML may include the condensed-cyclic compound represented by Formula 1 as previously described. The EML may include only the condensed-cyclic compound of Formula 1; include the condensed-cyclic compound of Formula 1 as a host and a well known dopant; or include a well known host and the condensed-cyclic compound of Formula 1 as a dopant. Examples of the well known host include Alq_3, 4,4'-N,N'-dicarbazole-biphenyl (CBP), poly(n-vinylcarbazole) (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-2-naphthylanthracene (TBADN), E3, and distyrylarylene (DSA), but are not limited thereto.



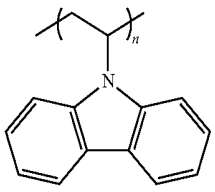
TPBI



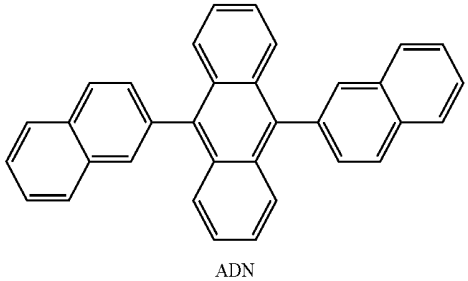
TBADN



E3

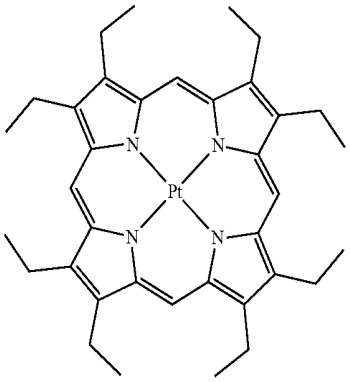


PVK

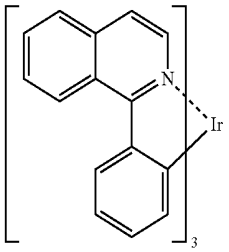


ADN

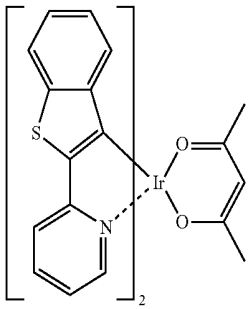
[0086] Examples of a well known red dopant include PtOEP, $Ir(piq)_3$, and $Btp_2Ir(acac)$, but are not limited thereto.



PtOEP

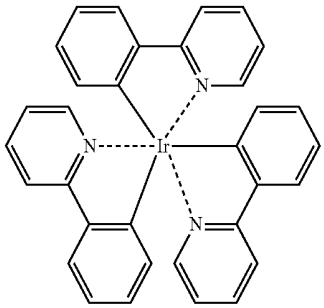


$Ir(piq)_3$

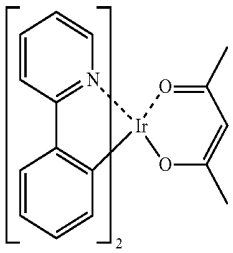


$Btp_2Ir(acac)$

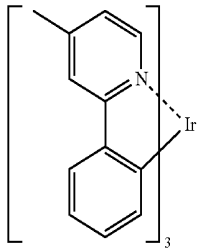
[0087] Also, examples of well known green dopant include $Ir(ppy)_3$ (ppy=phenylpyridine), $Ir(ppy)_2(acac)$, and $Ir(mpyp)_3$, but are not limited thereto.



$Ir(ppy)_3$

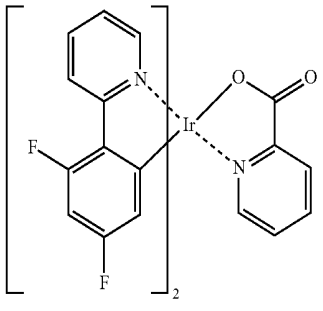


$Ir(ppy)_2(acac)$

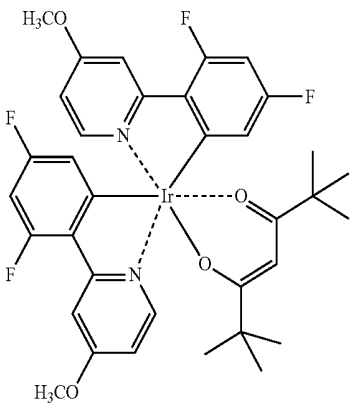


$Ir(mpyp)_3$

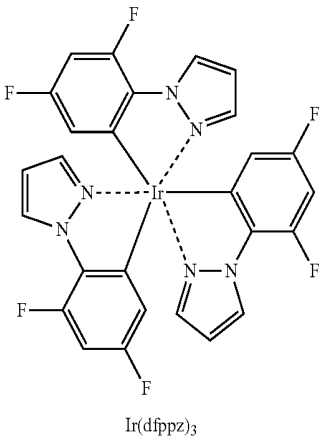
[0088] Examples of well known blue dopant include F_2Irpic, $(F_2ppy)_2Ir(tmd)$, $Ir(dfppz)_3$, ter-fluorene, 4,4'-bis(4-diphenylaminostyryl)biphenyl (DPAVBi), and 2,5,8,11-tetra-t-butyl pherylene (TBP), but are not limited to.



F_2Irpic

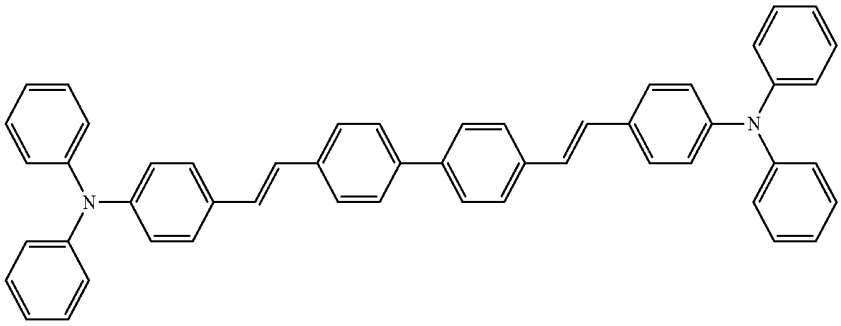


$(F_2ppy)_2Ir(tmd)$

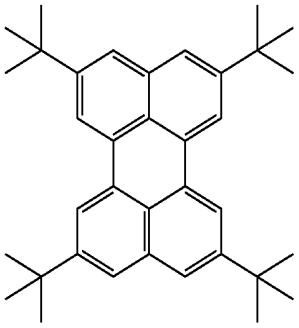


$Ir(dfppz)_3$

-continued



DPAVBi



TBPe

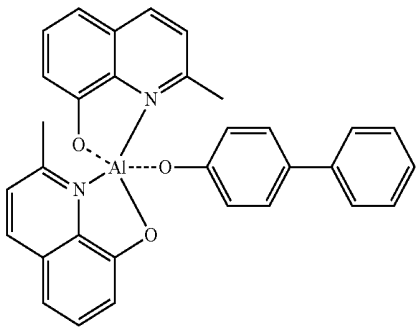
[0089] When the EML includes a host and a dopant, an amount of the dopant may be generally in a range from about 0.01 to about 15 parts by weight based on about 100 parts by weight of the host, but is not limited thereto.

[0090] The thickness of the EML may be about 100 Å to about 1000 Å, and for example, about 200 Å to about 600 Å. When the thickness of the EML is within this range, the EML may have excellent emitting ability without a substantial increase in driving voltage.

[0091] When a phosphorescent dopant is also used to form the EML, a HBL may be formed between the HTL and the EML by using a vacuum deposition method, a spin coating method, a casting method, a LB method, or the like, in order to prevent diffusion of triplet excitons or holes into an ETL. When the HBL is formed by using a vacuum deposition method or a spin coating method, the conditions for deposition and coating may be similar to those for the formation of the HIL, although the conditions for deposition and coating may vary according to the material that is used to form the HBL. Any material that is commonly used to form a HBL may be used. Examples of materials for forming the HBL include an oxadiazole derivative, a triazole derivative, and a phenanthroline derivative, but are not limited thereto.

[0092] The thickness of the HBL may be in the range of about 50 Å to about 1000 Å, for example, about 100 Å to about 300 Å. When the thickness of the HBL is within these ranges, the HBL may have an excellent hole blocking ability without a substantial increase in driving voltage.

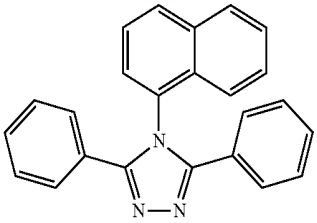
[0093] Then, an ETL is formed by using a vacuum deposition method, a spin coating method, a casting method, or the like. When the ETL is formed by using a vacuum deposition method or a spin coating method, the deposition and coating conditions may be similar to those for formation of the HIL, although the deposition and coating conditions may vary according to a compound that is used to form the ETL. The ETL may be formed of the condensed-cyclic compound of Formula 1. Alternatively, a material that is used to form the ETL may be a material that stably transports electrons injected from the electron injecting electrode (cathode) and any known material may be used. Examples of materials for forming the ETL include a quinoline derivative, tris(8-quinolinorate)aluminum (Alq_3), TAZ, Balq, and beryllium bis(benzoquinolin-10-olate) ($bebq_2$), but are not limited thereto.



BAlq

TAZ

-continued



TAZ

[0094] The thickness of the ETL may be about 100 Å to about 1000 Å, and for example, about 150 Å to about 500 Å. When the thickness of the ETL is within this range, the ETL may have satisfactory electron transporting ability without a substantial increase in driving voltage.

[0095] Then, an EIL may be formed on the ETL. A material for forming the EIL is not limited as long as it allows electrons to be easily injected from the cathode.

[0096] Examples of materials for forming the EIL include LiF, NaCl, CsF, Li_2O, and BaO, which are known in the art. Deposition conditions for forming the EIL are similar to those for formation of the HIL, although the deposition conditions may vary according to a material that is used to form the EIL.

[0097] The thickness of the EIL may be about 1 Å to about 100 Å, specifically about 3 Å to about 90 Å. When the thickness of the EIL is within this range, the EIL may have satisfactory electron injection ability without a substantial increase in driving voltage.

[0098] Finally, the second electrode **17**, which may be a transparent electrode, is disposed on the organic layer **15**. The second electrode **17** may be a cathode that is an electron injection electrode. Here, a second electrode forming metal may be a metal having a low work function, an alloy having a low work function, an electro-conductive compound, or mixtures thereof. The second electrode **17** may be formed of lithium (Li), magnesium (Mg), aluminum (Al), aluminum (Al)-lithium (Li), calcium (Ca), magnesium (Mg)-indium (In), magnesium (Mg)-silver (Ag), or the like, and may be formed as a thin film type transmission electrode. In addition, the transmission electrode may be formed of ITO or IZO to manufacture a top-emission type light-emitting device.

[0099] Hereinafter, one or more embodiments of the present embodiments will be described in detail with reference to the following examples. However, these examples are not intended to limit the purpose and scope of the one or more embodiments.

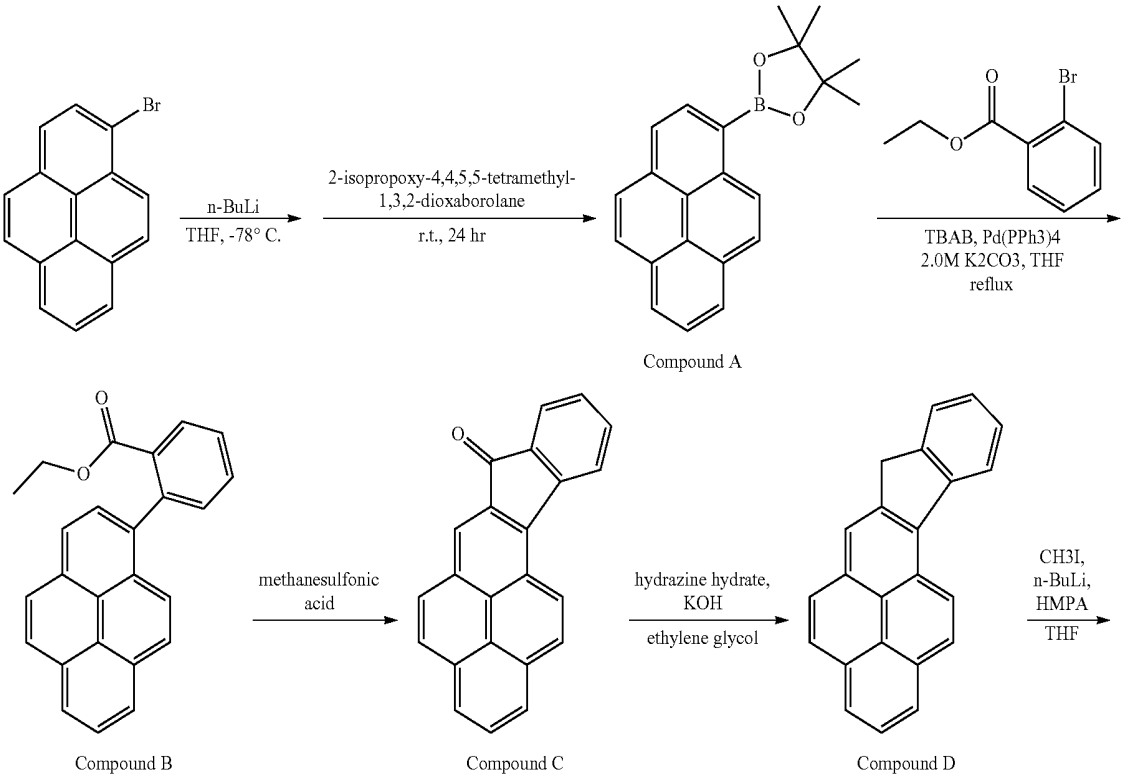
EXAMPLES

Synthesis Example 1

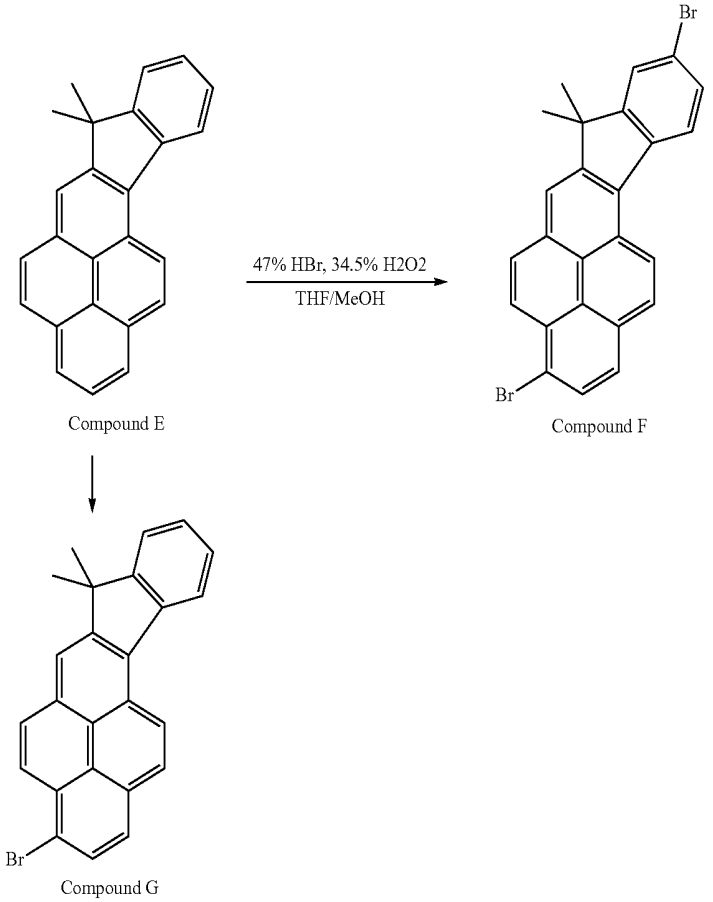
Synthesis of Compounds F and G

[0100] Compounds F and G were synthesized through Reaction Scheme 2 below:

Reaction Scheme 2



-continued



Synthesis of Compound A

[0101] 100 g (355.68 mmol) of 2-bromopyrene was mixed with 1 L of tetrahydrofuran (THF) in a flask, the temperature of the mixture in the flask was decreased to −78° C., 213.4 ml (533.52 mmol) of 2.5M n-butyllithium (n-BuLi) in hexanes was slowly added dropwise to the dilution under a nitrogen atmosphere and then the resulting mixture thereof was stirred for 30 minutes. 99.41 mL (487.28 mmol) of 2-isopropoxy-4,4,5,5-tetramethyl-1,3,2-dioxaborolane was slowly to the reaction mixture, and then the flask was allowed to warm to room temperature.

[0102] The reaction was stopped by the addition of 1N (hydrochloric acid) HCl, and then were extracted with ethyl acetate (EA). Then, the extract was washed with water and brine, dried over magnesium sulfate ($MgSO_4$), and concentrated under reduced pressure. The concentrate was suspended in hexane and collected to give 75 g (yield=64%) of solid Compound A.

[0103] ^{1}H-NMR($CDCl_3$, 300 MHz) δ 1.48 (s, 12H), 7.97-8.04 (m, 3H), 8.07-8.22 (m, 4H), 8.53 (d, J=6.9 Hz, 1H), 8.06 (d, J=9.3 Hz, 1H).

Synthesis of Compound B

[0104] 85 g (258.98 mmol) of 4,4,5,5-tetramethyl-2-(pyren-1-yl)-1,3,2-dioxaborolane, 45.23 mL (284.88 mmol) of ethyl 2-bromobenzoate, 83.49 g (258.98 mmol) of tetrabutylammonium bromide, 259 mL (517.96 mmol) of 2M potassium carbonate, and 14.96 g (12.95 mmol) of $Pd(PPh_3)_4$ were combined in toluene. The resultant mixture was stirred while increasing the temperature to ?, for 12 hours. The reaction was stopped by adding water to the mixture, and was extracted with ethyl acetate. The organic extract was washed with water and brine, dried over $MgSO_4$, and then concentrated under reduced pressure. The concentrate was subjected to column chromatography (ethyl acetate:Hexane (HEX)=1:50) so as to give 83 g (yield=91.5%) of thin light yellow solid Compound B.

[0105] ^{1}H-NMR($CDCl_3$, 300 MHz)δ 0.38 (t, J=6.9 Hz, 3H), 3.66-3.81 (in, 2H), 7.50 (d, J=6.9 Hz, 1H), 7.56-7.61, (m, 1H), 7.65-7.70 (m, 1H), 7.75 (d, J=9.3 Hz, 1H), 7.87 (d, J=7.8 Hz, 1H), 7.96-8.03 (m, 2H), 8.11 (m, 2H), 8.13-8.14 (m, 2H), 8.20-8.22 (m, 2H).

Synthesis of Compound C

[0106] 35 g (99.88 mmol) of Compound B was added to 500 mL of methanesulfonic acid, and the resultant reaction mixture was stirred at 75° C. for about 4 hours. After checking that a starting material has disappeared by a thin layer chromatography (TLC), the reaction mixture was cooled down to 0° C. A red solid formed on cooling. The reaction mixture was stirred and the precipitate was collected by filtration. The filtrate was over with $MgSO_4$ and concentrated under reduced pressure to give 29 g (yield=95%) of red solid Compound C.

[0107] ^{1}H-NMR(300 MHz) δ 7.97-7.99 (m, 4H), 8.05-8.15 (m, 4H), 8.32 (m, 1H), 8.44-8.49 (m, 2H) 8.75 (d, J=7.8 Hz, 1H), 9.36 (s, 1H).

Synthesis of Compound D

[0108] 30 g (98.57 mmol) of Compound C was added to 500 mL of ethylene glycol, and followed by the addition of 148.08 mL (2957.1 mmol) of hydrazine hydrate. 132.74 g (2365.8 mmol) of potassium hydroxide was next added to the reaction mixture, and the reaction mixture was stirred overnight at a temperature from 180° C. to 190° C. Next, the reaction mixture was cooled down to room temperature, and then poured into ice water. A precipitate was formed on neutralizing the reaction mixture by the slow addition of 2N HCl. The precipitate was collected by filtration and was dissolved in methylene chloride (MC) to give an organic layer. The organic layer was dried over $MgSO_4$, and then concentrated under reduced pressure. Accordingly, 10 g (yield=35%) of yellow solid Compound D was obtained.

[0109] ^{1}H-NMR($CDCl_3$, 300 MHz) δ 4.29 (s, 2H), 7.41 (t, J=7.5 Hz, 1H), 7.55 (t, J=7.5 Hz, 1H), 7.72 (d, J=7.5 Hz, 1H), 8.00-8.09 (m, 3H), 8.20-8.27 (m, 3H), 8.35 (s, 1H), 8.59 (d, J=7.5Hz, 1H), 9.02 (d, J=6.3 Hz, 1H).

Synthesis of Compound E

[0110] 55.1 mL (137.76 mmol) of 2.5M n-BuLi in hexanes was put into a flask at −78° C., and then 16 g (55.1 mmol) of Compound D that has been dissolved in dried THF, was slowly added to the flask at −78° C. To the resultant reaction mixture was added 8.58 mL (137.76 mmol) of methyl iodide at −78° C., and the temperature was slowly increased to room temperature, and the reaction mixture was stirred for about 2 to 3 hours. Water was poured to the reaction mixture and then the reaction mixture was neutralized with 2N HCl. The reaction mixture were extracted with melthylene chloride, dried over $MgSO_4$, concentrated under reduced pressure, and then purified with column chromatography (ethyl acetate:hexane=1:100) to give obtain 11 g (yield=63%) of yellow solid Compound E.

[0111] ^{1}H-NMR($CDCl_3$, 300 MHz)δ 1.63 (s, 6H), 7.41 (t, J=7.2 Hz, 1H), 7.50 (t, J=7.2 Hz, 1H), 7.60 (d, J=7.5 Hz, 1H), 7.98 (t. J=7.2 Hz, 1H), 8.09-8.16 (m, 2H), 8.19-8.26 (m, 4H), 8.53 (d, J=7.5 Hz, 1H), 9.00 (d, J=9.3 Hz, 1H).

Synthesis of Compound F

[0112] 11 g (34.55 mmol) of Compound E was dissolved in 80 mL of THF in a 1 L round-bottom flask (RBF), and then 400 mL of methanol (MeOH) was slowly added to the RBF. 9.5 mL (76.00 mmol) of 48% hydrobromic acid was slowly added to the reactant in the resultant reaction mixture at 0° C., followed by the slow addiction of 34.5% The temperature of the resultant reaction mixture was slowly increased from 0° C. to room temperature, while stirring the reaction mixture. After 2 the precipitate formed was filtered, dissolved in methylene chloride, washed with water, neutralized saturated $NaHCO_3$ solution, dried over $MgSO_4$, and then concentrated under reduced pressure. The concentrate was purified with column chromatography to give 5.2 g (yield=31.6%) of yellow solid Compound F.

[0113] ^{1}H-NMR($CDCl_3$, 300 MHz)δ 1.70 (s, 6H),7.45 (t, J=7.2 Hz, 1H) 7.52 (t, J=7.8 Hz,1H), 7.63 (d, J=7.2 Hz, 1H), 8.21 (d, J=9.3 Hz,1H), 8.32 (s, 1H), 8.38 (d, J=9.3 Hz,1H), 8.51-8.56 (m, 3H), 9.11 (d, J=9.9 Hz, 1H).

Synthesis of Compound G

[0114] 7.8 g (yield=56%) of Compound G was obtained in the same manner as in Synthesis of Compound F, except that the reaction time was reduced to 8 hours, instead of 2 days.

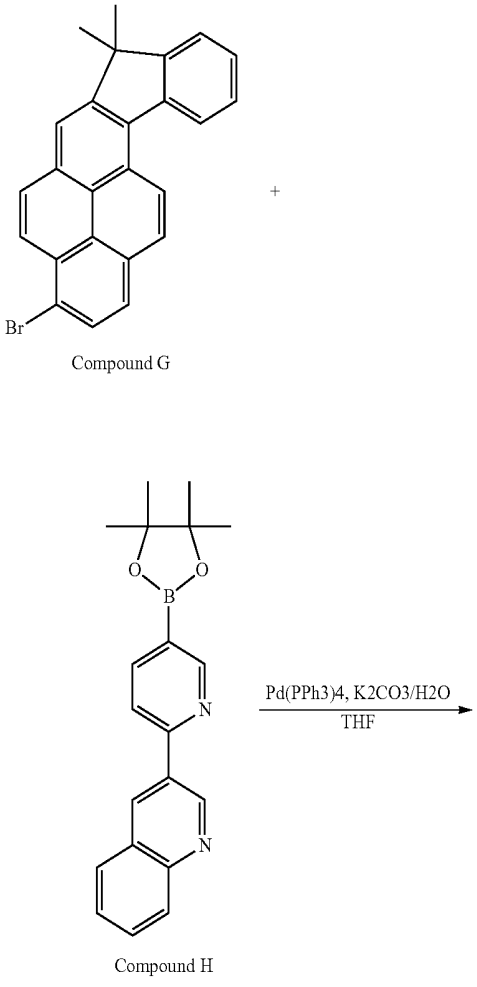
[0115] ^{1}H-NMR($CDCl_3$, 300 MHz)δ 1.70 (s, 6H), 7.24 (t, J=7.1 Hz, 1H) 7.45 (t, J=7.8 Hz,1H), 7.52 (t, J=7.8 Hz,1H), 7.61 (d, J=7.1 Hz, 1H), 8.21 (d, J=9.3 Hz,1H), 8.32 (s, 1H), 8.38 (d, J=9.3 Hz,1H), 8.51-8.56 (m, 3H), 9.11 (d, J=9.9 Hz, 1H).

Synthesis Example 2

Synthesis of Compound 3

[0116] Compound 3 was synthesized through Reaction Scheme 3 below:

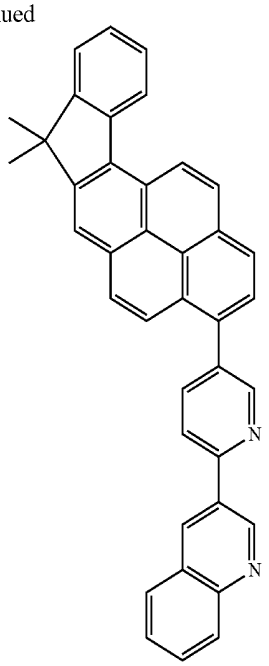
Reaction Scheme 3



Compound G

Compound H

-continued



Compound 3

[0117] 2.0 g (5.0 mmol) of Compound G and 1.84 g (5.5 mmol) of Compound H were added to a THF solution of 2.07 g (15.0 mmol) potassium carbonate, 173 mg (3 mol %) of $Pd(PPh_3)_4$ was added to the resultant reaction mixture with stirring, and the reaction mixture was heated for 24 hours. The mixture was cooled to room temperature extracted with dichloromethane. The organic layer was collected, dried over anhydrous magnesium sulfate and concentrated under reduced pressure. The concentrate was subjected to a column chromatography (ethyl acetate:dichloromethane=3:7) to give 2.07 g (yield=79%) of yellow solid Compound 3. The structure of Compound 3 was identified using ^{1}H-NMR).

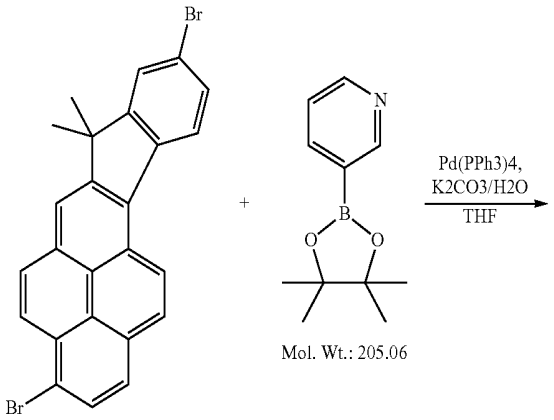
[0118] H NMR ($CDCl_3$, 300 MHz) δ 9.21(1H), 8.82(1H), 8.73(1H), 8.18-8.03(4H), 7.81(1H), 7.71-7.60(8H), 7.45-7.43(2H), 7.24(2H), 1.71(6H)

Synthesis Example 3

Synthesis of Compound 19

[0119] Compound 19 was synthesized through Reaction Scheme 4 below:

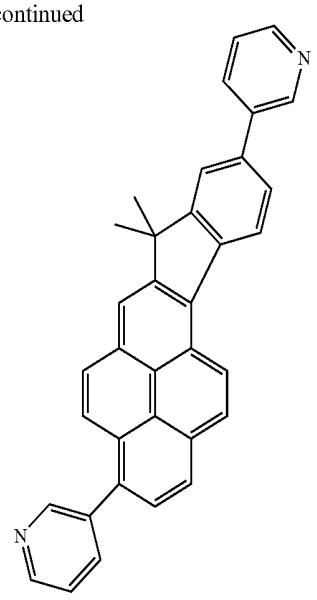
Reaction Scheme 4



Compound F

Mol. Wt.: 205.06

-continued



Compound 19

[0120] 2.0 g (4.20 mmol) of Compound F and 2.58 g (12.6 mmol) of 3-pyridylboron acid pinacol ester were added to THF solution of 2.32 g (16.8 mmol) potassium carbonate, to this reaction mixture was added, 194 mg (4 mol %) of $Pd(PPh_3)_4$ was added with stirring, and the resultant reaction mixture was heated for 24 hours. The reaction mixture was cooled to room temperature and extracted with dichloromethane. Then, the organic layer was collected, dried over anhydrous magnesium sulfate and concentrated under reduced pressure. The concentrate was dried over column chromatography (ethyl acetate:dichloromethane=3:7) to give 1.59 g (yield=80%) of yellow solid Compound 19. The structure of Compound 19 was identified using ^{1}H-NMR.

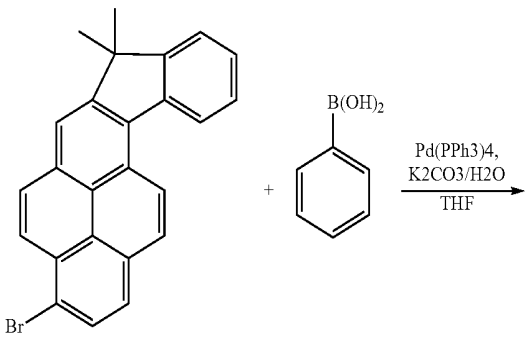
[0121] H NMR (CDCl3, 300 MHz) δ 8.72(2H), 8.51(2H), 8.18-8.12(2H), 8.02-7.97(3H), 7.85-7.81(2H), 7.71-7.65(5H), 7.45-7.41(2H), 1.72(6H)

Synthesis Example 4

Synthesis of Compound 40

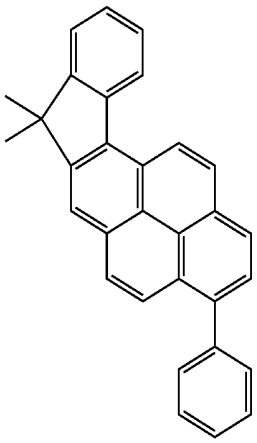
[0122] Compound 40 was synthesized through Reaction Scheme 5 below:

Reaction Scheme 5



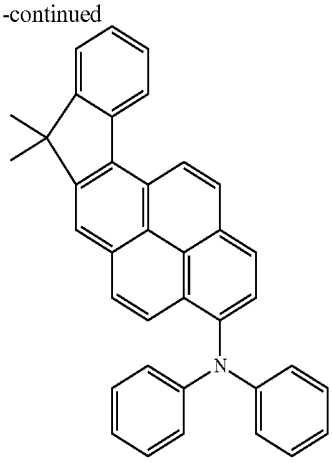
Compound G

-continued



Compound 40

-continued



Compound 35

[0123] Compound 40 was synthesized in the same manner as Synthesis Example 3, except that Compound G was used instead of Compound F, and phenylboron acid was used instead of 3-pyridylboron acid pinacol ester (yield=84%). The structure of Compound 40 was identified using ^{1}H-NMR.

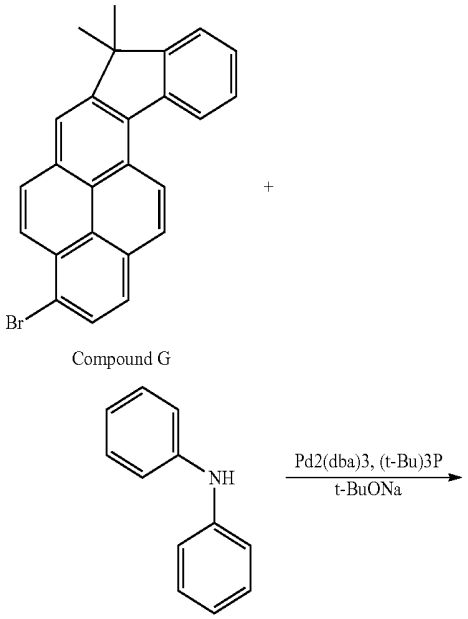
[0124] H NMR ($CDCl_3$, 300 MHz) δ 8.21(1H), 8.06-8.01 (2H), 7.81(1H), 7.78-7.62(5H) 7.48-7.43(3H), 7.32-7.25 (4H), 1.70(6H)

Synthesis Example 5

Synthesis of Compound 35

[0125] Compound 35 was synthesized through Reaction Scheme 6 below:

Reaction Scheme 6



Compound G

[0126] 2 g (5.0 mmol) of Compound G and 1.28 g (7.55 mmol) of diphenylamine was dissolved in 50 mL of toluene. To this reaction mixture was added 2.40 g (25 mmol) of t-BuONa, 90.6 mg (2 mol %) of tris(dibenzylideneacetone) bispalladium (0) ($Pd_2(dba)_3$), and 20 mg (2 mol %) of (t-Bu)$_3$P were added thereto, and then the resultant reaction mixture was stirred for 4 hours at 90° C.

[0127] The reaction mixture was extracted 3 times by with 50 mL of dichloromethane and the organic layers were combined. The combined organic layers were dried over magnesium sulfate then evaporated to dryness. The residue was separately purified using silica gel column chromatography to give 1.76 g (yield=72%) of Compound 35. The structure of Compound 35 was identified using ^{1}H-NMR.

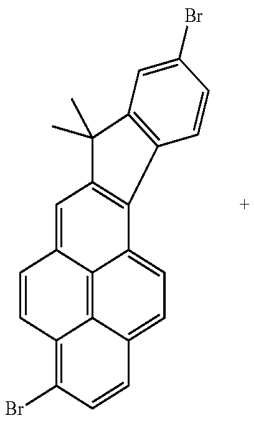
[0128] ^{1}H-NMR(300 MHz) δ 7.98(1H) 7.87-7.81(2H) 7.72-7.63(5H), 7.44(1H), 7.21(1H), 7.05-6.97(6H), 6.65-6.46(5H), 1.71(6H)

Synthesis Example 6

Synthesis of Compound 34

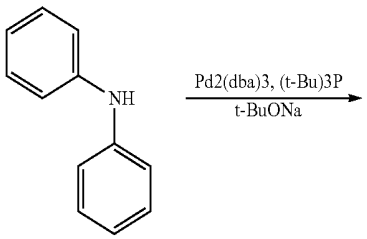
[0129] Compound 34 was synthesized through Reaction Scheme 7 below:

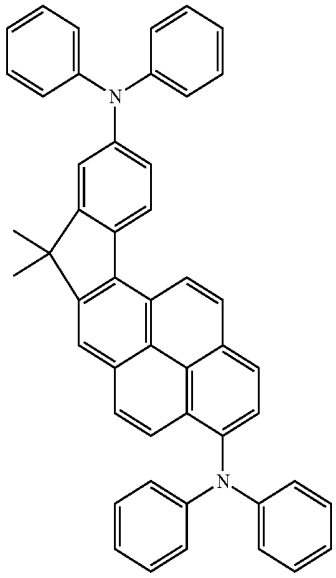
Reaction Scheme 7



Compound F

-continued





Compound 34

[0130] 2.4 g (5.0 mmol) of Compound F and 2.54 g (15.0 mmol) of diphenylamine was dissolved in 100 mL of toluene. To this reaction mixture was added 2.40 g (25 mmol) of t-BuONa, 137 mg (3 mol %) of $Pd_2(dba)_3$, and 30 mg (3 mol %) of (t-Bu)3P and the resultant mixture was stirred for 6 hours at 90° C.

[0131] The reaction mixture was extracted 3 times with 100 mL of dichloromethane and the organic layers were combined. The combined organic layers were dried with magnesium sulfate then evaporated to dryness. The residue was subjected to silica gel column chromatography to give 2.27 g (yield=69%) of Compound 34. The structure of Compound 34 was identified using 1H-NMR.

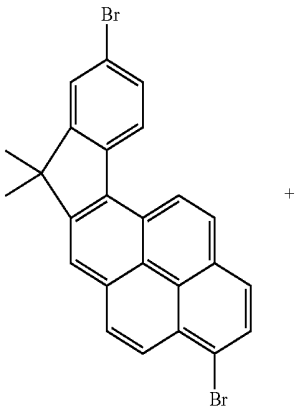
[0132] ^{1}H-NMR(300 MHz) δ 7.89(1H), 7.82-7.80(2H), 7.83-7.70(4H), 7.11-7.04(10H), 6.82(2H), 6.65-6.59(4H), 6.52-6.47(7H), 1.72(6H)

Synthesis Example 7

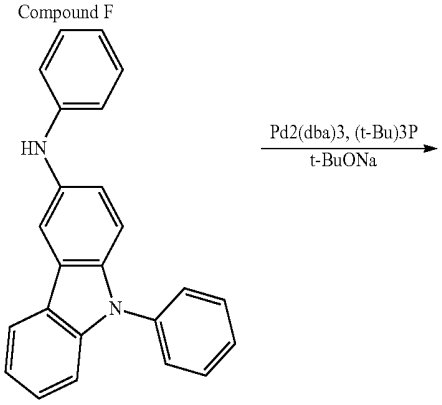
Synthesis of Compound 43

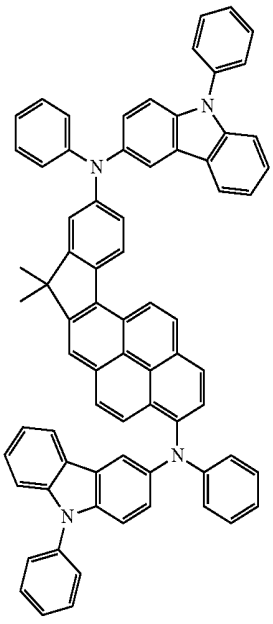
[0133] Compound 43 was synthesized through Reaction Scheme 8 below:

Reaction Scheme 8



Compound F





Compound 43

[0134] 2.4 g (5.0 mmol) of Compound F and 5.01 g (15.0 mmol) of phenyl-(phenylcarbazole) was dissolved in 200 mL

of toluene. To the resultant reaction mixture was added 2.40 g (25 mmol) of t-BuONa, 137 mg (3 mol %) of $Pd_2(dba)_3$, and 30 mg (3 mol %) of $(t\text{-}Bu)_3P$, and then the resultant reaction mixture was stirred for 6 hours at 90° C.

[0135] The reaction mixture was then extracted 3 times with 100 mL of dichloromethane and the organic layers were combined, dried over magnesium sulfate to evaporate the solvent. The residue was subjected to silica gel column chromatography to obtain 2.73 g (yield=56%) of Compound 43. The structure of Compound 43 was identified using ^{1}H-NMR.

[0136] ^{1}H-NMR(300 MHz) δ 7.87(1H), 7.82(1H), 7.76-7.72(5H), 7.56(2H), 7.42(2H), 7.39-7.13(12H), 7.08-6.98(10H), 6.81-6.46(9H), 6.28(2H), 1.71(6H)

Comparative Example 1

[0137] A 15 Ω/cm^2 (1200 Å) ITO glass substrate (available from Corning Co.) was cut to a size of 50 mm×50 mm×0.7 mm, ultrasonically washed with isopropyl alcohol for 5 minutes and then with pure water for 5 minutes, and washed again with UV ozone for 30 minutes. Then, m-MTDATA was vacuum deposited on the substrate to form a hole injection layer having a thickness of 750 Å, and then α-NPD was vacuum deposited on the hole injection layer to form a hole transport layer having a thickness of 150 Å. 97 wt % of DSA as a host and 3 wt % of TBPe as a dopant were deposited on the HTL to form an EML with a thickness of 300 Å. Alq3 was vacuum-deposited on the EML to form an ETL having a thickness of 200 Å. LiF was vacuum-deposited on the ETL to form an EIL having a thickness of 80 Å and Al was vacuum-deposited on the EIL to form a cathode having a thickness of 3000 Å.

Example 1

[0138] An OLED was manufactured in the same manner as in Comparative Example 1, except that Compound 34 was used instead of m-MTDATA to form the HTL.

Example 2

[0139] An OLED was manufactured in the same manner as in Comparative Example 1, except that Compound 40 was used instead of DSA as the host of the EML.

Example 3

[0140] An OLED was manufactured in the same manner as in Comparative Example 1, except that Compound 35 was used instead of TBPe as the dopant of the EML.

Example 4

[0141] An OLED was manufactured in the same manner as in Comparative Example 1, except that Compound 43 was used instead of Alq_3 to form the ETL.

Example 5

[0142] An OLED was manufactured in the same manner as in Comparative Example 1, except that Compound 19 was used instead of Alq_3 to form the ETL.

Example 6

[0143] An OLED was manufactured in the same manner as in Comparative Example 1, except that Compound 3 was used instead of Alq_3 to form the ETL.

EVALUATION EXAMPLE

[0144] Efficiency and half lifetime characteristics of the OLEDs manufactured in Comparative Example 1 and Examples 1 through 6 were measured using a PR650 (Spectroscan) Source Measurement Unit. (available from Photo-Research, Inc.). The results are shown in Table 1 below.

TABLE 1

	Compound	Use of Compound	Luminance Efficiency (cd/A)	Half Lifetime (hour) @ 1000 nit
Example 1	Compound 34	Hole Transport Layer	4.2	3700
Example 2	Compound 40	Host	4.3	4200
Example 3	Compound 35	Dopant	3.7	3800
Example 4	Compound 43	Hole Transport Layer	4.1	4200
Example 5	Compound 19	Electron Transport Layer	4.4	4500
Example 6	Compound 3	Electron Transport Layer	3.9	2600
Comparative Example	—	—	2.8	1400

[0145] Referring to Table 1, it can be confirmed that the OLEDs of Examples 1 through 6 have higher luminance efficiencies and half lifetime, compared to the OLED of Comparative Example 1.

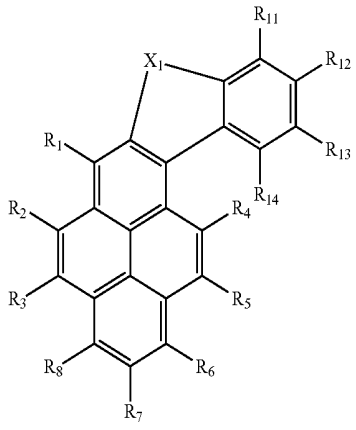
[0146] An OLED including an organic layer containing the condensed-cyclic compound of Formula 1 above may have high efficiency and long durability.

[0147] While the present embodiments have been particularly shown and described with reference to exemplary embodiments thereof, 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 embodiments as defined by the following claims.

What is claimed is:

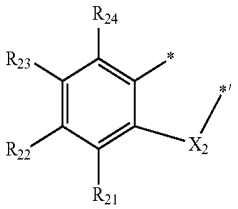
1. A condensed-cyclic compound represented by Formula 1 below:

Formula 1



wherein R_8 and R_7 are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or

unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a group represented by $—(Ar_1)_a—Ar_{11}$, and a group represented by $—N[—(Ar_2)_b—Ar_{12}][—(Ar_3)_c—Ar_{13}]$; or R_8 is connected to * of Formula 2 and R_7 is connected to *' of Formula 2 represented by:



wherein R_1 through R_6, R_{11} through R_{14}, and R_{21} through R_{24} are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a group represented by $—(Ar_4)_d—Ar_{14}$, and a group represented by $—N[—(Ar_5)_e—Ar_{15}][—(Ar_6)_f—Ar_{16}]$;

wherein Ar_1 through Ar_6 are each independently selected from the group consisting of a substituted or unsubstituted C_1-C_{30} alkylene group, a substituted or unsubstituted C_2-C_{30} alkenylene group, a substituted or unsubstituted C_5-C_{30} arylene group, and a substituted or unsubstituted C_4-C_{30} heteroarylene group;

wherein Ar_{11} through Ar_{16} are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a substituted or unsubstituted C_5-C_{30} aryl group, and a substituted or unsubstituted C_4-C_{30} heteroaryl group;

wherein a through f are each independently an integer from 0 to 10;

wherein the moieties represented by Ar_1 in the group represented by $—(Ar_1)_a—Ar_{11}$ are identical to or different from each other, the moieties represented by Ar_2 in the group represented by $—(Ar_2)_b—Ar_{12}$ are identical to or different from each other, the moieties represented by Ar_3 in the group represented by $—(Ar_3)_c—Ar_{13}$ are identical to or different from each other, the moieties represented by Ar_4 in the group represented by $—(Ar_4)_d—Ar_{14}$ are identical to or different from each other, the moieties represented by Ar_5 in the group represented by $—(Ar_5)_e—Ar_{15}$ are identical to or different from each other, and the moieties represented by Ar_6 in the group represented by $[—(Ar_6)_f—Ar_{16}]$ are identical to or different from each other;

wherein X_1 and X_2 are each independently a divalent linking group selected from the group consisting of $—C(Q_1)(Q_2)-$ and $—N(Q_3)-$; and

wherein Q_1 through Q_3 are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a substituted or unsubstituted C_5-C_{30} aryl group, and a substituted or unsubstituted C_4-C_{30} heteroaryl group.

2. The condensed-cyclic compound of claim **1**, wherein R_1, R_2 R_3 R_4, R_5, R_6, and R_7 are hydrogen;

R_8 is selected from the group consisting of hydrogen, a substituted or unsubstituted C_1-C_{10} alkyl group, a substituted or unsubstituted C_2-C_{10} alkenyl group, a substituted or unsubstituted C_2-C_{10} alkynyl group, a substituted or unsubstituted C_1-C_{10} alkoxy group, a group represented by $—(Ar_1)_a—Ar_{11}$, and a group represented by $—N[—(Ar_2)_b—Ar_{12}][—(Ar_3)_c—Ar_{13}]$;

R_{11}, R_{12}, R_{13} and R_{14} are each independently selected from the group consisting of hydrogen, a substituted or unsubstituted C_1-C_{10} alkyl group, a substituted or unsubstituted C_2-C_{10} alkenyl group, a substituted or unsubstituted C_2-C_{10} alkynyl group, a substituted or unsubstituted C_1-C_{10} alkoxy group, a group represented by $—(Ar_4)_d—Ar_{14}$, and a group represented by $—N[—(Ar_5)_e—Ar_{15}][—(Ar_6)_f—Ar_{16}]$;

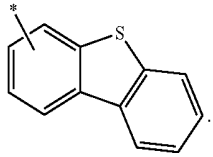
Ar_1, Ar_2, Ar_3, Ar_4, Ar_5 and Ar_6 are each independently selected from the group consisting of a substituted or unsubstituted C_1-C_{30} alkylene group, a substituted or unsubstituted C_2-C_{30} alkenylene group, a substituted or unsubstituted C_5-C_{30} arylene group, and a substituted or unsubstituted C_4-C_{30} heteroarylene group; and

Ar_{11} and Ar_{16} are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a substituted or unsubstituted C_5-C_{30} aryl group, and a substituted or unsubstituted C_4-C_{30} heteroaryl group.

3. The condensed-cyclic compound of claim **2**, wherein a, b, c, d, e and f are each independently 0, 1, or 2.

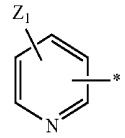
4. The condensed-cyclic compound of claim **2**, wherein Ar_1, Ar_2, Ar_3, Ar_4, Ar_5 and Ar_6 are each independently selected from the group consisting of a pyridinylene group, a quinolinylene group, a benzimidazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, a phenylene group, a C_1-C_{10} alkyl phenylene group, a carbazolylene group, a phenylcarbazolylene group, a fluorenylene group, a C_1-C_{10} alkylfluorenylene group, a di(C_1-C_{10} alkyl) fluorenylene group, an ethylene group, and a naphthylene group.

5. The condensed-cyclic compound of claim **2**, wherein Ar_{11} Ar_{12}, Ar_{13}, Ar_{14}, Ar_{15} and Ar_{16} are each independently selected from the group consisting of a methyl group, ethyl, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pyridinyl group, a quinolinyl group, a benzimidazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, a phenyl group, a carbazolyl group, a fluorenyl group, a di(C_1-C_{10} alkyl)fluorenyl group, a naphthyl group, and a functional group represented by the formula

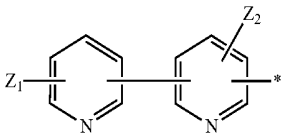


6. The condensed-cyclic compound of claim **2**, wherein R_8 and R_{11}, R_{12}, R_{13} and R_{14} are each independently selected from the group consisting of hydrogen and functional groups represented by Formulae 3A through 3O below:

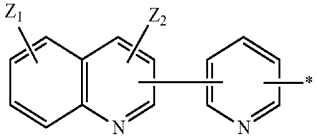
Formula 3A



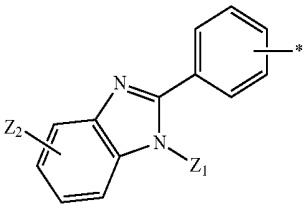
Formula 3B



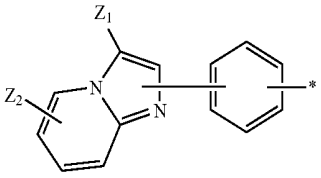
Formula 3C



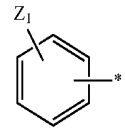
Formula 3D



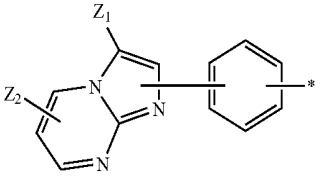
Formula 3E



Formula 3F

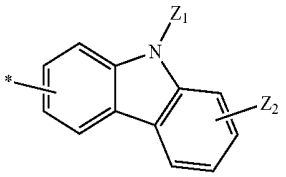


Formula 3G

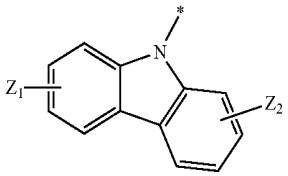


-continued

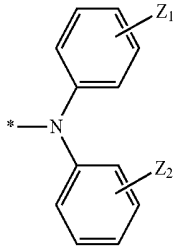
Formula 3H



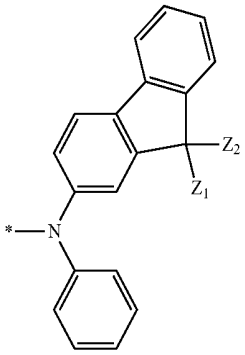
Formula 3I



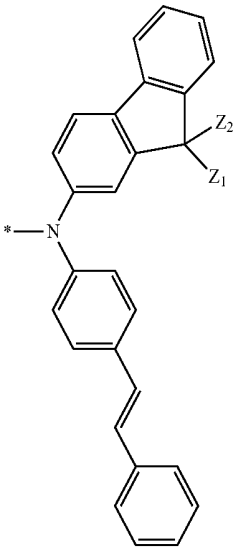
Formula 3J



Formula 3K

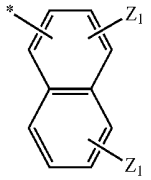


Formula 3L

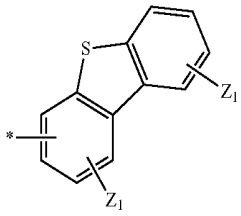


-continued

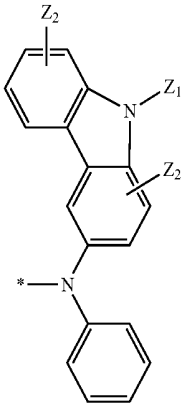
Formula 3M



Formula 3N



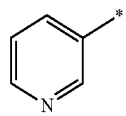
Formula 3O



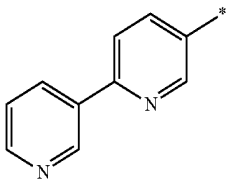
wherein, in Formulae 3A through 3O, Z_1 and Z_2 are each independently selected from the group consisting of hydrogen, a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, and a naphthyl group.

7. The condensed-cyclic compound of claim **2**, wherein R_8 and R_{11} R_{12}, R_{13} and R_{14} are each independently selected from the group consisting of hydrogen and functional groups represented by Formulae 4A through 4R below:

Formula 4A

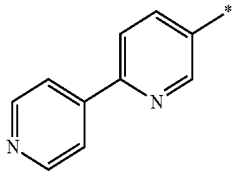


Formula 4B

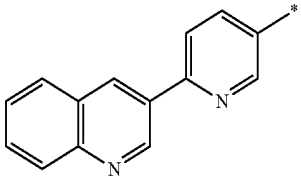


-continued

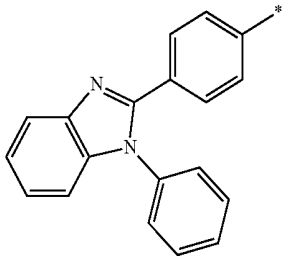
Formula 4C



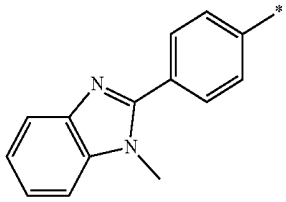
Formula 4D



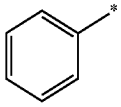
Formula 4E



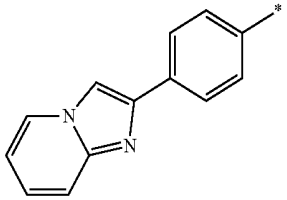
Formula 4F



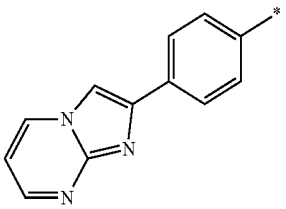
Formula 4G



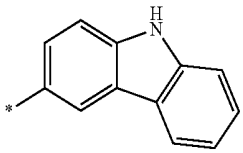
Formula 4H



Formula 4I

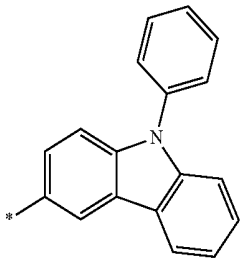


Formula 4J

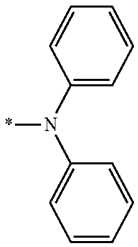


-continued

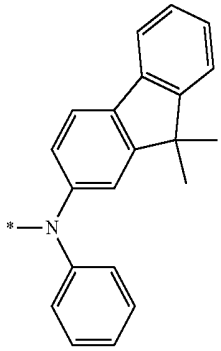
Formula 4K



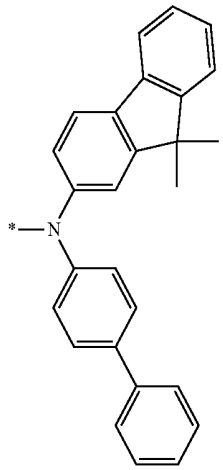
Formula 4L



Formula 4M

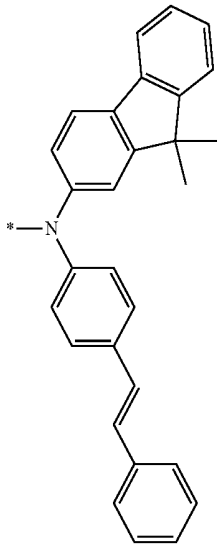


Formula 4N

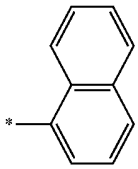


-continued

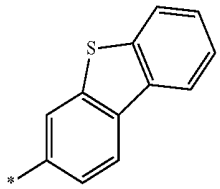
Formula 4O



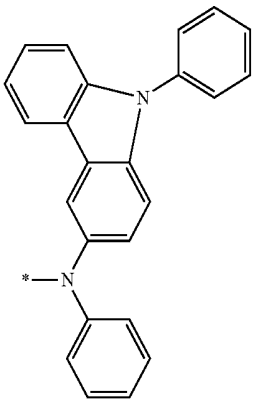
Formula 4P



Formula 4Q



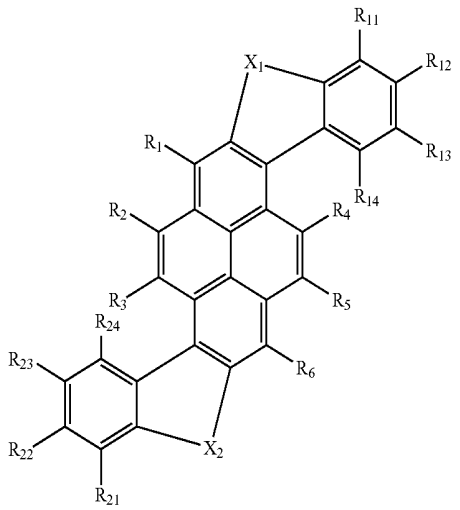
Formula 4R



8. The condensed-cyclic compound of claim **2**, wherein Q_1 through Q_3 are each independently selected from the group consisting of hydrogen, a C_1-C_{30} alkyl group, a C_1-C_{30} alkoxy group, a C_5-C_{14} aryl group, and a C_4-C_{14} heteroaryl group.

9. The condensed-cyclic compound of claim **1**, wherein R_8 is connected to * of Formula 2 and R_7 is connected to *' of Formula 2 so as to be represented by Formula 1a below:

Formula 1a



10. The condensed-cyclic compound of claim **9**, wherein R_1 R_2, R_3, R_4, R_5 and R_6 are hydrogen;

R_{11} R_{12}, R_{13}, R_{14} R_{21} R_{22}, R_{23} and R_{24} are each independently selected from the group consisting of hydrogen, a substituted or unsubstituted C_1-C_{10} alkyl group, a substituted or unsubstituted C_2-C_{10} alkenyl group, a substituted or unsubstituted C_2-C_{10} alkynyl group, a substituted or unsubstituted C_1-C_{10} alkoxy group, a group represented by $—(Ar_4)_d—Ar_{14}$, and a group represented by $—N[—(Ar_5)_e—Ar_{15}][—(Ar_6)_f—Ar_{16}]$;

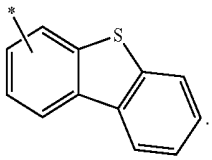
Ar_4, Ar_5 and Ar_6 are each independently selected from the group consisting of a substituted or unsubstituted C_1-C_{30} alkylene group, a substituted or unsubstituted C_2-C_{30} alkenylene group, a substituted or unsubstituted C_5-C_{30} arylene group, and a substituted or unsubstituted C_4-C_{30} heteroarylene group; and

Ar_{14} and Ar_{16} are each independently selected from the group consisting of a hydrogen atom, a halogen atom, a hydroxyl group, a cyano group, a substituted or unsubstituted C_1-C_{30} alkyl group, a substituted or unsubstituted C_2-C_{30} alkenyl group, a substituted or unsubstituted C_2-C_{30} alkynyl group, a substituted or unsubstituted C_1-C_{30} alkoxy group, a substituted or unsubstituted C_5-C_{30} aryl group, and a substituted or unsubstituted C_4-C_{30} heteroaryl group.

11. The condensed-cyclic compound of claim **9**, wherein d, e and f are each independently 0, 1, or 2.

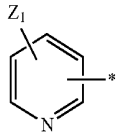
12. The condensed-cyclic compound of claim **9**, Ar_4, Ar_5 and Ar_6 are each independently selected from the group consisting of a pyridinylene group, a quinolinylene group, a benzimidazolylene group, an imidazopyridinylene group, an imidazopyrimidinylene group, a phenylene group, a C_1-C_{10} alkyl phenylene group, a carbazolylene group, a phenylcarbazolylene group, a fluorenylene group, a C_1-C_{10} alkyl fluorenylene group, a di(C_1-C_{10} alkyl)fluorenylene group, an ethylene group, and a naphthylene group.

13. The condensed-cyclic compound of claim **9**, wherein Ar_{14}, Ar_{15} and Ar_{16} are each independently selected from the group consisting of a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pyridinyl group, a quinolinyl group, a benzimidazolyl group, an imidazopyridinyl group, an imidazopyrimidinyl group, a phenyl group, a carbazolyl group, a fluorenyl group, di(C_1-C_{10} alkyl)fluorenyl group, a naphthyl group, and a functional group represented by the formula

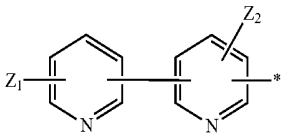


14. The condensed-cyclic compound of claim **9**, wherein R_{11} R_{12}, R_{13}, R_{14} R_{21} R_{22}, R_{23} and R_{24} are each independently selected from the group consisting of hydrogen and functional groups represented by Formulae 3A through 3O below:

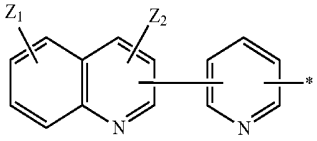
Formula 3A



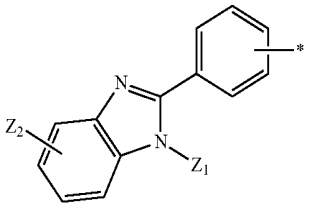
Formula 3B



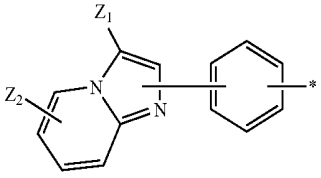
Formula 3C



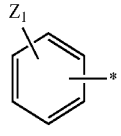
Formula 3D



Formula 3E

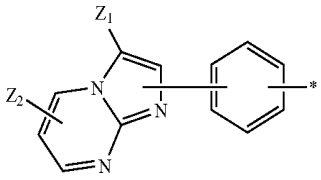


Formula 3F

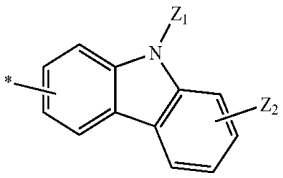


-continued

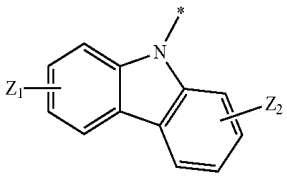
Formula 3G



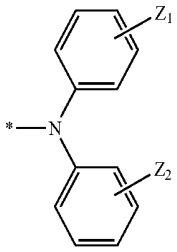
Formula 3H



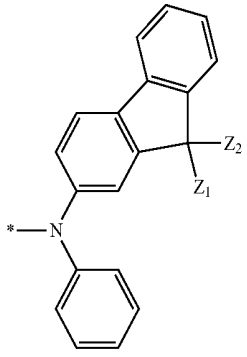
Formula 3I



Formula 3J

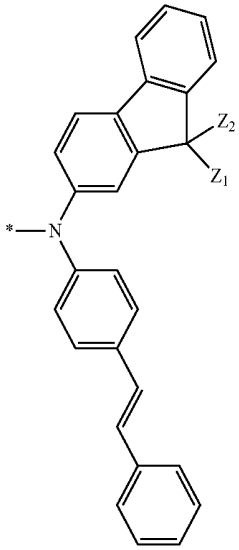


Formula 3K

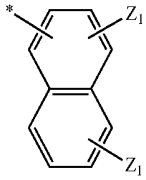


-continued

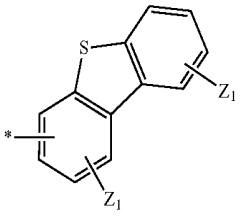
Formula 3L



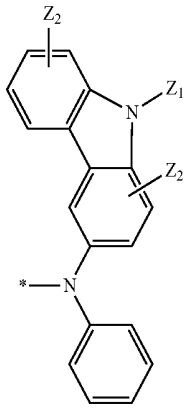
Formula 3M



Formula 3N



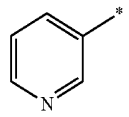
Formula 3O



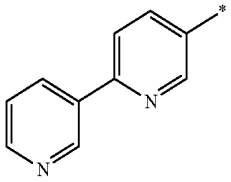
wherein, in Formulae 3A through 3O, Z_1 and Z_2 are each independently selected from the group consisting of hydrogen, a methyl group, an ethyl group, a propyl group, a butyl group, a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a phenyl group, and a naphthyl group.

15. The condensed-cyclic compound of claim **9**, wherein R_{11} R_{12}, R_{13} R_{14} R_{21} R_{22}, R_{23} and R_{24} are each independently selected from the group consisting of hydrogen and functional groups represented by Formulae 4A through 4R below:

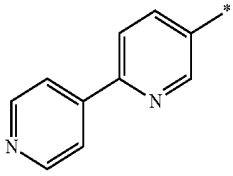
Formula 4A



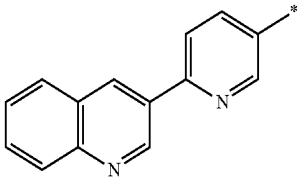
Formula 4B



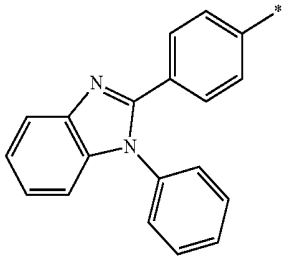
Formula 4C



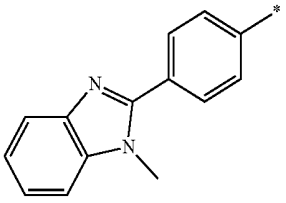
Formula 4D



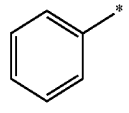
Formula 4E



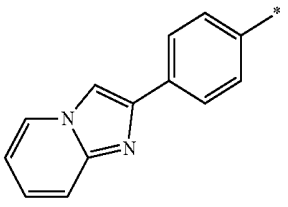
Formula 4F



Formula 4G

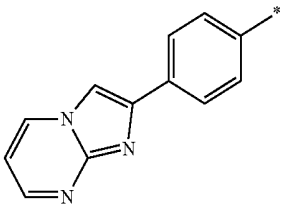


Formula 4H

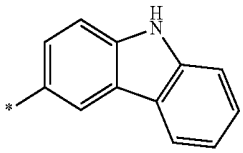


-continued

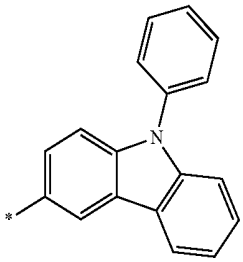
Formula 4I



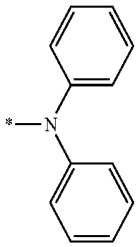
Formula 4J



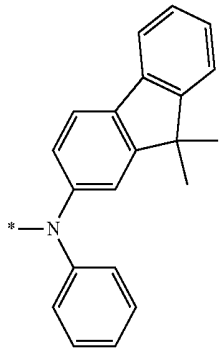
Formula 4K



Formula 4L

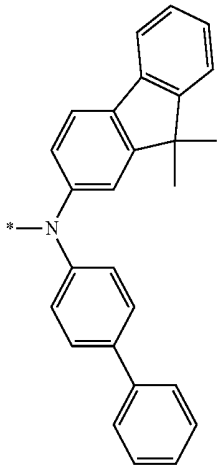


Formula 4M

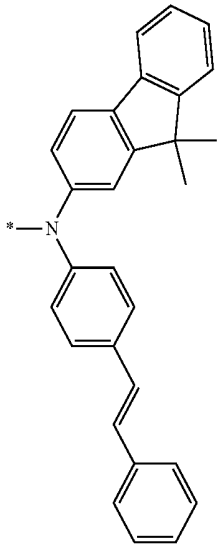


-continued

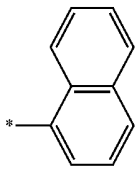
Formula 4N



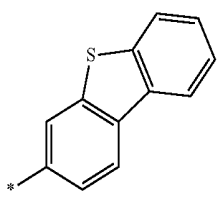
Formula 4O



Formula 4P

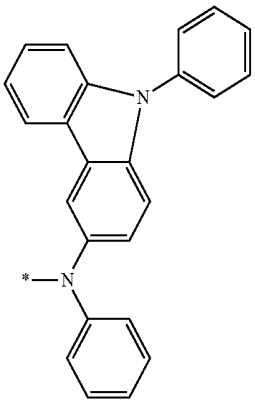


Formula 4Q



-continued

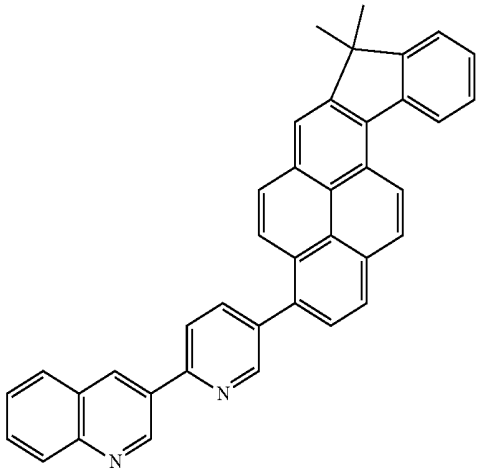
Formula 4R



16. The condensed-cyclic compound of claim **9**, wherein Q_1, Q_2 and Q_3 are each independently selected from the group consisting of hydrogen, a C_1-C_{30} alkyl group, a C_1-C_{30} alkoxy group, a C_5-C_{14} aryl group, and a C_4-C_{14} heteroaryl group.

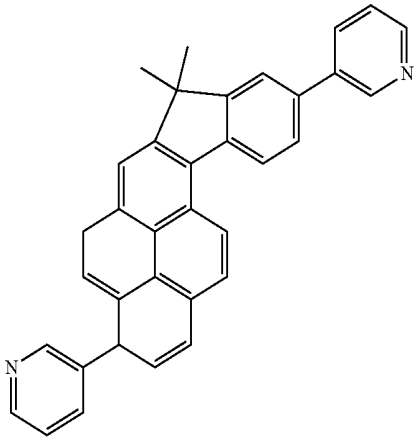
17. The condensed-cyclic compound of claim **1**, wherein the condensed-cyclic compound is compound 3, 19, 34, 35, 40, or 43 below:

Compound 3

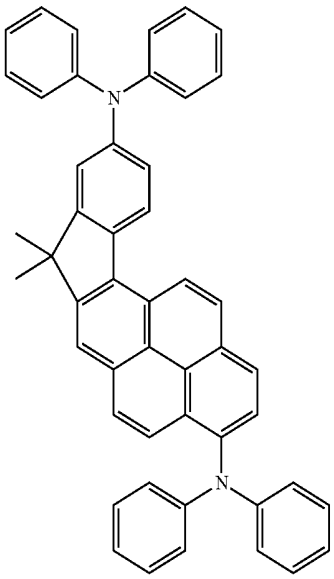


-continued

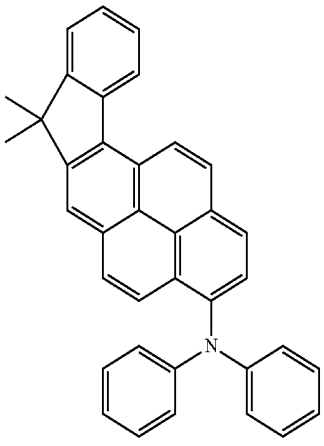
Compound 19



Compound 34

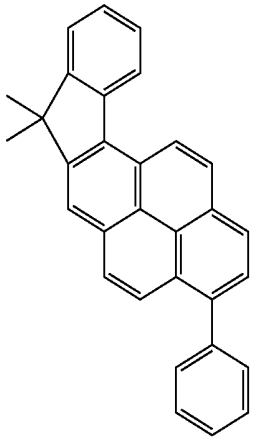


Compound 35

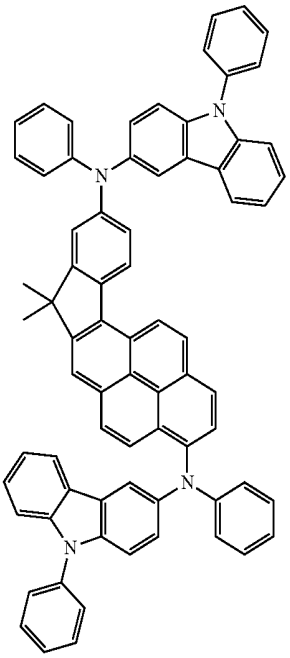


-continued

Compound 40



Compound 43



18. An organic light emitting diode comprising:

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 comprises the condensed-cyclic compound of claim **1**.

19. The organic light emitting diode of claim **18**, wherein the organic layer is a hole transport layer, an emissive layer, or an electron transport layer.

20. The organic light emitting diode of claim **18**, further comprising, between the first electrode and the second electrode, at least one layer selected from the group consisting of a hole injection layer, a hole transport layer, an emissive layer, a hole blocking layer, an electron transport layer, and an electron injection layer.

* * * * *

专利名称(译)	缩合环状化合物和有机发光二极管，包括含有稠环化合物的有机层		
公开(公告)号	US20110084256A1	公开(公告)日	2011-04-14
申请号	US12/895732	申请日	2010-09-30
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星移动显示器有限公司.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	KIM HEE YEON YANG SEUNG GAK LEE KWAN HEE		
发明人	KIM, HEE-YEON YANG, SEUNG-GAK LEE, KWAN-HEE		
IPC分类号	H01L51/50 C07C25/22 C07D401/04 C07D401/10 C07C211/61 C07D403/12 C07C13/615		
CPC分类号	C07C13/62 C07C211/61 C07C2103/18 C07C2103/54 C07D213/06 H01L51/5052 C07D235/08 C07D401/04 C07D487/04 H01L51/0056 H01L51/5048 C07D213/22 C07C2603/18 C07C2603/54		
优先权	1020090096393 2009-10-09 KR		
其他公开文献	US9000420		
外部链接	Espacenet USPTO		

摘要(译)

由下式1表示的稠环化合物和包含该稠环化合物的有机发光二极管：