US 20200052224A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2020/0052224 A1**

UNO (43) **Pub. Date: Feb. 13, 2020**

(54) **ORGANIC ELECTROLUMINESCENCE DEVICE AND CONDENSED CYCLIC COMPOUND FOR ORGANIC ELECTROLUMINESCENCE DEVICE**

(71) Applicant: **Samsung Display Co., Ltd.**, Yongin-Si (KR)

(72) Inventor: **Takuya UNO**, Yokohama (JP)

(21) Appl. No.: **16/443,807**

(22) Filed: **Jun. 17, 2019**

(30) **Foreign Application Priority Data**

Aug. 10, 2018 (KR) 10-2018-0093700

Publication Classification

(51) **Int. Cl.**

H01L 51/00	(2006.01)
C07D 487/04	(2006.01)
C07D 498/04	(2006.01)
C07D 513/04	(2006.01)

(52) **U.S. Cl.**

CPC ***H01L 51/0072*** (2013.01); ***H01L 51/0073*** (2013.01); ***H01L 51/0074*** (2013.01); ***H01L 51/0054*** (2013.01); ***H01L 51/006*** (2013.01); *H01L 51/5056* (2013.01); ***H01L 51/0067*** (2013.01); ***C07D 487/04*** (2013.01); ***C07D 498/04*** (2013.01); ***C07D 513/04*** (2013.01); ***H01L 51/0061*** (2013.01)

(57) **ABSTRACT**

Provided is an organic electroluminescence device including a first electrode, a hole transport region disposed on the first electrode, an emission layer disposed on the hole transport region, an electron transport region disposed on the emission layer, and a second electrode disposed on the electron transport region, in which the hole transport region includes a condensed cyclic compound, thereby securing high emission efficiency.

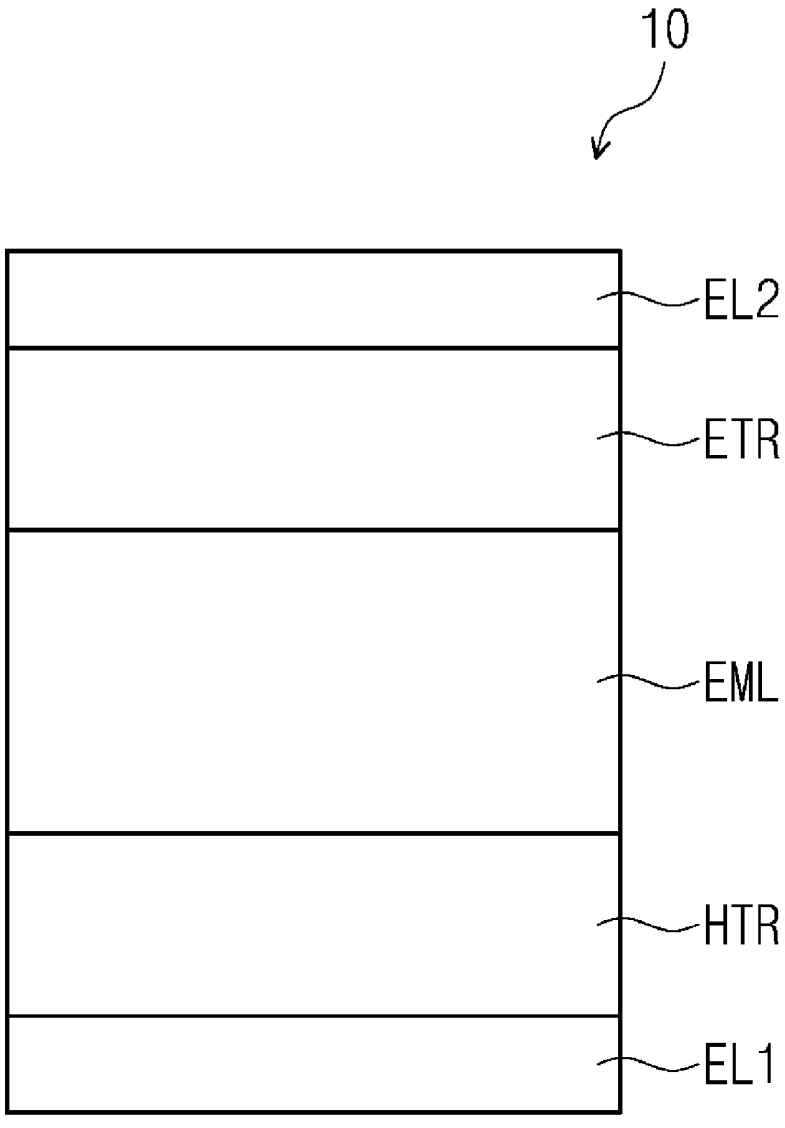


FIG. 1

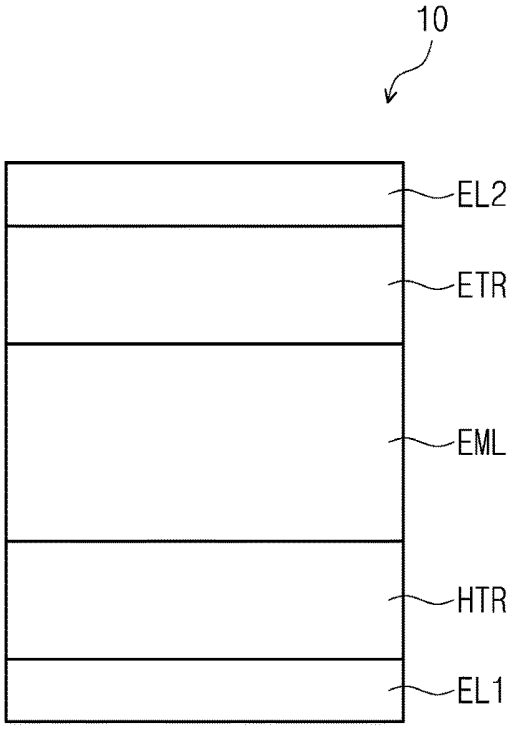


FIG. 2

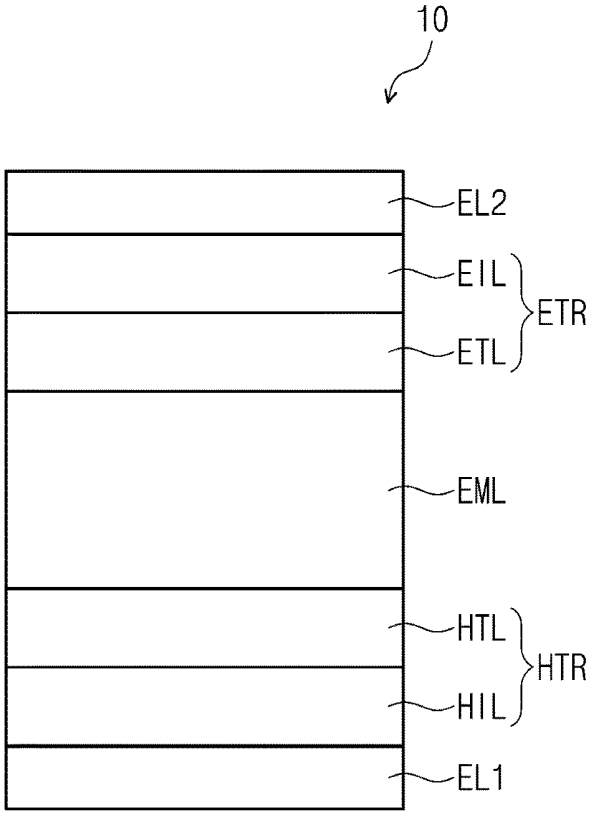
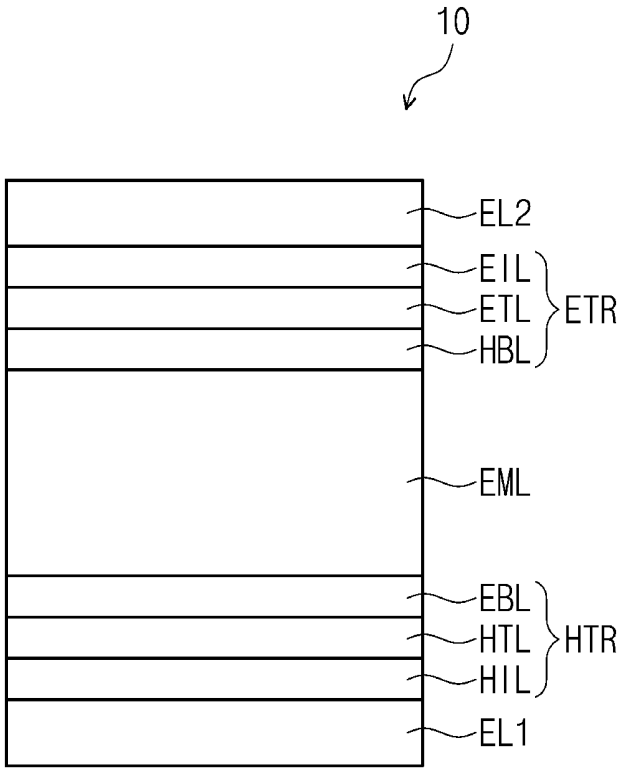


FIG. 3



ORGANIC ELECTROLUMINESCENCE DEVICE AND CONDENSED CYCLIC COMPOUND FOR ORGANIC ELECTROLUMINESCENCE DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This U.S. non-provisional patent application claims priority under 35 U.S.C. § 119 of Korean Patent Application No. 10-2018-0093700 filed on Aug. 10, 2018, the entire content of which is hereby incorporated by reference.

BACKGROUND

[0002] The present disclosure herein relates to an organic electroluminescence device and a condensed cyclic compound used for the same.

[0003] Development of organic electroluminescence display as an image display is being actively conducted. An organic electroluminescence display is different from a liquid crystal display in that it is a self-luminescent display. An organic electroluminescence display achieves a display by recombining holes and electrons injected from a first electrode and a second electrode, respectively, in an emission layer. The combination of holes and electrons emits light from a luminescent material, which is an organic compound included in the emission layer.

[0004] In applying an organic electroluminescence device to a display, decrease of a driving voltage, increase of emission efficiency and extension of life for the organic electroluminescence device are desired. Hence, development of material that may allow stable implementation of these desired characteristics in the organic electroluminescence device is ongoing.

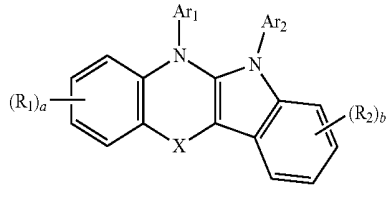
[0005] Furthermore, much effort has been directed to developing materials for a hole transport layer that implement an organic electroluminescence device with high efficiency.

SUMMARY

[0006] The present disclosure provides an organic electroluminescence device and a condensed cyclic compound used for the same.

[0007] An embodiment of the inventive concept provides an organic electroluminescence device including a first electrode, a hole transport region disposed on the first electrode, an emission layer disposed on the hole transport region, an electron transport region disposed on the emission layer, and a second electrode disposed on the electron transport region, wherein the hole transport region includes a condensed cyclic compound represented by the following Formula 1.

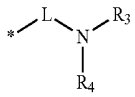
[Formula 1]



[0008] In Formula 1, X is a direct linkage, O, S, NR_5, or SiR_6R_7, Ar_1 and Ar_2 are each independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, R_1 and R_2 are each independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, and a and b are each independently an integer of 0 to 4.

[0009] In Formula 1, R_5 to R_7 are each independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and the substituted ones are substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and any one of Ar_1, R_1 or R_2 is represented by the following Formula 2.

[Formula 2]

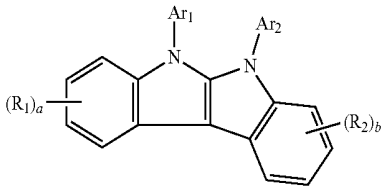


[0010] In Formula 2, L is a substituted or unsubstituted arylene group having 6 to 40 carbon atoms for forming a ring, and R_3 and R_4 are each independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and the substituted ones are substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted cycloalkyl group having 3 to 40 carbon atoms for forming a ring, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

[0011] In an embodiment, the hole transport region may include a hole injection layer and a hole transport layer disposed between the hole injection layer and the emission layer, and the hole transport layer may include the condensed cyclic compound. In an embodiment, the hole transport layer may include a plurality of organic layers, and an organic layer adjacent to the emission layer among the plurality of organic layers may include the condensed cyclic compound.

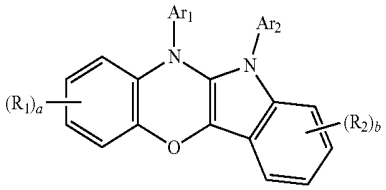
[0012] In an embodiment, Formula 1 may be represented by any one of the following Formulae 1-1 to 1-5.

[Formula 1-1]

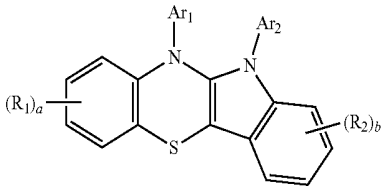


-continued

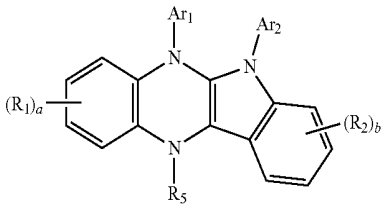
[Formula 1-2]



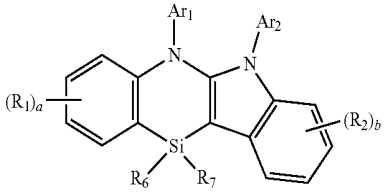
[Formula 1-3]



[Formula 1-4]



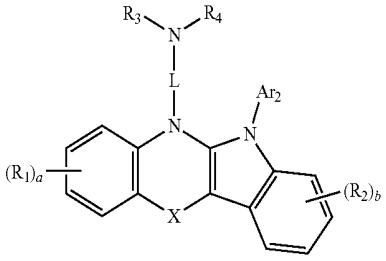
[Formula 1-5]



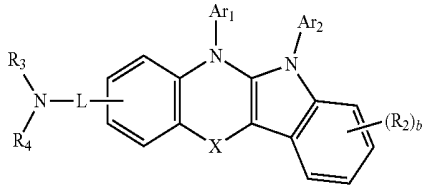
[0013] In Formulae 1-1 to 1-5, Ar_1, Ar_2, R_1, R_2, R_5 to R_7, a, and b are the same as defined in Formula 1.

[0014] In an embodiment, Formula 1 may be represented by any one of the following Formulae 3-1 to 3-3.

[Formula 3-1]

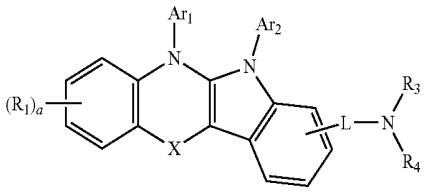


[Formula 3-2]



-continued

[Formula 3-3]



[0015] In Formulae 3-1 to 3-3, X, Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formulae 1 and 2.

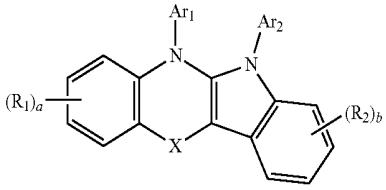
[0016] In an embodiment, R_1 and R_2 in Formula 1 may be each independently a substituted or unsubstituted phenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted phenanthryl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted terphenyl group, a substituted or unsubstituted quaterphenyl group, a substituted or unsubstituted quinqphenyl group, a substituted or unsubstituted sexiphenyl group, a substituted or unsubstituted triphenylenyl group, a substituted or unsubstituted pyrenyl group, a substituted or unsubstituted benzofluoranthenyl group, or a substituted or unsubstituted chrysenyl group.

[0017] In an embodiment, L in Formula 2 may be a substituted or unsubstituted phenylene group, a substituted or unsubstituted biphenylene group, a substituted or unsubstituted naphthylene group, a substituted or unsubstituted anthracenylene group, a substituted or unsubstituted phenanthrene group, or a substituted or unsubstituted fluorenylene group.

[0018] In an embodiment, R_3 and R_4 in Formula 2 may be each independently a substituted or unsubstituted phenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted phenanthryl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted terphenyl group, a substituted or unsubstituted quaterphenyl group, a substituted or unsubstituted thiophene group, a substituted or unsubstituted benzothiophene group, a substituted or unsubstituted dibenzothiophene group, a substituted or unsubstituted furan group, a substituted or unsubstituted benzofuranyl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted naphthobenzofuranyl group.

[0019] An embodiment of the inventive concept provides a condensed cyclic compound represented by the following Formula 1.

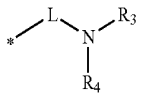
[Formula 1]



[0020] In Formula 1, X is a direct linkage, O, S, NR_5, or SiR_6R_7, Ar_1 and Ar_2 are each independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, R_1 and R_2 are each independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, and a and b are each independently an integer of 0 to 4.

[0021] In Formula 1, each of R_5, R_6, and R_7 is independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and the substituted ones are substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and any one of Ar_1, R_1 or R_2 is represented by the following Formula 2.

[Formula 2]



[0022] In Formula 2, L is a substituted or unsubstituted arylene group having 6 to 40 carbon atoms for forming a ring, and each of R_3 and R_4 is independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and the substituted ones are substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted cycloalkyl group having 3 to 40 carbon atoms for forming a ring, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

BRIEF DESCRIPTION OF THE FIGURES

[0023] The accompanying drawings are included to provide a further understanding of the inventive concept, and are incorporated in and constitute a part of this specification. The drawings illustrate exemplary embodiments of the inventive concept and, together with the description, serve to explain principles of the inventive concept. In the drawings:

[0024] FIG. **1** is a schematic cross-sectional view of an organic electroluminescence device according to an embodiment of the inventive concept;

[0025] FIG. **2** is a schematic cross-sectional view of an organic electroluminescence device according to an embodiment of the inventive concept; and

[0026] FIG. **3** is a schematic cross-sectional view of an organic electroluminescence device according to an embodiment of the inventive concept.

DETAILED DESCRIPTION

[0027] The above objects, other objects, features and advantages of the inventive concept will be easily understood from preferred exemplary embodiments with reference to the accompanying drawings. The inventive concept may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the inventive concept to those skilled in the art.

[0028] Like reference numerals refer to like elements for explaining each drawing. In the accompanying drawings, the sizes of elements may be enlarged for clarity of the inventive concept. It will be understood that, although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element discussed below could be termed a second element, and similarly, a second element could be termed a first element. As used herein, the singular forms are intended to include the plural forms as well, unless the context clearly indicates otherwise.

[0029] It will be understood that the terms "comprise" or "have," when used in this specification, specify the presence of stated features, numerals, steps, operations, elements, parts, or a combination thereof, but do not preclude the presence or addition of one or more other features, numerals, steps, operations, elements, parts, or a combination thereof. It will also be understood that when a layer, a film, a region, a plate, etc. is referred to as being "on" another part, it can be "directly on" the other part, or intervening layers may also be present. On the contrary, when a layer, a film, a region, a plate, etc. is referred to as being "under" another part, it can be "directly under" the other part, or intervening layers may also be present.

[0030] In the present disclosure, * means a part to be connected.

[0031] First of all, an organic electroluminescence device according to an embodiment of the inventive step will be explained referring to FIGS. **1** to **3**.

[0032] Referring to FIGS. **1** to **3**, an organic electroluminescence device **10** according to an embodiment of the inventive concept may include a first electrode EL**1**, a hole transport region HTR, an emission layer EML, an electron transport region ETR, and a second electrode EL**2**, laminated in order.

[0033] The first electrode EL**1** and the second electrode EL**2** are disposed oppositely, and a plurality of organic layers may be disposed between the first electrode EL**1** and the second electrode EL**2**. The plurality of organic layers may include a hole transport region HTR, an emission layer EML and an electron transport region ETR. An organic electroluminescence device **10** according to an embodiment of the inventive concept may include the condensed cyclic compound according to an embodiment of the inventive concept in the hole transport region HTR.

[0034] FIG. **2** shows a schematic cross-sectional view illustrating an organic electroluminescence device **10** according to an embodiment of the inventive concept, in which a hole transport region HTR includes a hole injection layer HIL and a hole transport layer HTL, and an electron transport region ETR includes an electron injection layer EIL and an electron transport layer ETL. Furthermore, FIG. **3** shows a schematic cross-sectional view illustrating an organic electroluminescence device **10** according to an embodiment of the inventive concept, in which a hole

transport region HTR includes a hole injection layer HIL, a hole transport layer HTL and an electron blocking layer EBL, and an electron transport region ETR includes an electron injection layer EIL, an electron transport layer ETL and a hole blocking layer HBL.

[0035] The first electrode EL**1** has conductivity. The first electrode EL**1** may be a pixel electrode or an anode. The first electrode EL**1** may be a transmissive electrode, a transflective electrode, or a reflective electrode. In case the first electrode EL**1** is a transmissive electrode, the first electrode EL**1** may include a transparent metal oxide such as indium tin oxide (ITO), indium zinc oxide (IZO), zinc oxide (ZnO), or indium tin zinc oxide (ITZO). In case the first electrode EL**1** is a transflective electrode or reflective electrode, the first electrode EL**1** may include Ag, Mg, Cu, Al, Pt, Pd, Au, Ni, Nd, Ir, Cr, Li, Ca, LiF/Ca, LiF/Al, Mo, Ti, a compound thereof, or a mixture thereof (for example, a mixture of Ag and Mg). Also, the first electrode EL**1** may have a structure including a plurality of layers including a reflective layer or transflective layer formed using the above materials, and a transparent conductive layer formed using ITO, IZO, ZnO, or ITZO. For example, the first electrode EL**1** may have a triple-layer structure of ITO/Ag/ITO. However, an embodiment of the inventive concept is not limited thereto.

[0036] The thickness of the first electrode EL**1** may be from about 1,000 Å to about 10,000 Å, for example, from about 1,000 Å to about 3,000 Å.

[0037] A plurality of organic layers is disposed on the first electrode EL**1**. The organic layers may include a hole transport region HTR, an emission layer EML and an electron transport region ETR.

[0038] The hole transport region HTR is disposed on the first electrode EL**1**. The hole transport region HTR may include at least one of a hole injection layer HIL, a hole transport layer HTL, a hole buffer layer or an electron blocking layer. The thickness of the hole transport region HTR may be from about 1,000 Å to about 1,500 Å, for example.

[0039] In an embodiment of the inventive concept, the hole transport region HTR may include a condensed cyclic compound, which includes a core structure of indoloindole and a noncyclic tertiary amine group.

[0040] In the present disclosure, "substituted or unsubstituted" may mean unsubstituted or substituted with at least one substituent selected from the group consisting of deuterium, halogen, cyano, nitro, amino, silyl, boron, phosphine oxide, phosphine sulfide, alkyl, alkenyl, aryl and heterocyclic group. In addition, each of the substituent illustrated above may be substituted or unsubstituted. For example, biphenyl may be interpreted as aryl, or phenyl substituted with phenyl.

[0041] In the present disclosure, the terms "forming a ring by combining adjacent groups with each other" may mean forming a substituted or unsubstituted hydrocarbon ring, or a substituted or unsubstituted heterocycle by combining adjacent groups with each other. The hydrocarbon ring includes an aliphatic hydrocarbon ring and an aromatic hydrocarbon ring. The heterocycle includes an aliphatic heterocycle and an aromatic heterocycle. The hydrocarbon ring and heterocycle may be a monocycle or a polycycle. In addition, the ring formed by combining adjacent groups may be connected with another ring to form a spiro structure.

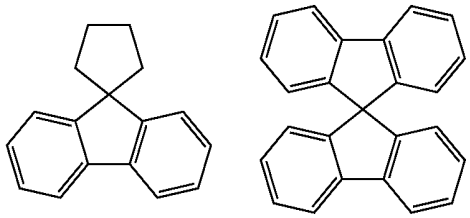
[0042] In the description, the term "an adjacent group" may mean a substituent substituted for an atom which is directly combined with an atom substituted with a corresponding substituent, another substituent substituted for an atom which is substituted with a corresponding substituent, or a substituent sterically positioned at the nearest position to a corresponding substituent. For example, in 1,2-dimethylbenzene, two methyl groups may be interpreted as "adjacent groups" to each other, and in 1,1-diethylcyclopentane, two ethyl groups may be interpreted as "adjacent groups" to each other.

[0043] In the present disclosure, examples of a halogen atom are a fluorine atom, a chlorine atom, a bromine atom, or an iodine atom.

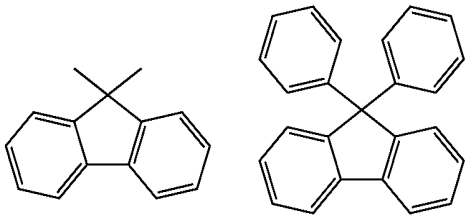
[0044] In the present disclosure, the alkyl group may have a linear, branched or cyclic form. The carbon number of the alkyl group may be 1 to 40, 1 to 30, 1 to 20, 1 to 10, or 1 to 6. Examples of the alkyl group may include methyl, ethyl, n-propyl, isopropyl, n-butyl, s-butyl, t-butyl, i-butyl, 2-ethylbutyl, 3,3-dimethylbutyl, n-pentyl, i-pentyl, neopentyl, t-pentyl, cyclopentyl, 1-methylpentyl, 3-methylpentyl, 2-ethylpentyl, 4-methyl-2-pentyl, n-hexyl, 1-methylhexyl, 2-ethylhexyl, 2-butylhexyl, cyclohexyl, 4-methylcyclohexyl, 4-t-butylcyclohexyl, n-heptyl, 1-methylheptyl, 2,2-dimethylheptyl, 2-ethylheptyl, 2-butylheptyl, n-octyl, t-octyl, 2-ethyloctyl, 2-butyloctyl, 2-hexyloctyl, 3,7-dimethyloctyl, cyclooctyl, n-nonyl, n-decyl, adamantyl, 2-ethyldecyl, 2-butyldecyl, 2-hexyldecyl, 2-octyldecyl, n-undecyl, n-dodecyl, 2-ethyldodecyl, 2-butyldodecyl, 2-hexyldodecyl, 2-octyldodecyl, n-tridecyl, n-tetradecyl, n-pentadecyl, n-hexadecyl, 2-ethylhexadecyl, 2-butylhexadecyl, 2-hexylhexadecyl, 2-octylhexadecyl, n-heptadecyl, n-octadecyl, n-nonadecyl, n-eicosyl, 2-ethyl eicosyl, 2-butyl eicosyl, 2-hexyl eicosyl, 2-octyl eicosyl, n-heneicosyl, n-docosyl, n-tricosyl, n-tetracosyl, n-pentacosyl, n-hexacosyl, n-heptacosyl, n-octacosyl, n-nonacosyl, n-triacontyl, etc., without limitation.

[0045] In the present disclosure, the aryl group means any functional group or substituent derived from an aromatic hydrocarbon ring. The aryl group may be monocyclic aryl or polycyclic aryl. The carbon number of the aryl group for forming a ring may be 6 to 60, 6 to 40, 6 to 30, 6 to 20, or 6 to 15. Examples of the aryl group may include phenyl, naphthyl, fluorenyl, anthracenyl, phenanthryl, biphenyl, terphenyl, quaterphenyl, quinqphenyl, sexiphenyl, biphenylene, triphenylene, pyrenyl, benzofluoranthenyl, chrysenyl, etc., without limitation.

[0046] In the present disclosure, the fluorenyl group may be substituted, and two substituents may be combined with each other to form a spiro structure. Examples of the substituted fluorenyl group may include the following groups, without limitation.



-continued



[0047] In the present disclosure, the heterocyclic group may be heterocycle including at least one of B, O, N, P, Si, or S as a heteroatom. When the heterocyclic group includes two or more heteroatoms, these heteroatoms may be the same or different from each other. The heterocyclic group may be monocyclic heterocycle or polycyclic heterocycle, and includes heteroaryl. The carbon number of the heterocyclic group for forming a ring may be 2 to 40, 2 to 30, 2 to 20, or 2 to 10. Examples of the heterocyclic group are thiophene, furan, pyrrole, imidazole, thiazole, oxazole, oxadiazole, triazole, pyridine, bipyridine, pyrimidine, triazine, triazole, acridyl, pyridazine, pyrazinyl, quinoline, quinazoline, quinoxaline, phenoxazine, phthalazine, pyrido pyrimidine, pyrido pyrazine, pyrazino pyrazine, isoquinoline, indole, carbazole, N-aryl carbazole, N-heteroaryl carbazole, N-alkyl carbazole, benzoxazole, benzoimidazole, benzothiazole, benzocarbazole, benzothiophene, dibenzothiophene, thienothiophene, benzofuran, phenanthroline, thiazole, isoxazole, oxadiazole, thiadiazole, phenothiazine, dibenzosilole, dibenzofuran, etc., without limitation.

[0048] In the present disclosure, the silyl group includes alkyl silyl and aryl silyl. Examples of the silyl group are trimethylsilyl, triethylsilyl, t-butyl dimethylsilyl, vinyl dimethylsilyl, propyl dimethylsilyl, triphenylsilyl, diphenylsilyl, phenylsilyl, etc., without limitation.

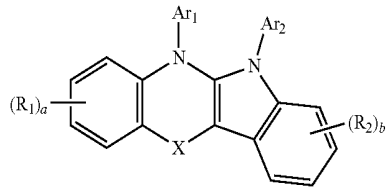
[0049] In the present disclosure, the carbon number of the amine group is not specifically limited, and may be 1 to 30. The amine group may include alkyl amine and aryl amine. Examples of the amine group are methylamine, dimethylamine, phenylamine, naphthylamine, 9-methyl-anthracenylamine, triphenylamine, etc., without limitation.

[0050] The above explanation on the aryl group may be applied to the arylene group, except that the arylene group is divalent.

[0051] The above explanation on the heteroaryl group may be applied to the heteroarylene group, except that the heteroarylene group is divalent.

[0052] In an embodiment of the inventive concept, the hole transport region HTR includes a condensed cyclic compound represented by the following Formula 1.

[Formula 1]



[0053] In Formula 1, X may be a direct linkage, O, S, NR_5, or SiR_6R_7.

[0054] In Formula 1, each of Ar_1 and Ar_2 may independently be a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring.

[0055] In an embodiment, R_1 and R_2 may be each independently a substituted or unsubstituted phenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted phenanthryl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted terphenyl group, a substituted or unsubstituted quaterphenyl group, a substituted or unsubstituted quinqphenyl group, a substituted or unsubstituted sexiphenyl group, a substituted or unsubstituted triphenylenyl group, a substituted or unsubstituted pyrenyl group, a substituted or unsubstituted benzofluoranthenyl group, or a substituted or unsubstituted chrysenyl group.

[0056] In Formula 1, each of R_1 and R_2 may independently be a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms.

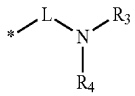
[0057] In Formula 1, each of a and b may independently be an integer of 0 to 4. In case a is an integer of 2 or more, a plurality of R_1 may be the same or different from each other. In case b is an integer of 2 or more, a plurality of R_2 may be the same or different from each other.

[0058] In Formula 1, R_5 to R_7 may be each independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

[0059] In Formula 1, the substituted ones may be substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

[0060] In Formula 1, any one of Ar_1, R_1 or R_2 is represented by the following Formula 2.

[Formula 2]



[0061] In Formula 2, L may be a substituted or unsubstituted arylene group having 6 to 40 carbon atoms for forming a ring.

[0062] In an embodiment, L may be a substituted or unsubstituted phenylene group, a substituted or unsubstituted biphenylene group, a substituted or unsubstituted naphthylene group, a substituted or unsubstituted anthracenylene group, a substituted or unsubstituted phenanthrene group, or a substituted or unsubstituted fluorenylene group.

[0063] In Formula 2, each of R_3 and R_4 may independently be a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

[0064] In R_3 and R_4, the substituted ones may be substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted

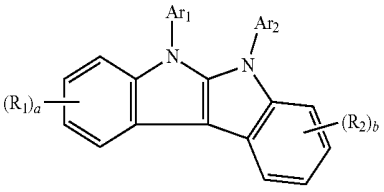
cycloalkyl group having 3 to 40 carbon atoms for forming a ring, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

[0065] In an embodiment, R_3 and R_4 may be each independently a substituted or unsubstituted phenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted phenanthryl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted terphenyl group, a substituted or unsubstituted quaterphenyl group, a substituted or unsubstituted thiophene group, a substituted or unsubstituted benzothiophene group, a substituted or unsubstituted dibenzothiophene group, a substituted or unsubstituted furan group, a substituted or unsubstituted benzofuranyl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted naphthobenzofuranyl group.

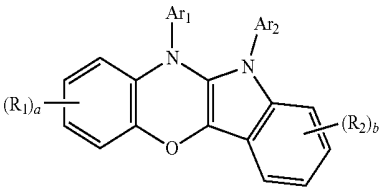
[0066] Meanwhile, Ar_2 in Formula 1 may not be represented by Formula 2. Especially in the case of the compound of Formula 1, in which X is O, S, NR_5 or SiR_6R_7, and Ar_2 is represented by Formula 2, degrades emission efficiency and life of the device employing the compound. That is, when X is O, S, NR_5 or SiR_6R_7 in Formula 1, the electron density of indoloindole ring is biased toward the state that the benzoxazine ring including X has relatively high electron density and the indole ring has relatively low electron density, and therefore, the indole ring with low electron density withdraws the electrons of the amine group with high electron density, and the strong electron resistance of the amine group may not be maintained.

[0067] For example, Formula 1 may be represented by any one of the following Formulae 1-1 to 1-5.

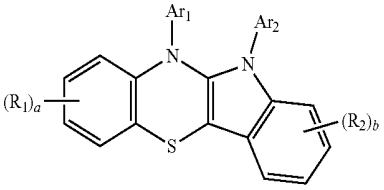
[Formula 1-1]



[Formula 1-2]

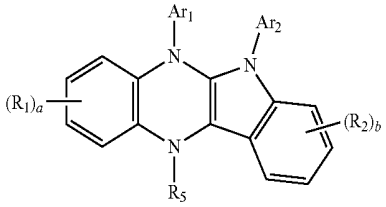


[Formula 1-3]

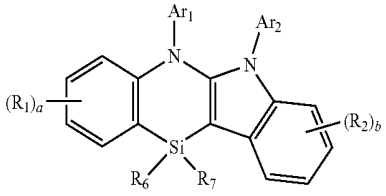


-continued

[Formula 1-4]



[Formula 1-5]

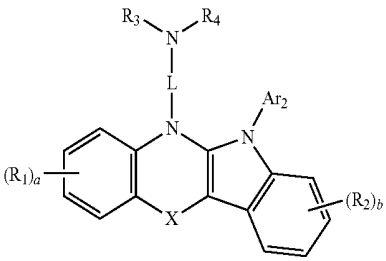


[0068] In Formulae 1-1 to 1-5, Ar_1, Ar_2, R_1, R_2, R_5 to R_7, a, and b are the same as defined in Formula 1.

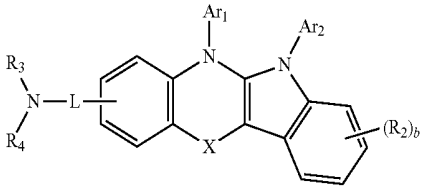
[0069] Formula 1-1 is an embodiment of Formula 1 in which X is a direct linkage, Formula 1-2 is an embodiment of Formula 1 in which X is O, Formula 1-3 is an embodiment of Formula 1 in which X is S, Formula 1-4 is an embodiment of Formula 1 in which X is NR_5, and Formula 1-5 is an embodiment of Formula 1 in which X is SiR_6R_7.

[0070] For example, Formula 1 may be represented by any one of the following Formulae 3-1 to 3-3.

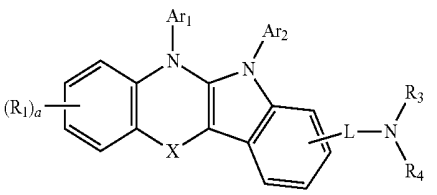
[Formula 3-1]



[Formula 3-2]



[Formula 3-3]



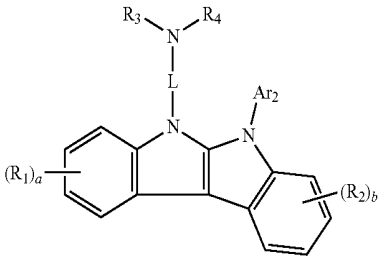
[0071] In Formulae 3-1 to 3-3, X, Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formulae 1 and 2.

[0072] Formula 3-1 is an embodiment of Formula 1 in which Ar_1 is represented by Formula 2, Formula 3-2 is an

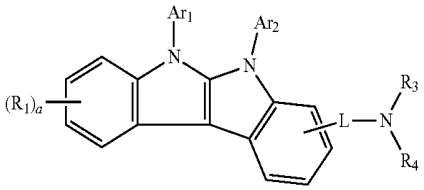
embodiment of Formula 1 in which R_1 is represented by Formula 2, and Formula 3-3 is an embodiment of Formula 1 in which R_2 is represented by Formula 2.

[0073] For example, Formula 1-1 may be represented by the following Formula 4-1 or 4-2.

[Formula 4-1]



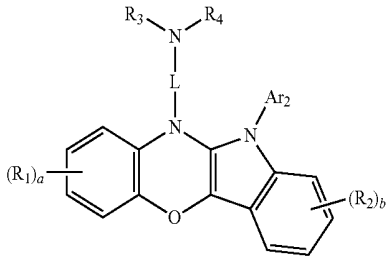
[Formula 4-2]



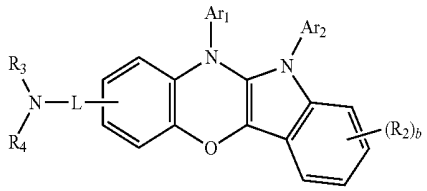
[0074] In Formulae 4-1 and 4-2, Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formulae 1 and 2.

[0075] For example, Formula 1-2 may be represented by any one of the following Formulae 5-1 to 5-3.

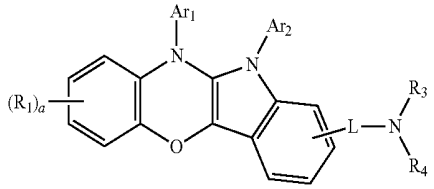
[Formula 5-1]



[Formula 5-2]



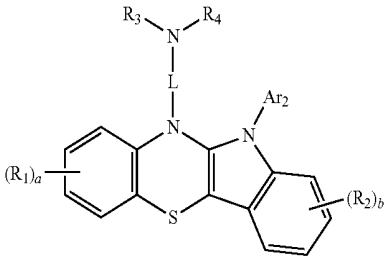
[Formula 5-3]



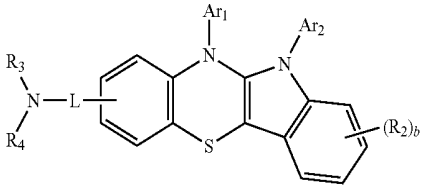
[0076] In Formulae 5-1 to 5-3, Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formulae 1 and 2.

[0077] For example, Formula 1-3 may be represented by any one of the following Formulae 6-1 to 6-3.

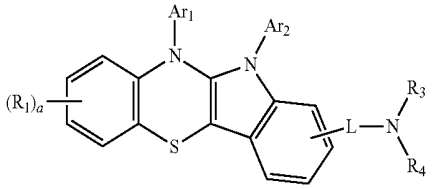
[Formula 6-1]



[Formula 6-2]



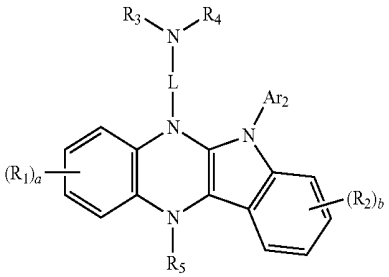
[Formula 6-3]



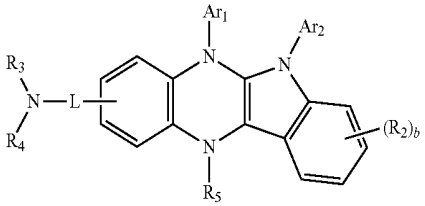
[0078] In Formulae 6-1 to 6-3, Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formulae 1 and 2.

[0079] For example, Formula 1-4 may be represented by any one of the following Formulae 7-1 to 7-3.

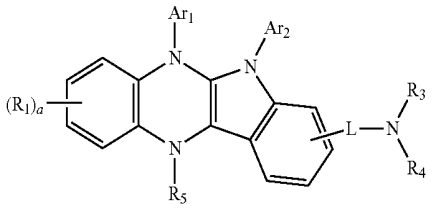
[Formula 7-1]



[Formula 7-2]



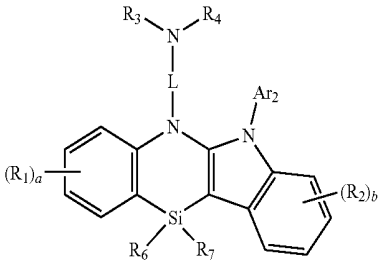
[Formula 7-3]



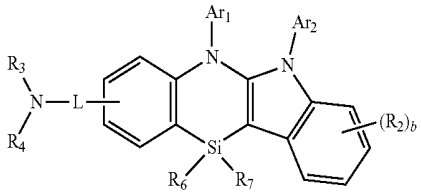
[0080] In Formulae 7-1 to 7-3, Ar_1, Ar_2, R_1 to R_5, L, a, and b are the same as defined in Formulae 1 and 2.

[0081] For example, Formula 1-5 may be represented by any one of the following Formulae 8-1 to 8-3.

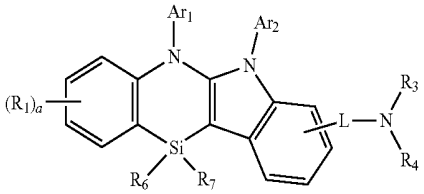
[Formula 8-1]



[Formula 8-2]



[Formula 8-3]

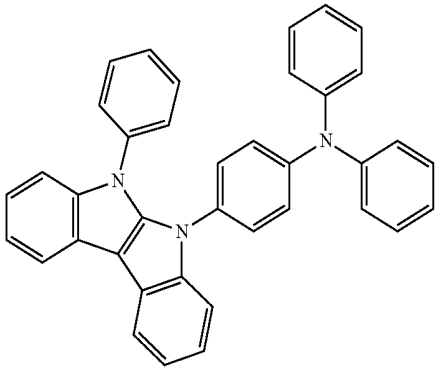


[0082] In Formulae 8-1 to 8-3, Ar_1, Ar_2, R_1 to R_4, R_6, R_7, L, a, and b are the same as defined in Formulae 1 and 2.

[0083] The condensed cyclic compound may be any one selected from the group consisting of compounds represented in the following Compound Groups 1 to 5. However, an embodiment of the inventive concept is not limited thereto.

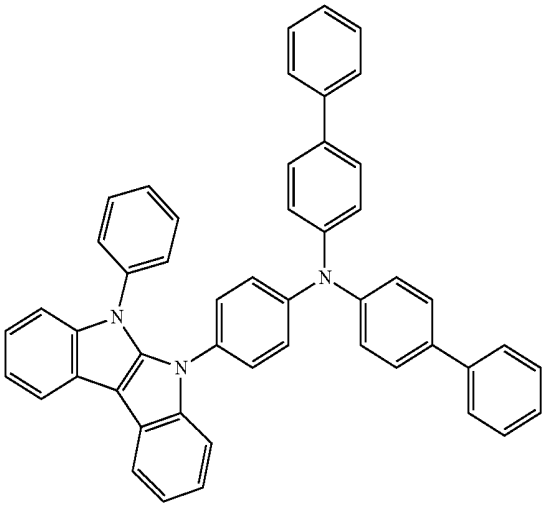
[0084] [Compound Group 1]

A1

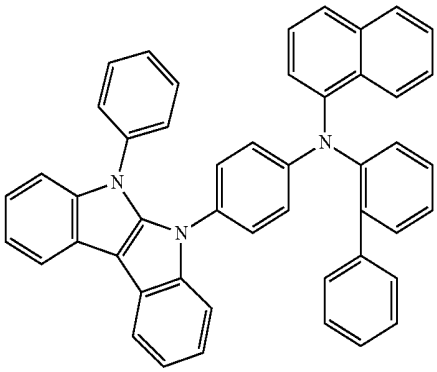


-continued

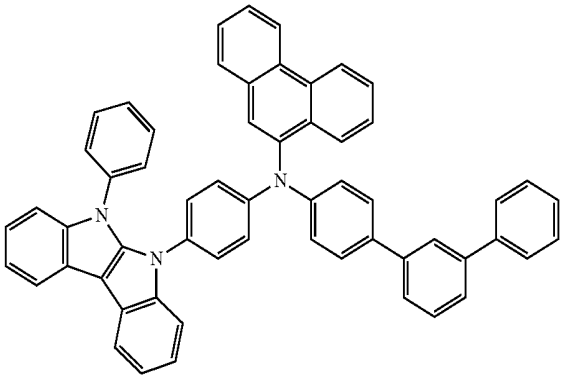
A2



A3

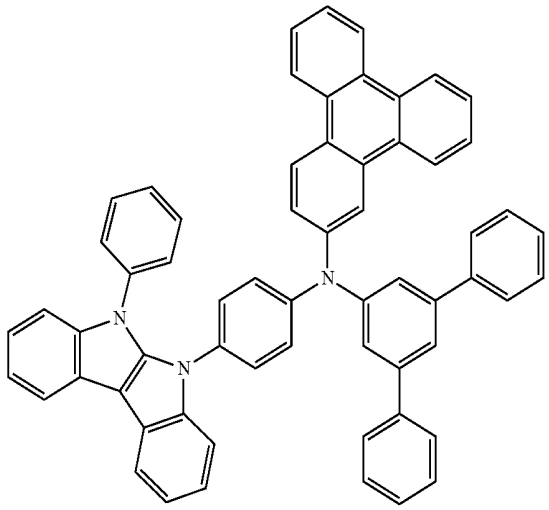


A4

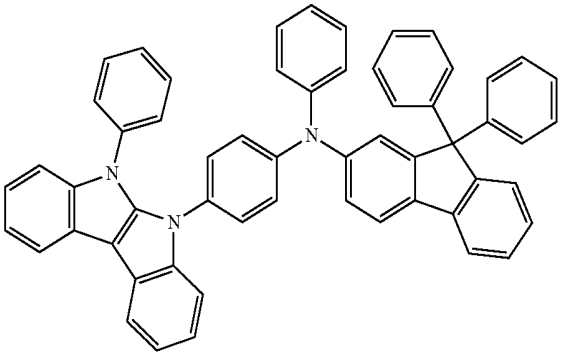


-continued

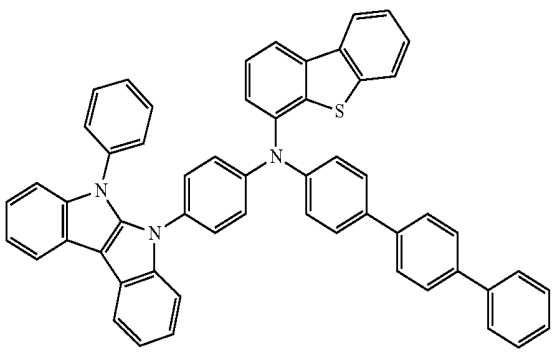
A5



A6

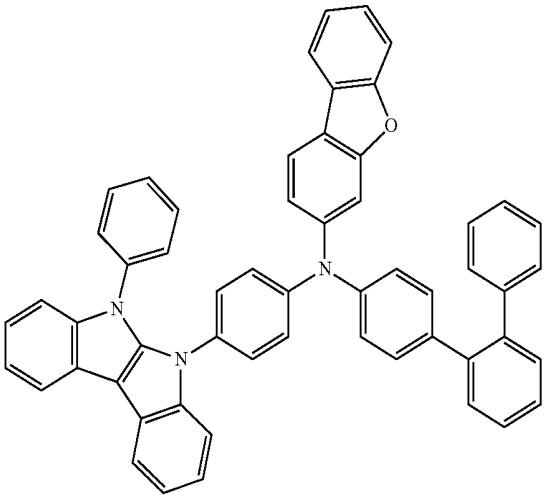


A7

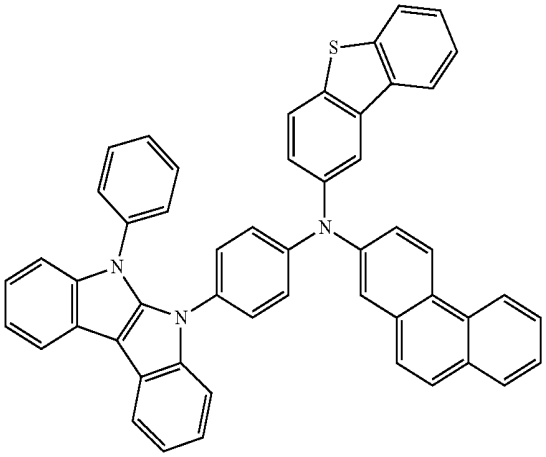


-continued

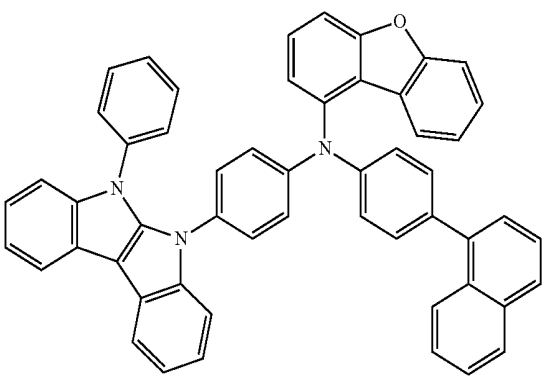
A8



A9

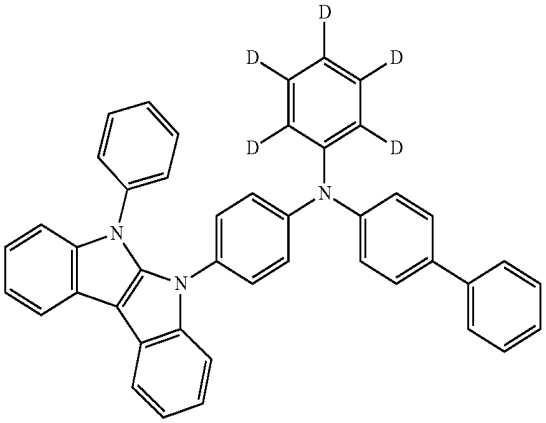


A10

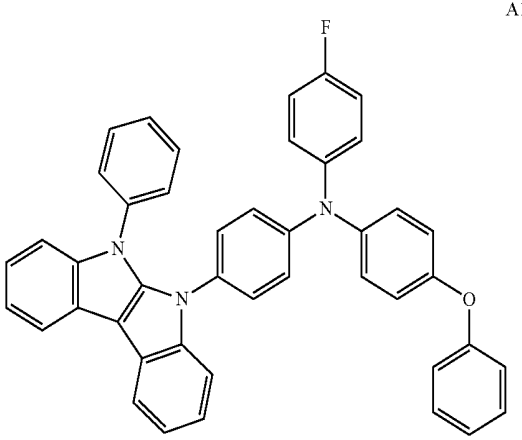


-continued

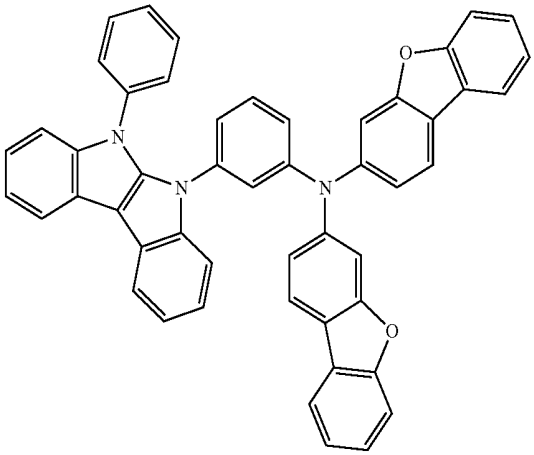
A11



A12

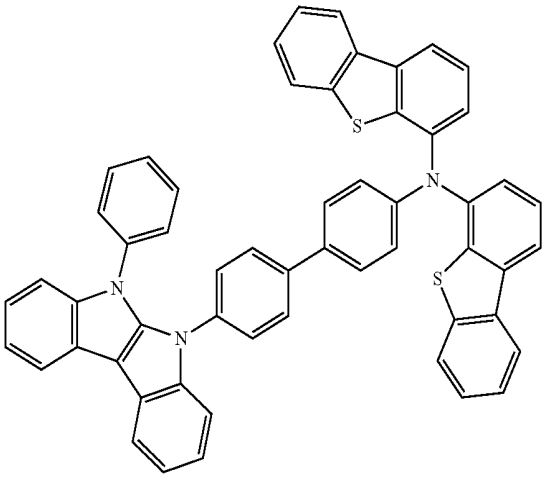


A13

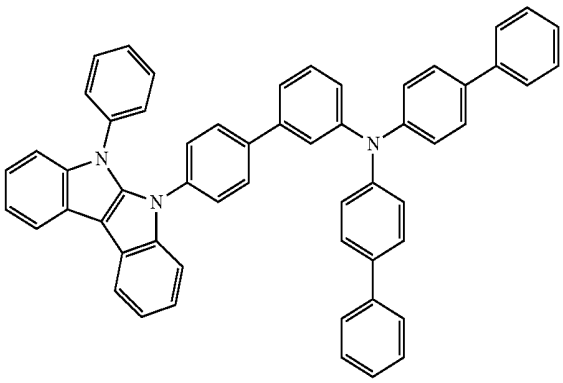


-continued

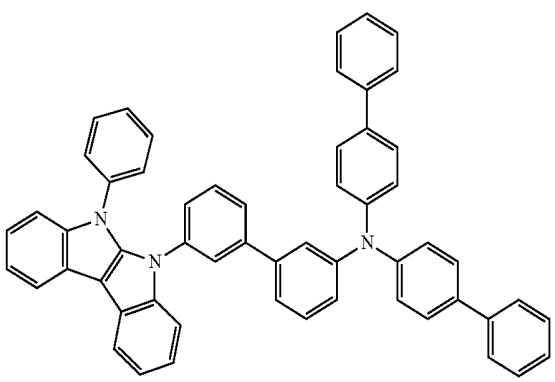
A14



A15

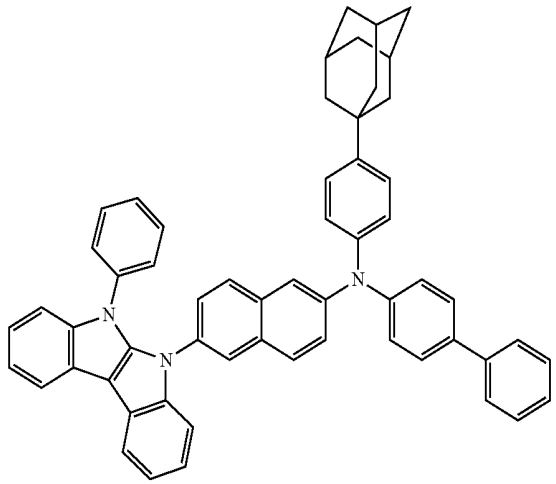


A16

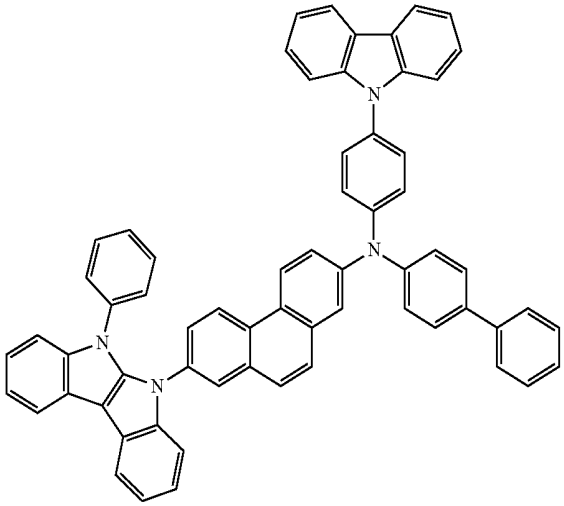


-continued

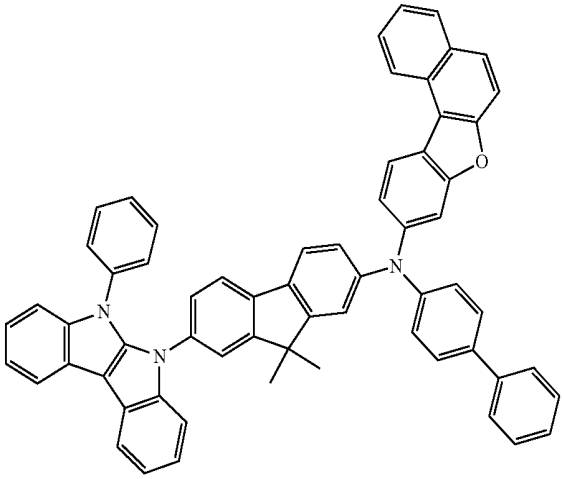
A17



A18

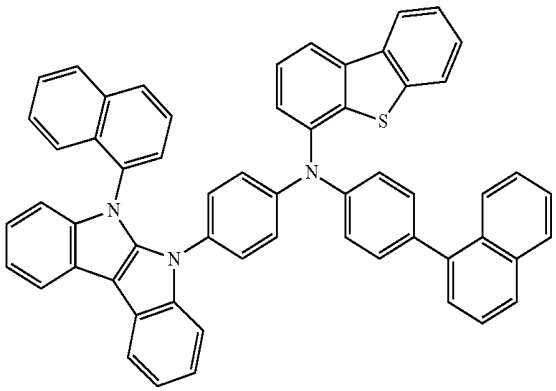


A19

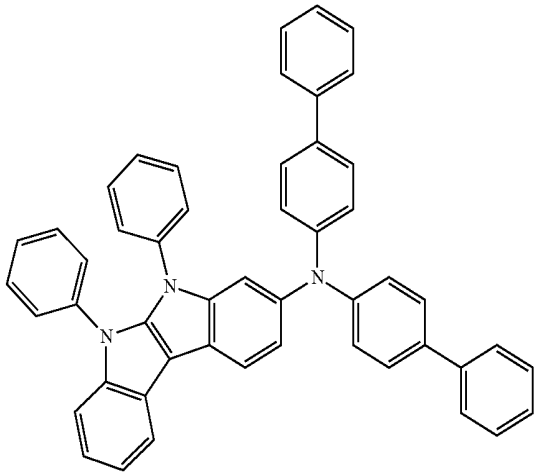


-continued

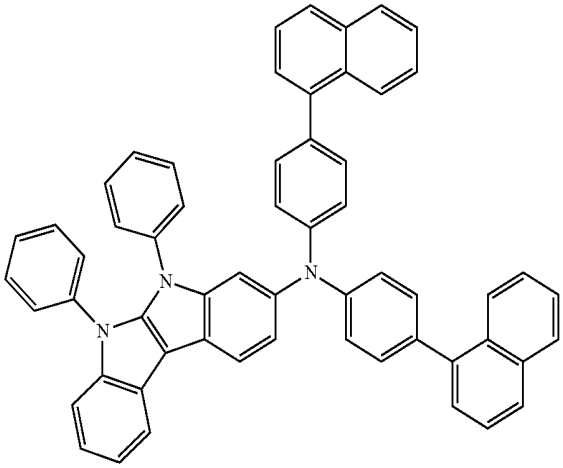
A20



A21

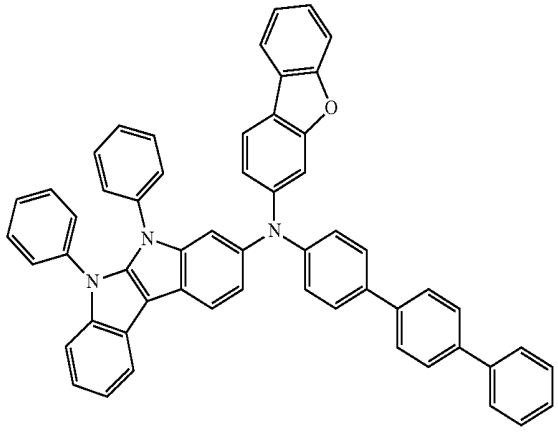


A22

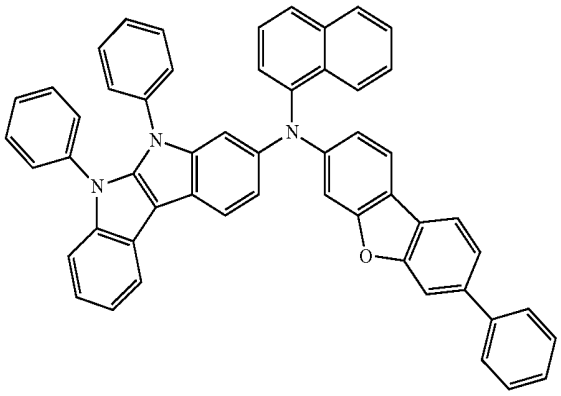


-continued

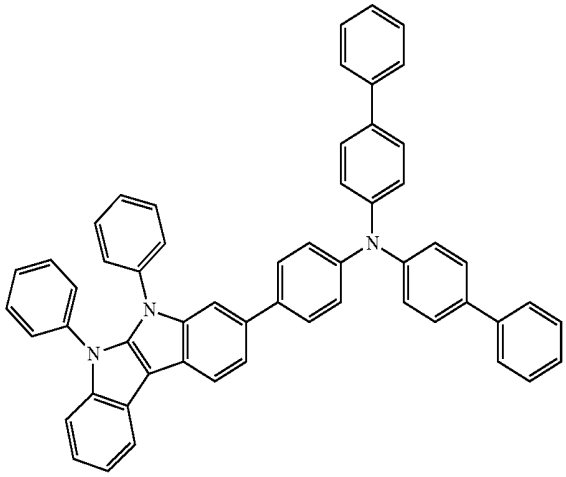
A23



A24

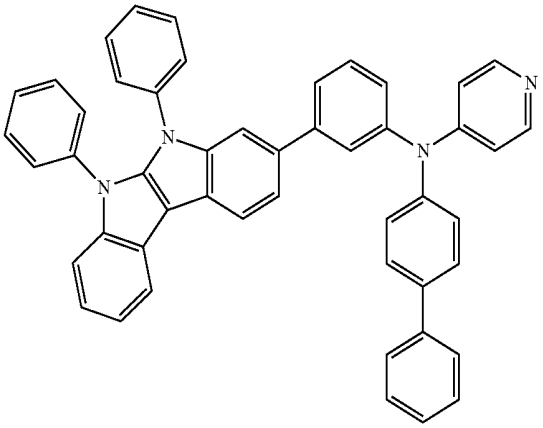


A25

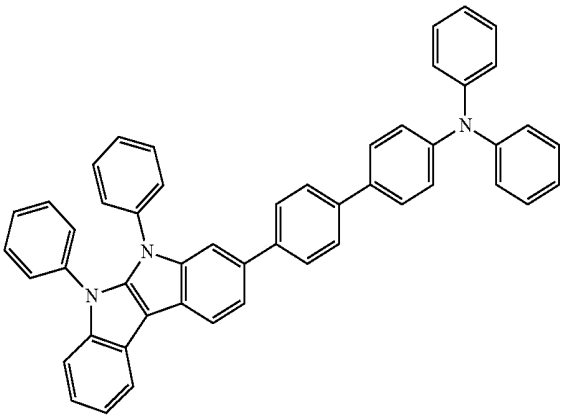


-continued

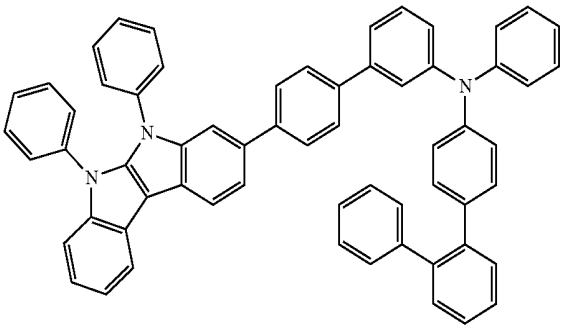
A26



A27

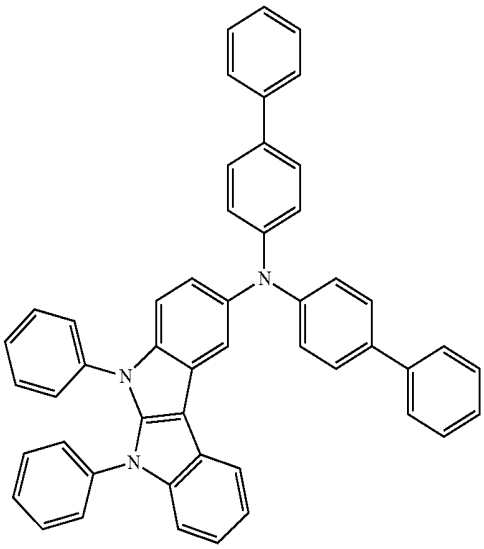


A28

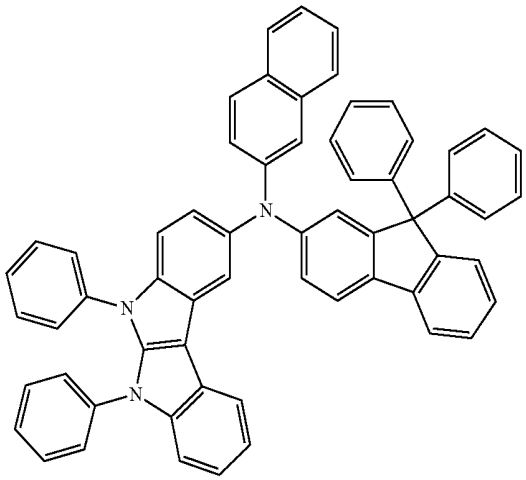


-continued

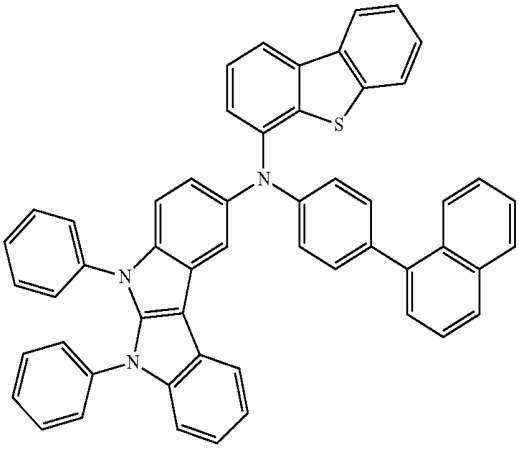
A29



A30

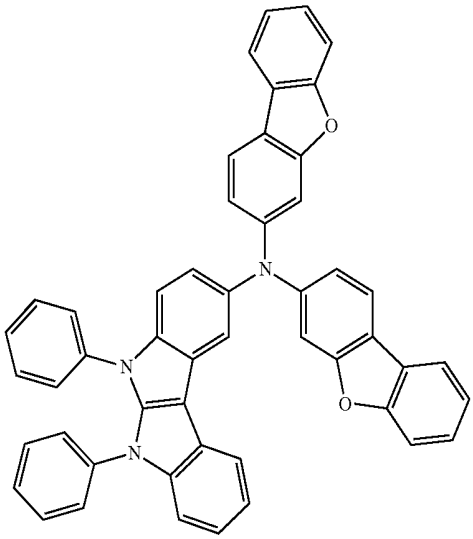


A31

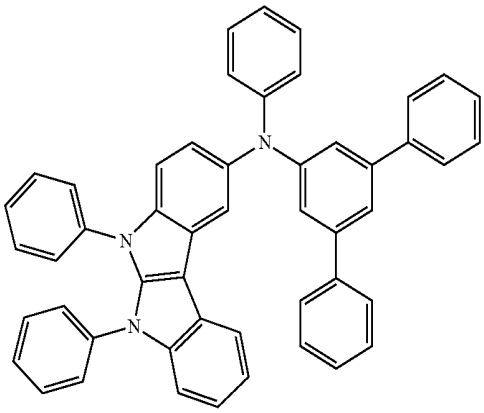


-continued

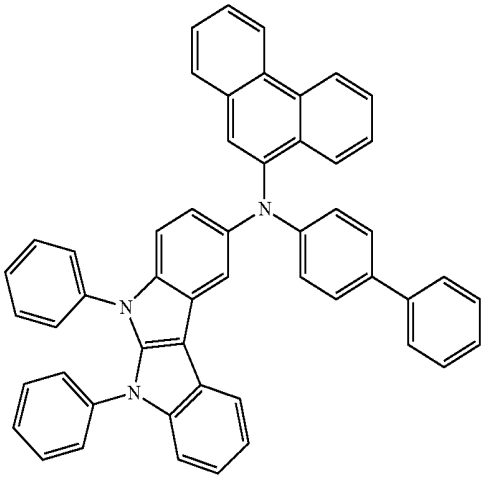
A32



A33

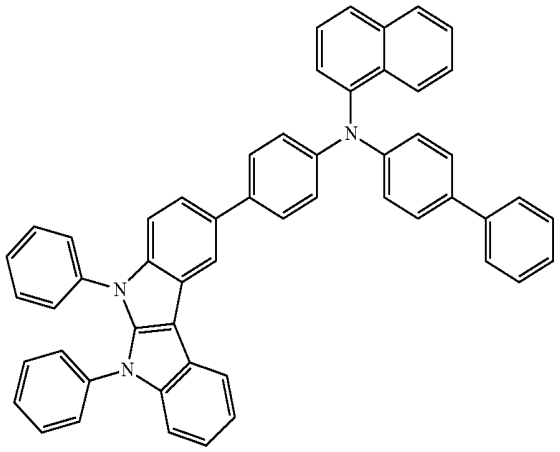


A34

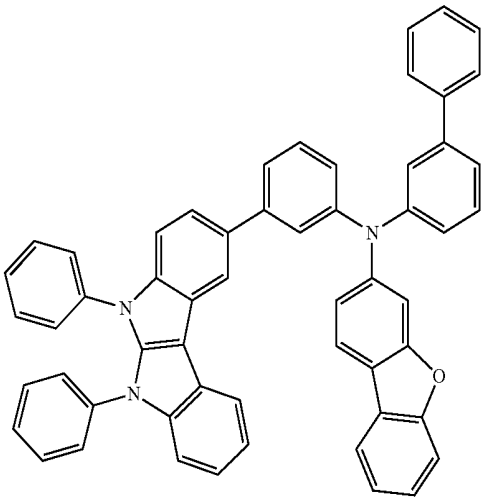


-continued

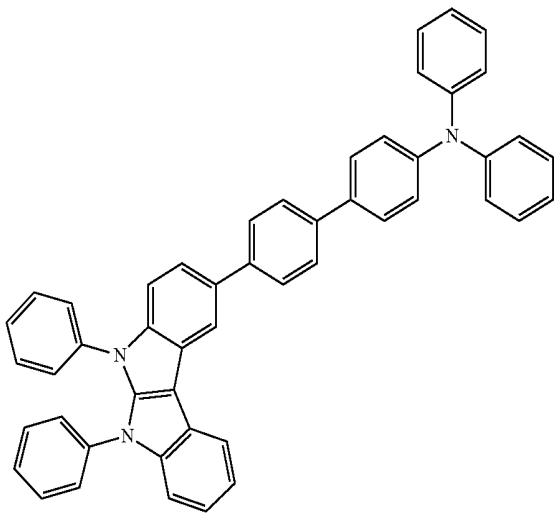
A35



A36

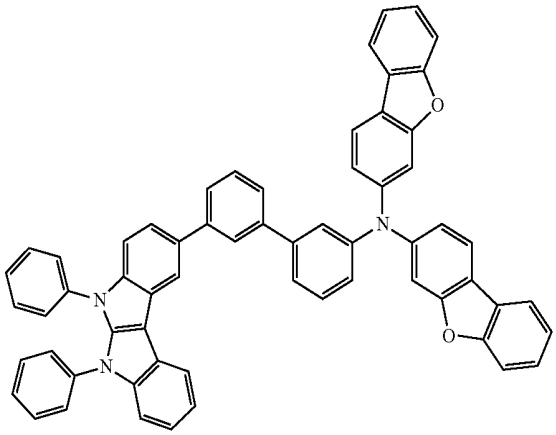


A37

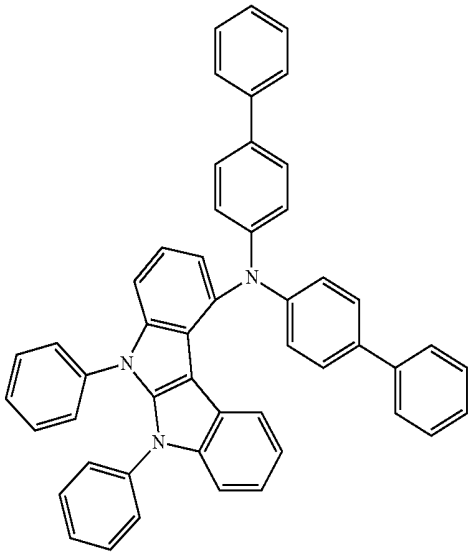


-continued

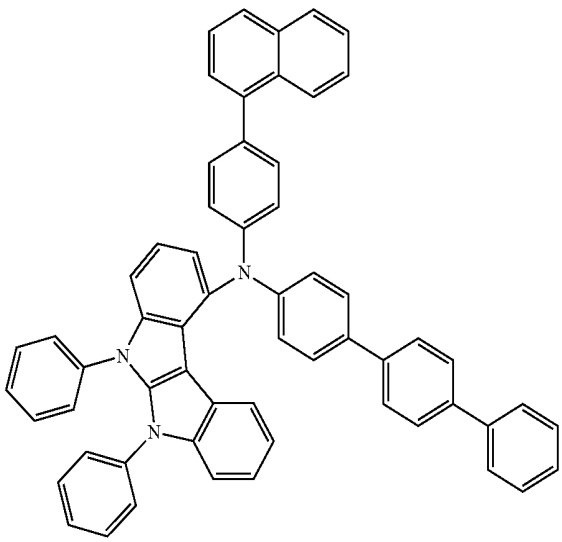
A38



A39

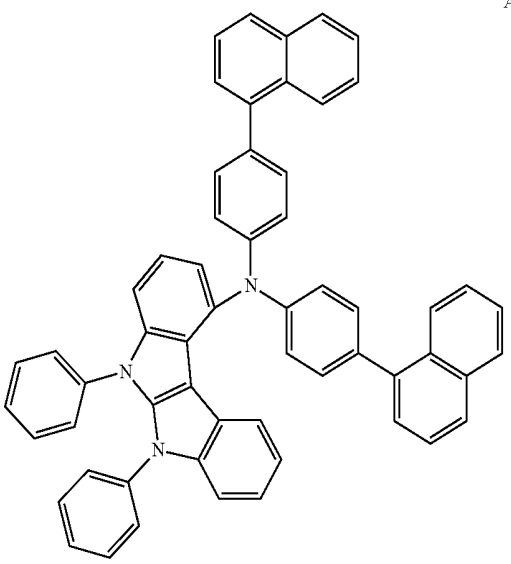


A40

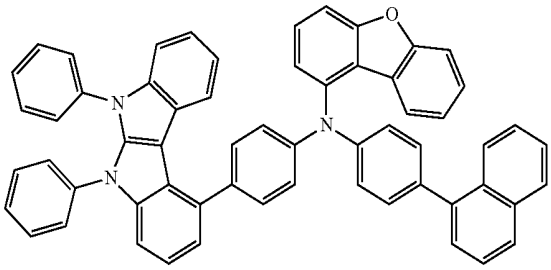


-continued

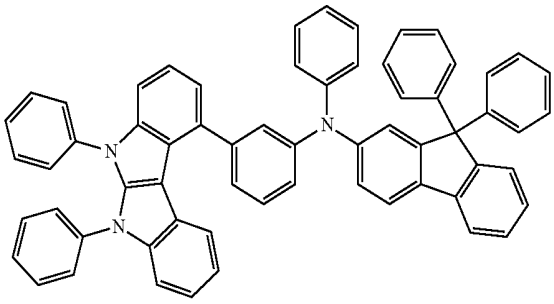
A41



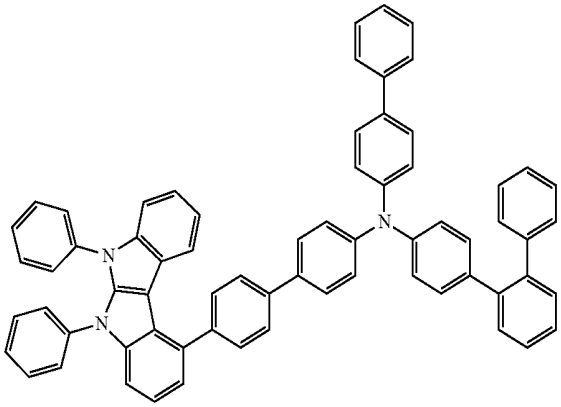
A42



A43

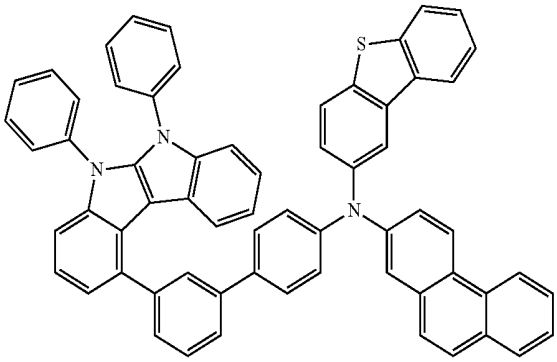


A44

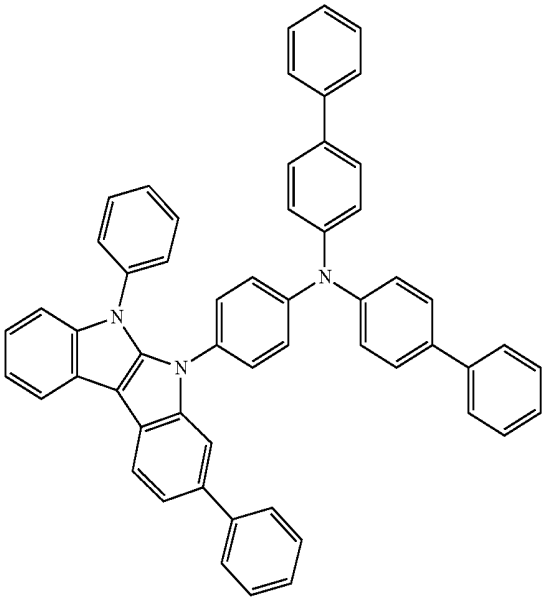


-continued

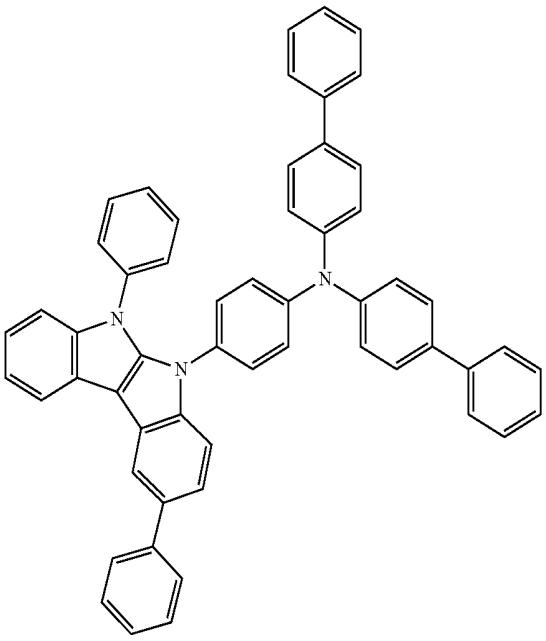
A45



A46

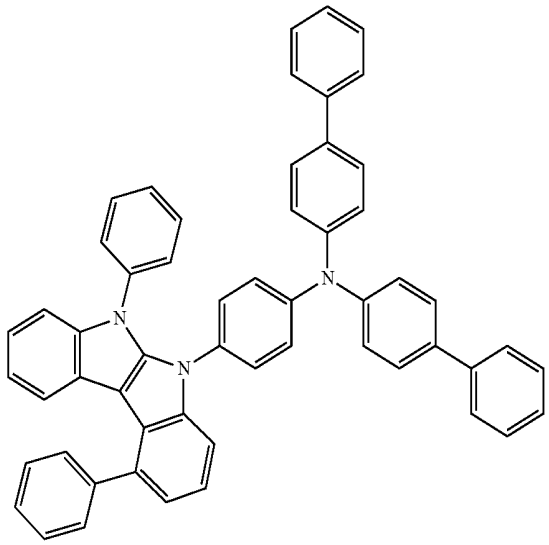


A47

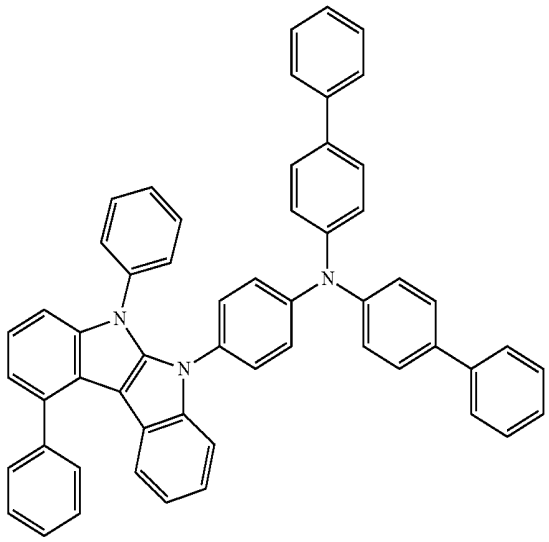


-continued

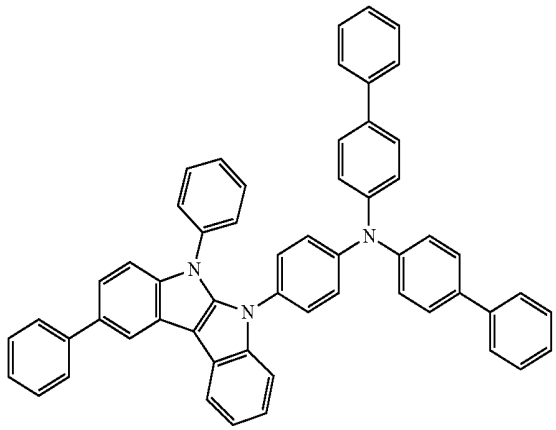
A48



A49

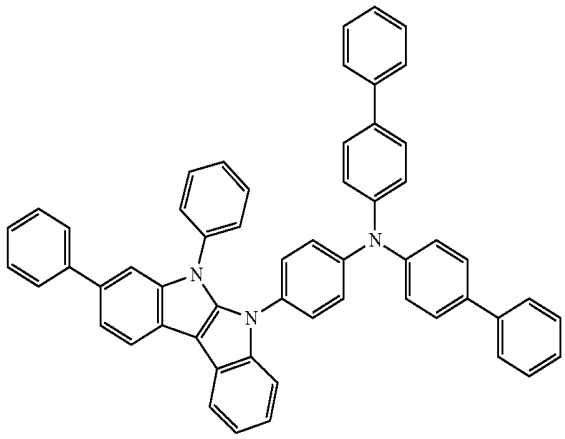


A50

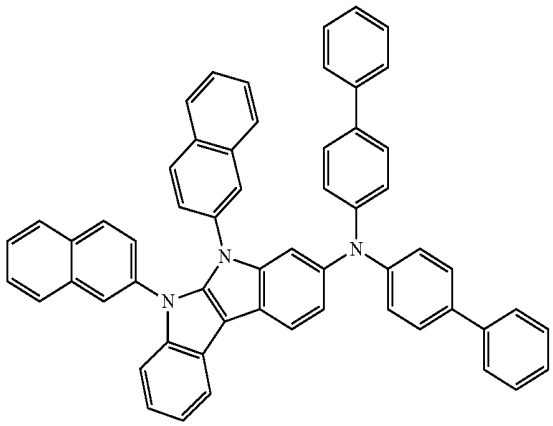


-continued

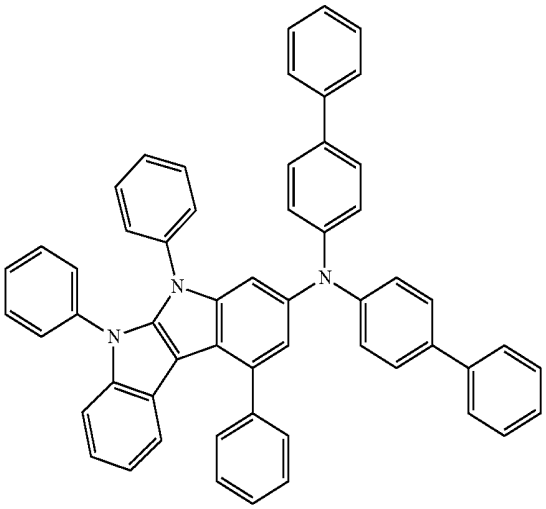
A51



A52

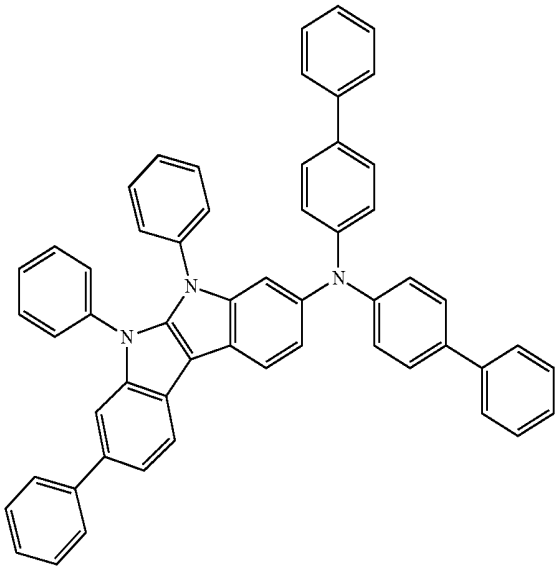


A53

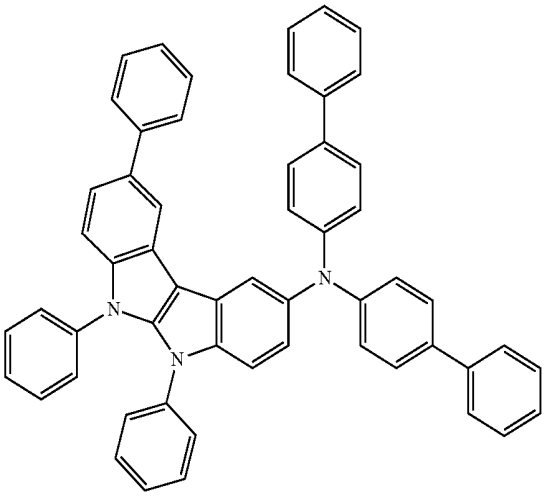


-continued

A54

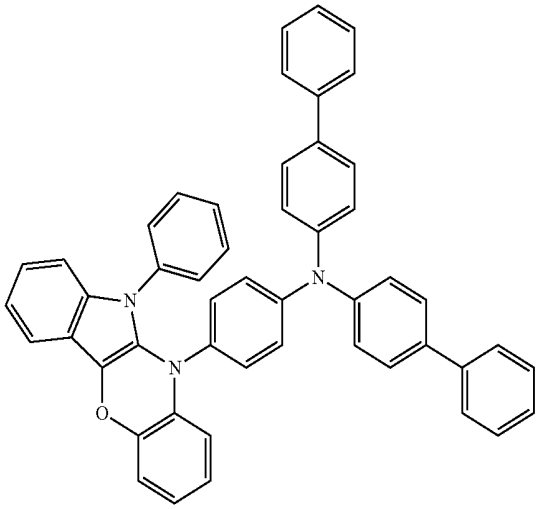


A55

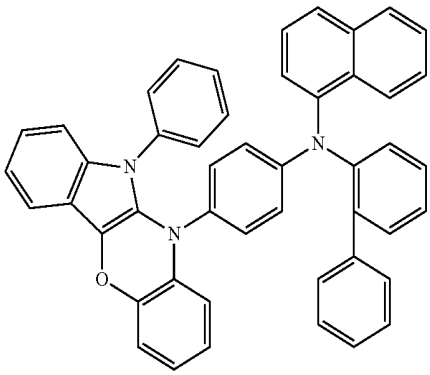


-continued

B2

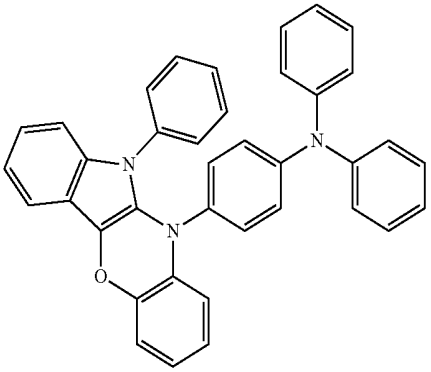


B3

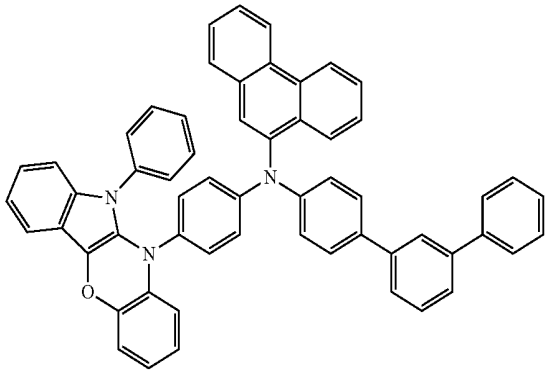


[0085] [Compound Group 2]

B1

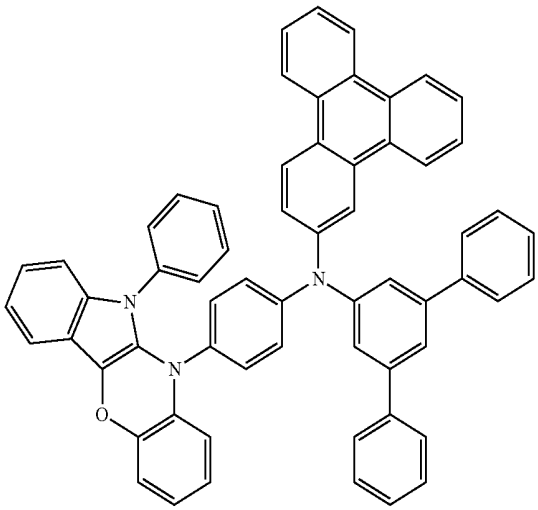


B4

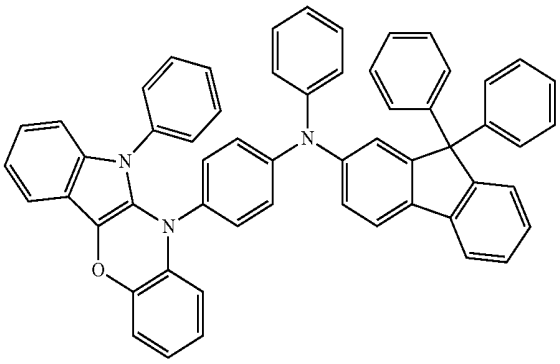


-continued

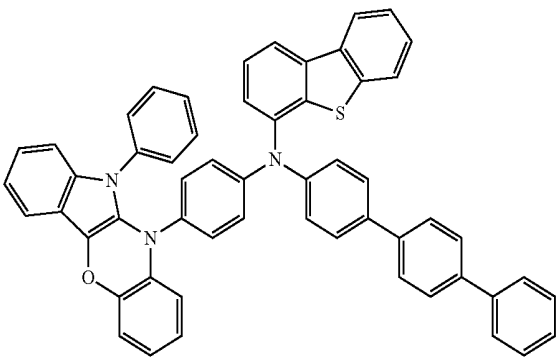
B5



B6

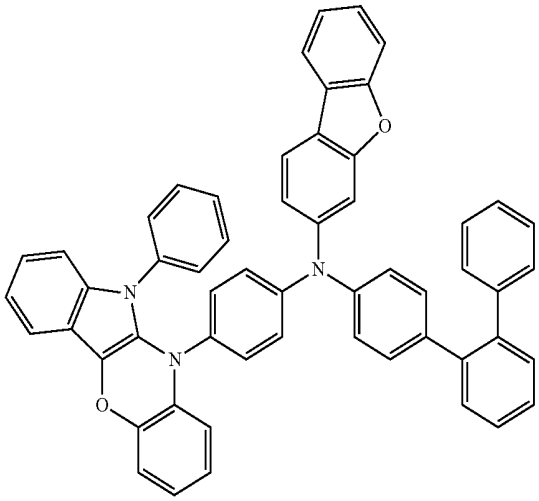


B7

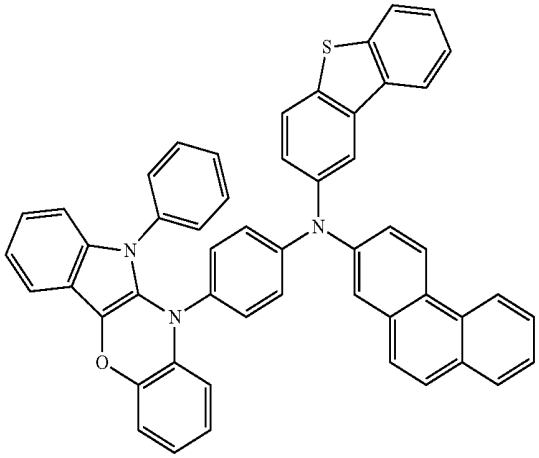


-continued

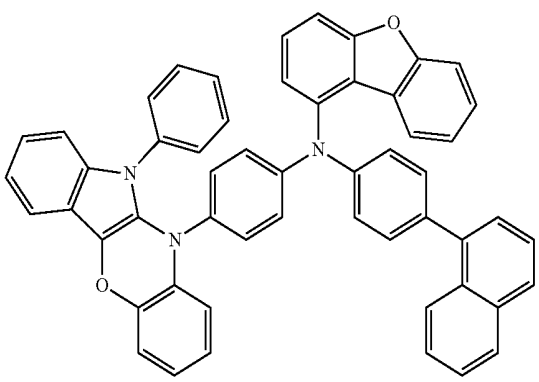
B8



B9

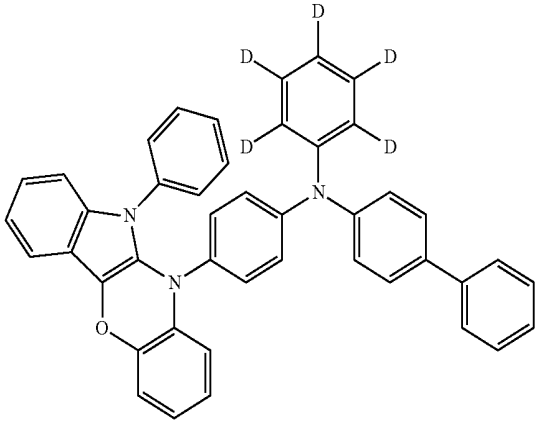


B10

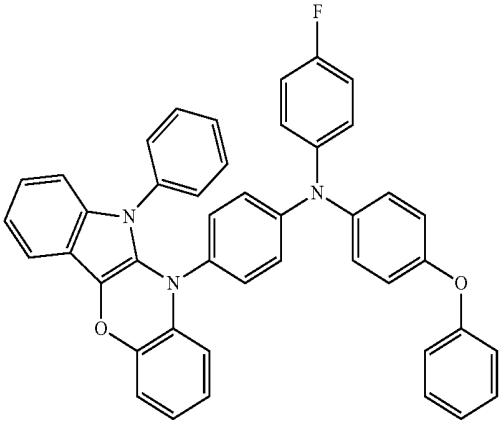


-continued

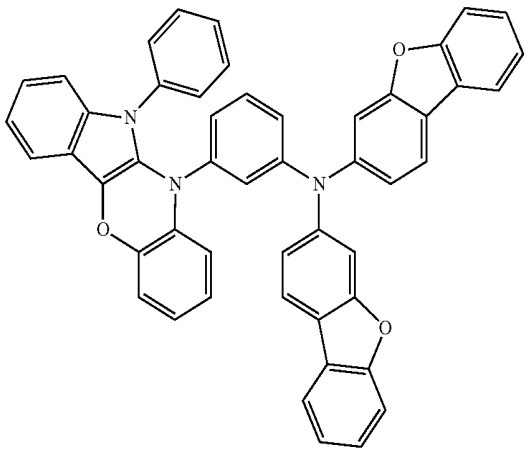
B11



B12

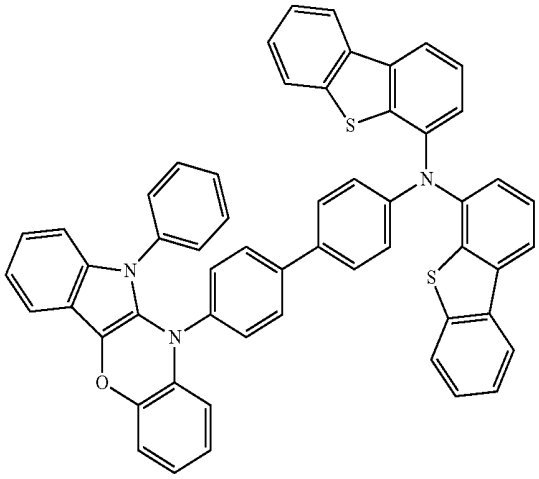


B13

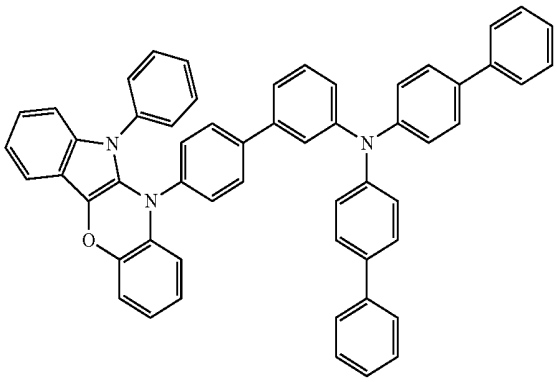


-continued

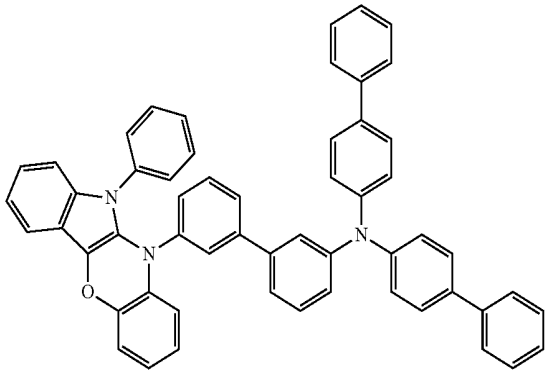
B14



B15

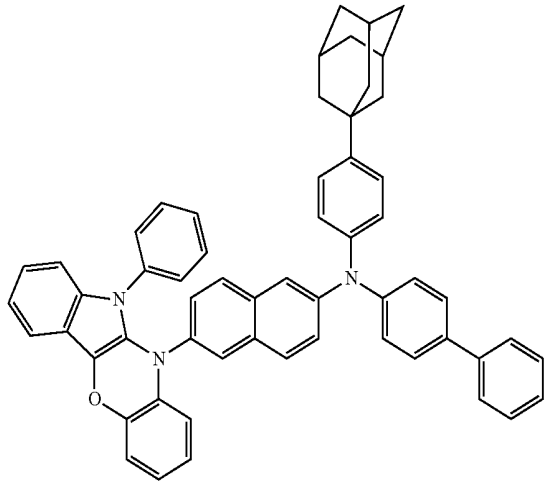


B16

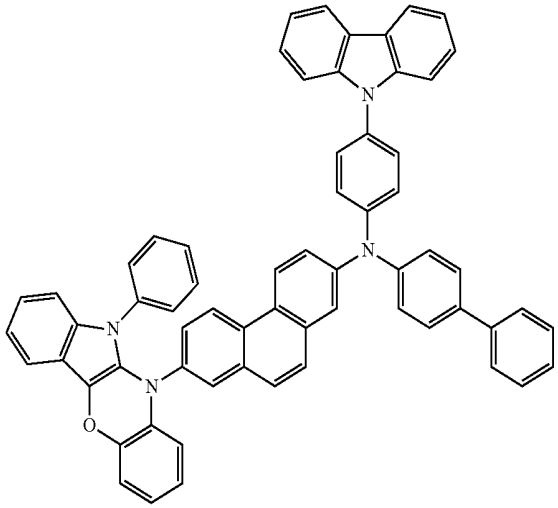


-continued

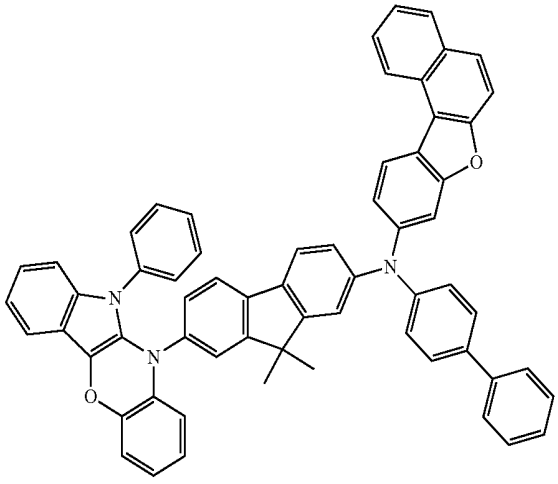
B17



B18

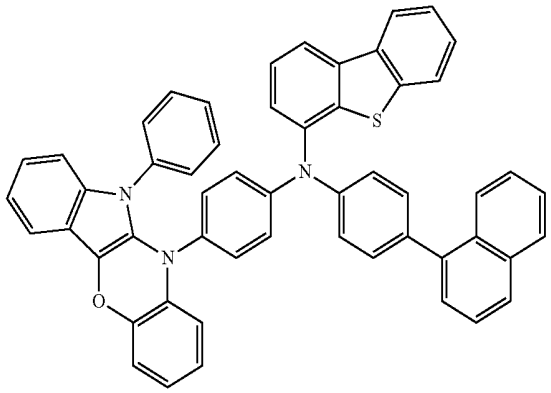


B19

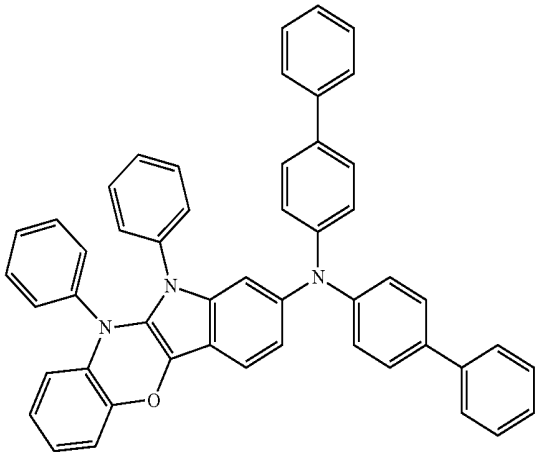


-continued

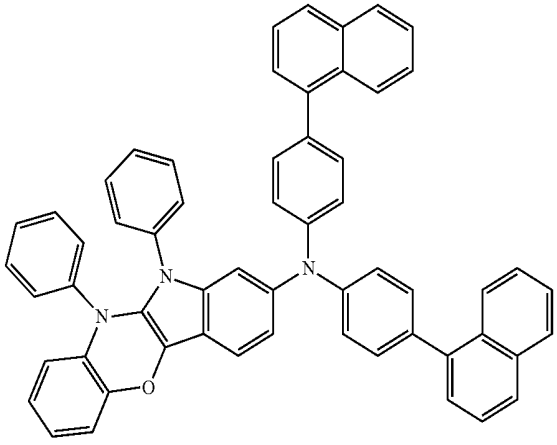
B20



B21

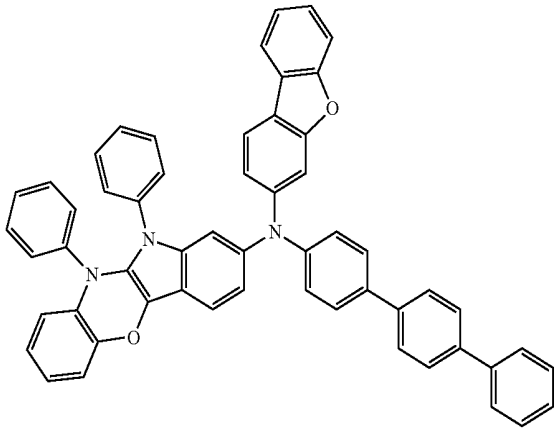


B22

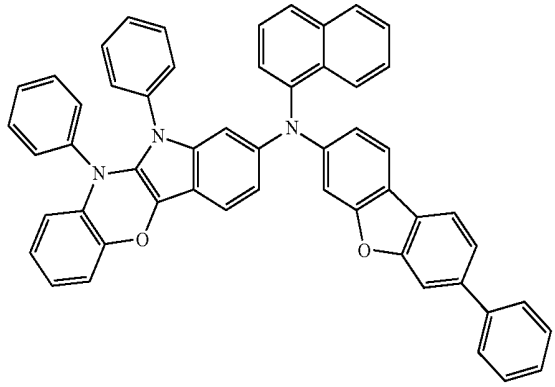


-continued

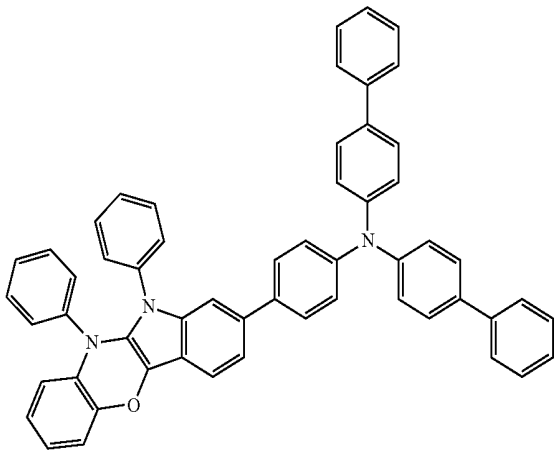
B23



B24

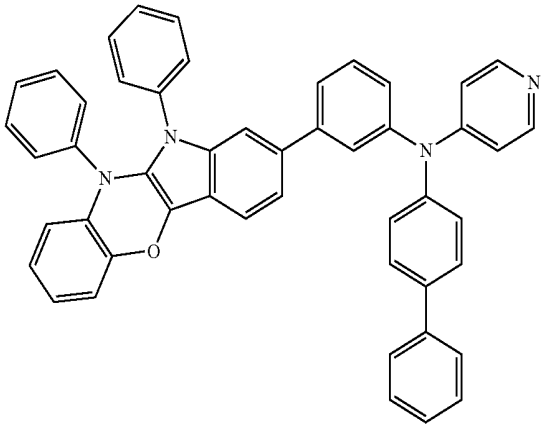


B25

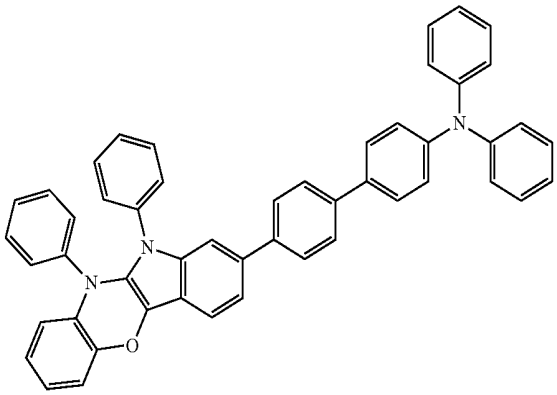


-continued

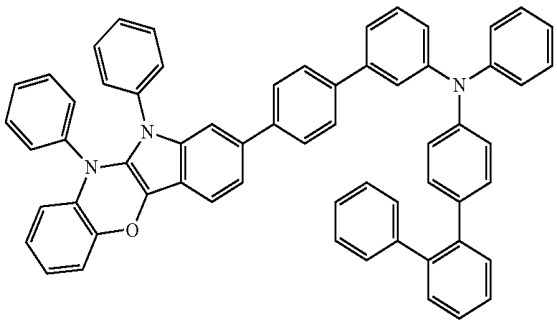
B26



B27

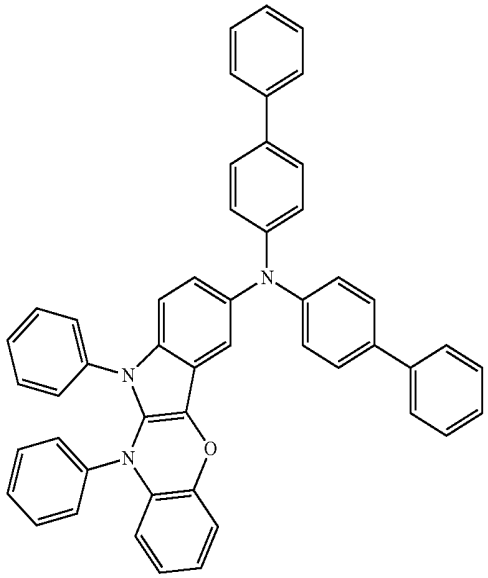


B28

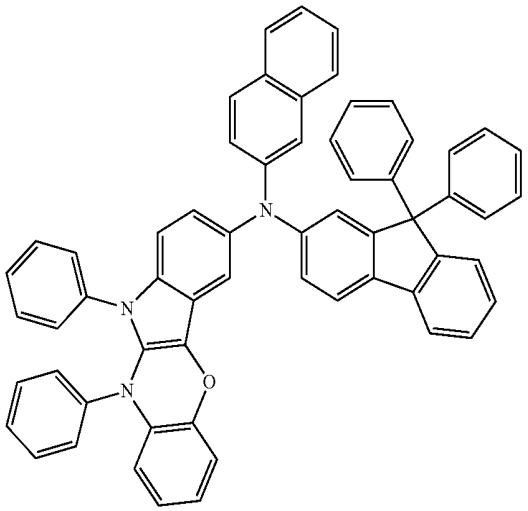


-continued

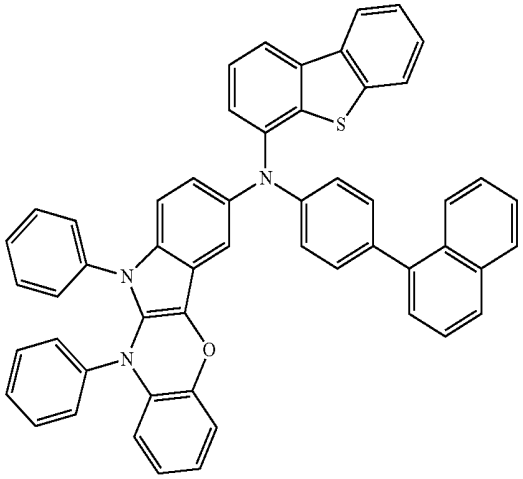
B29



B30

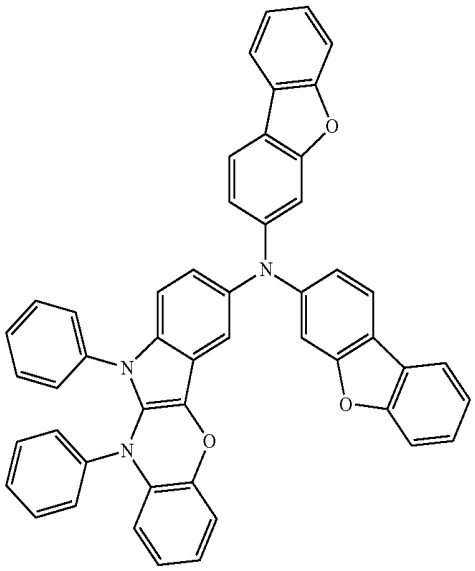


B31

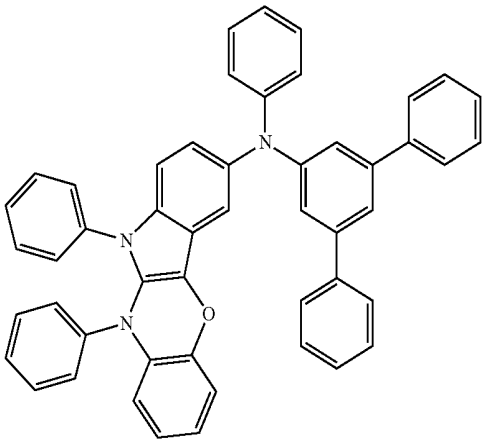


-continued

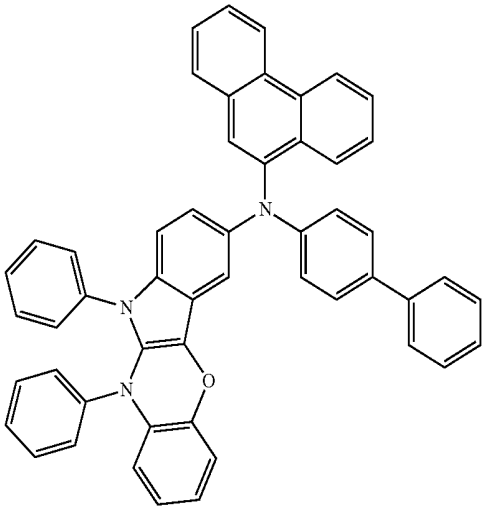
B32



B33

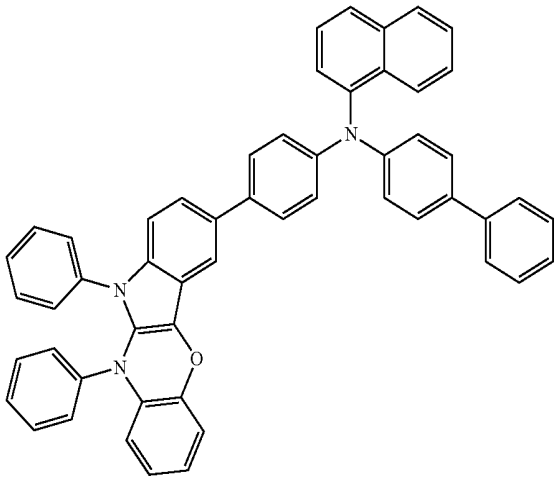


B34

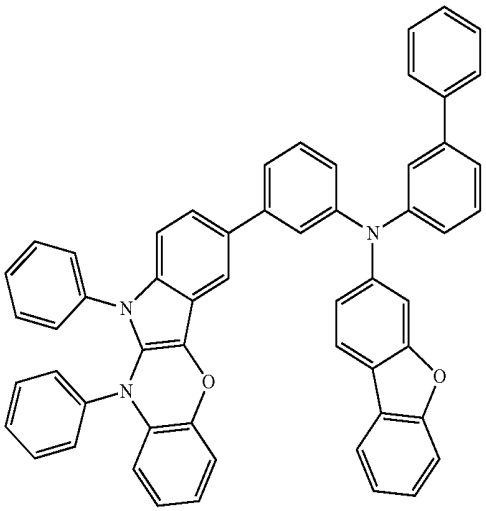


-continued

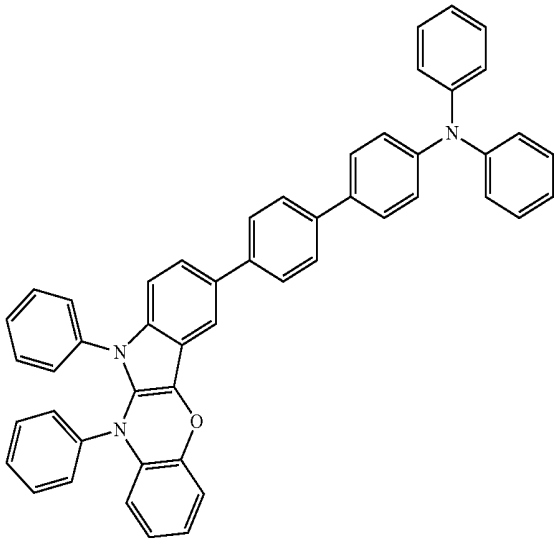
B35



B36

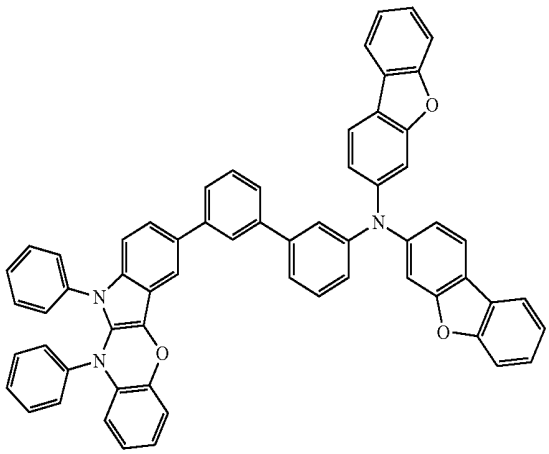


B37

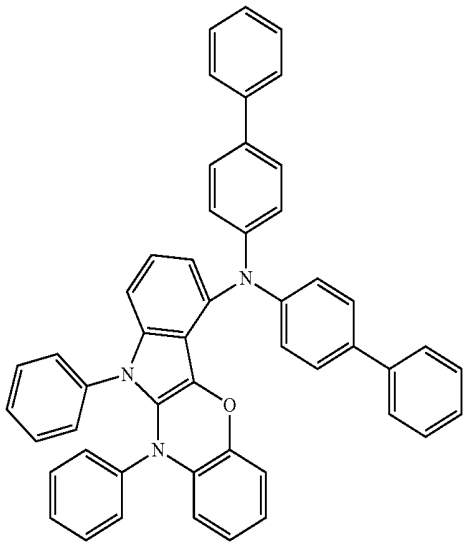


-continued

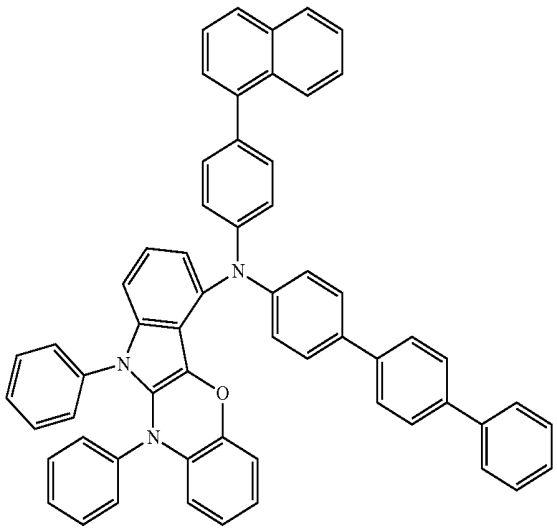
B38



B39

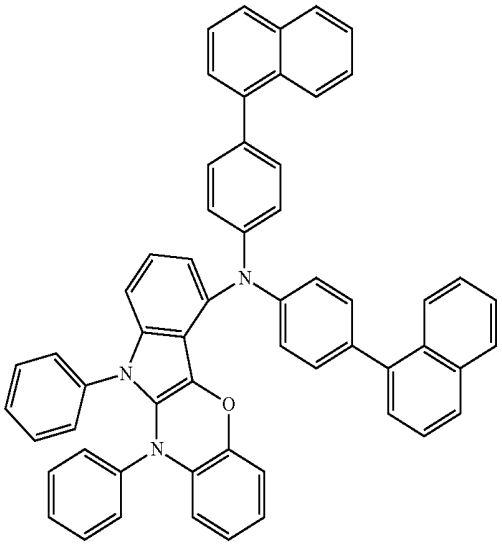


B40

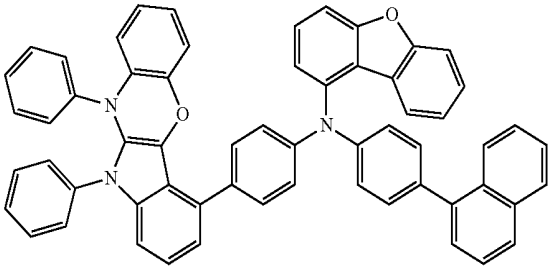


-continued

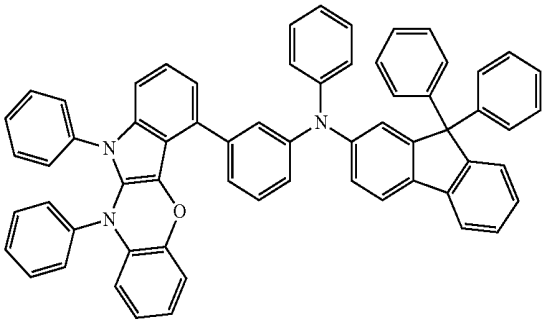
B41



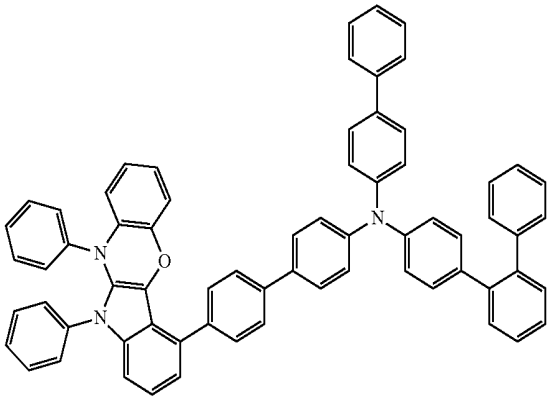
B42



B43

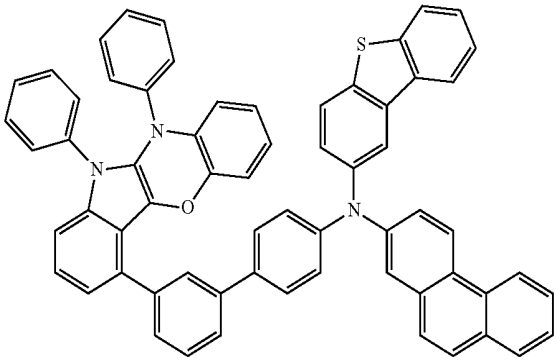


B44

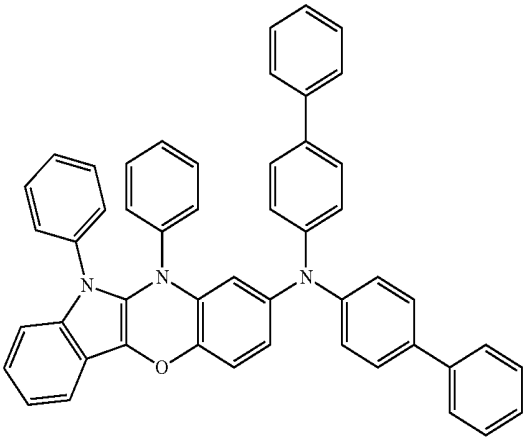


-continued

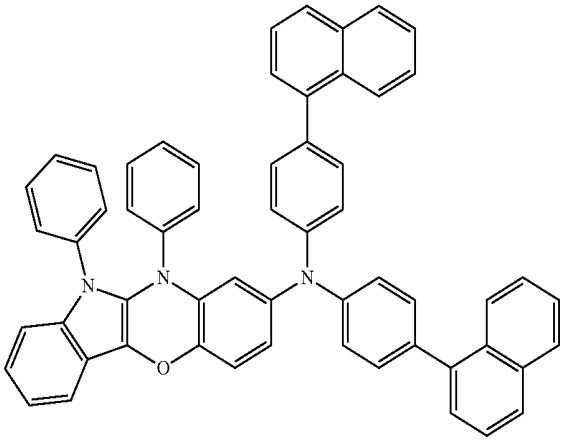
B45



B46

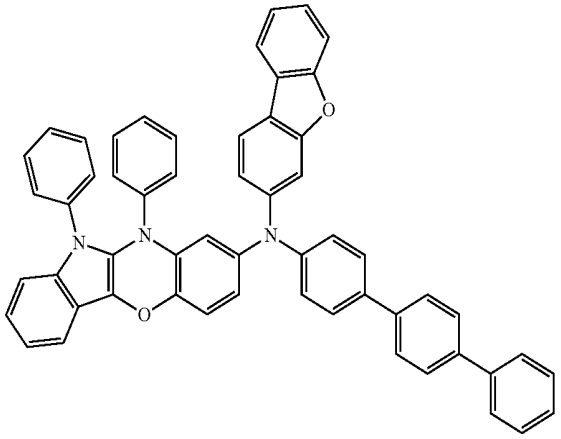


B47

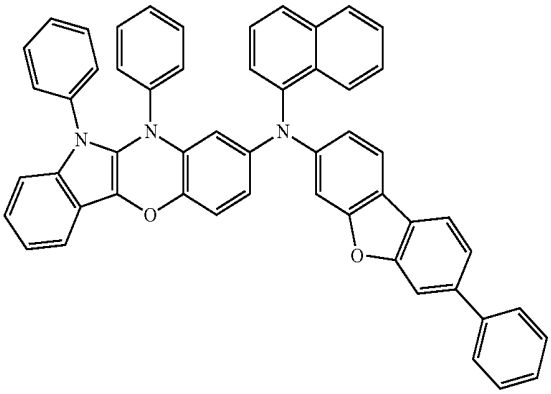


-continued

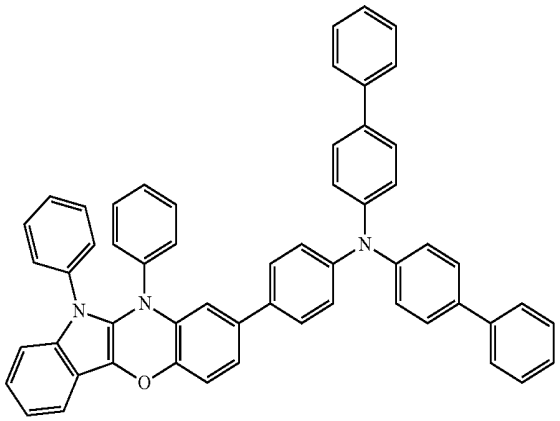
B48



B49

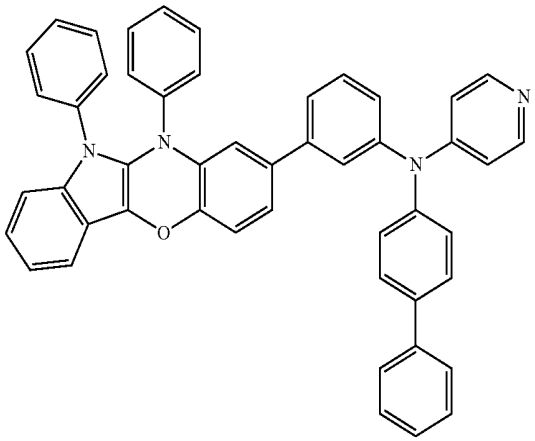


B50

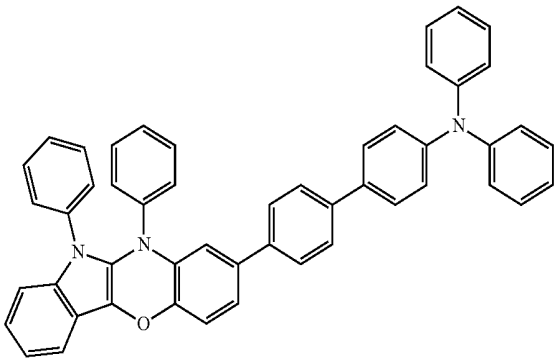


-continued

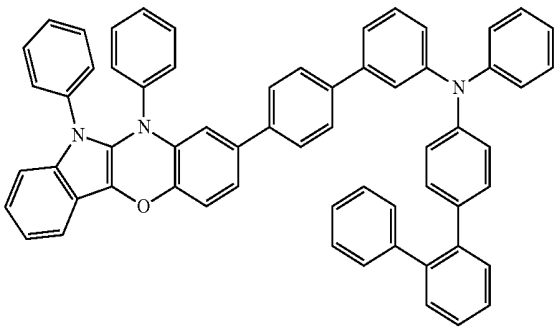
B51



B52

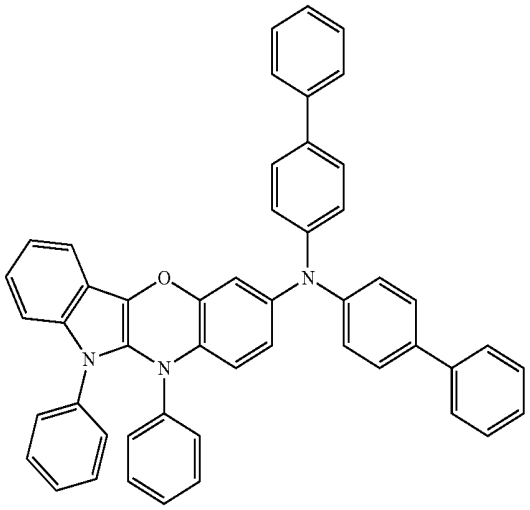


B53

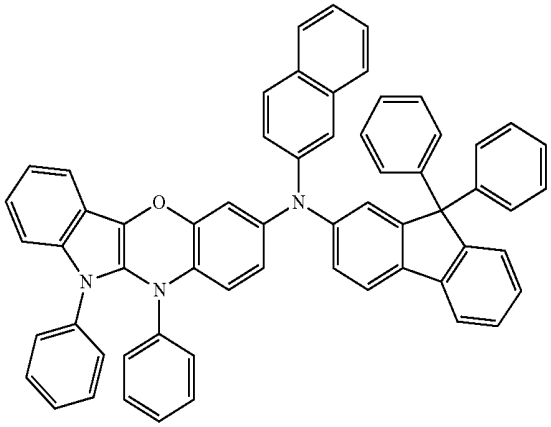


-continued

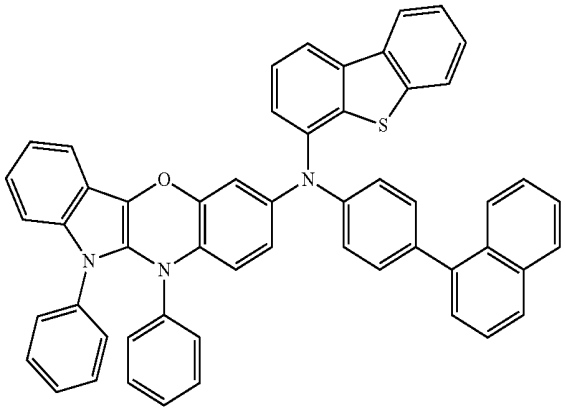
B54



B55

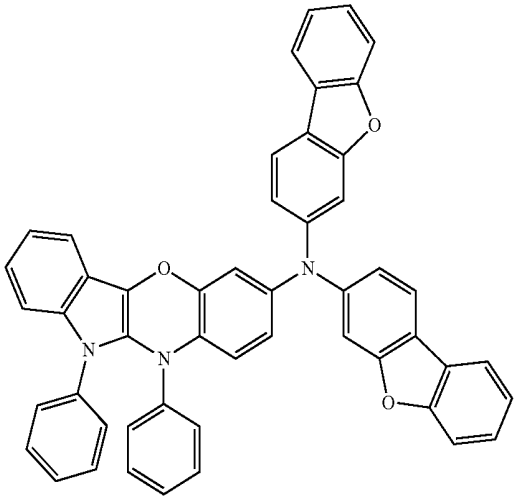


B56

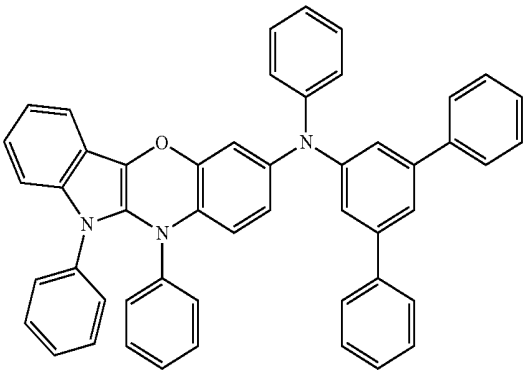


-continued

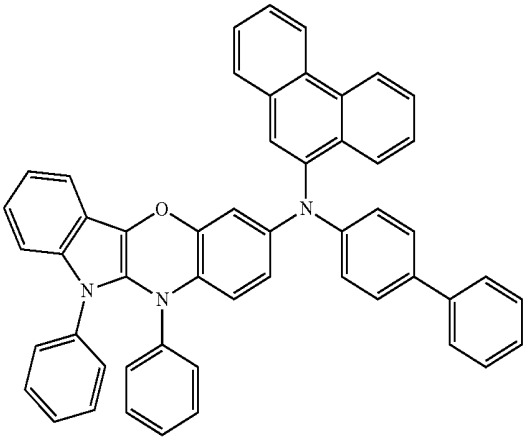
B57



B58

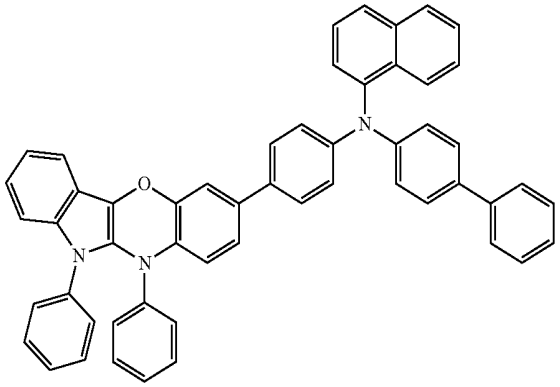


B59

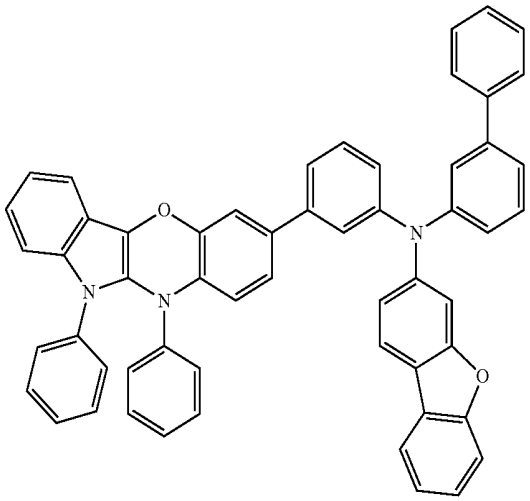


-continued

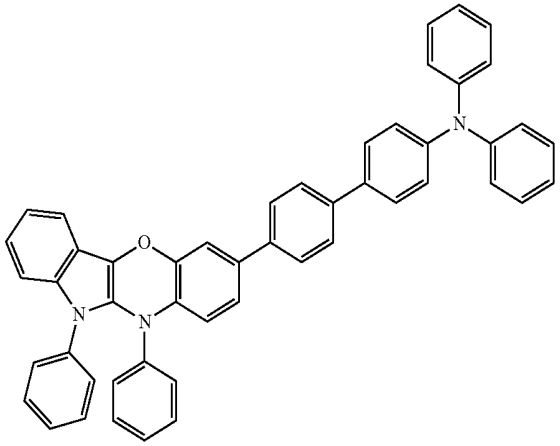
B60



B61

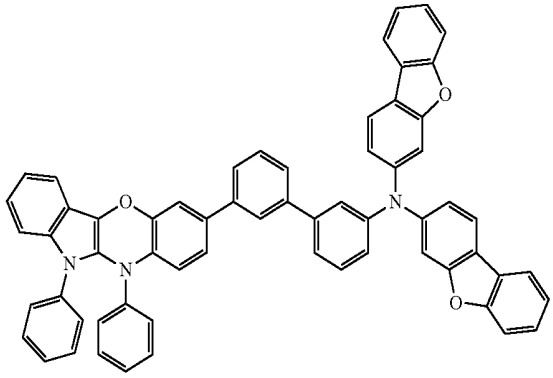


B62

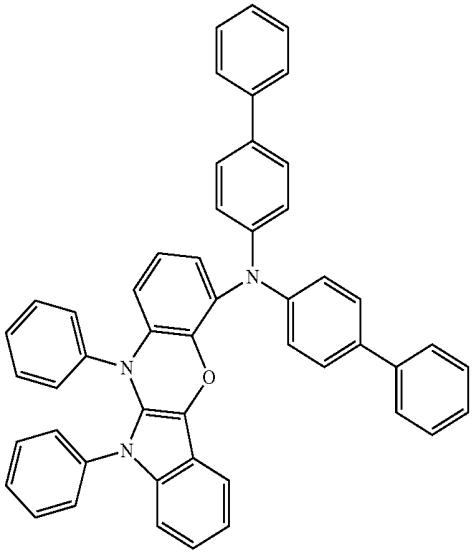


-continued

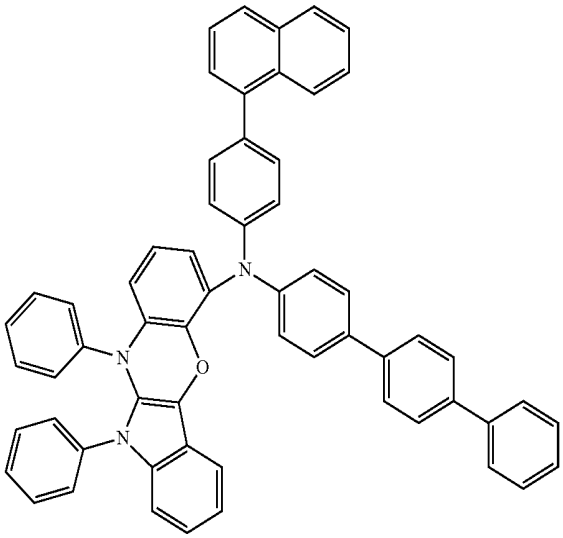
B63



B64

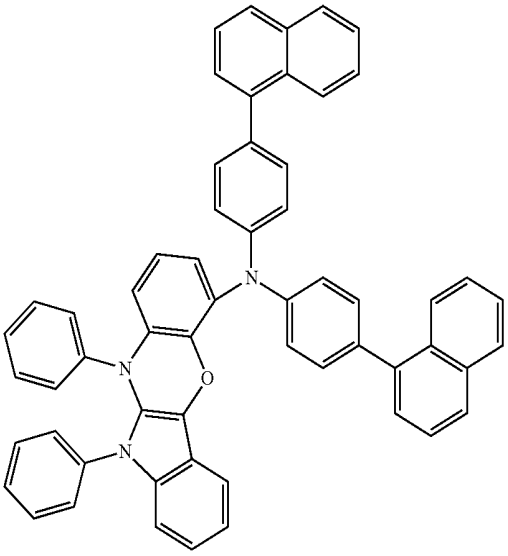


B65

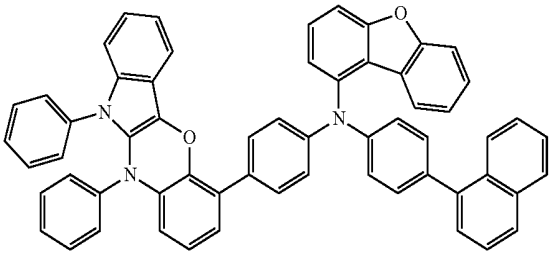


-continued

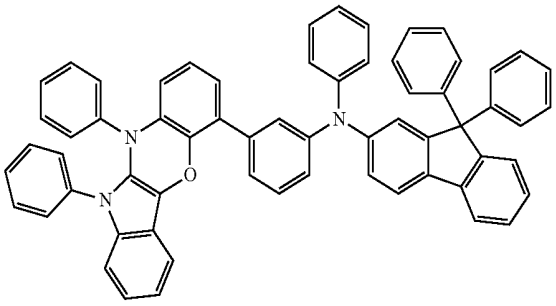
B66



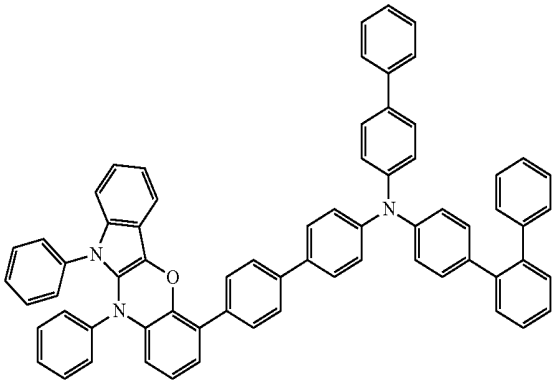
B67



B68

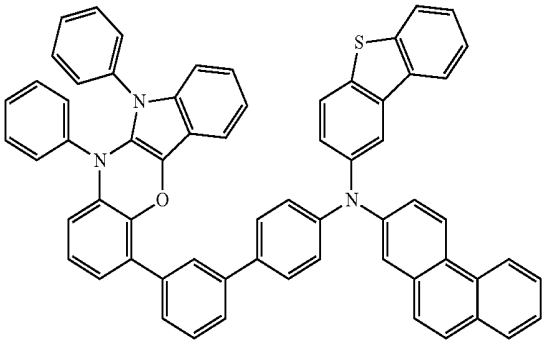


B69



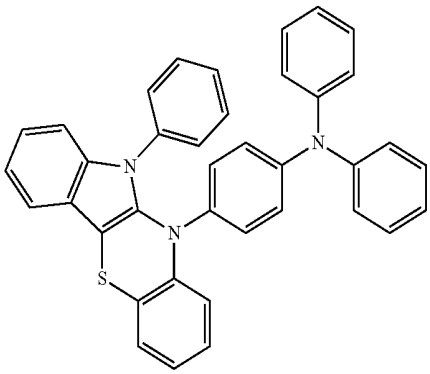
-continued

B70

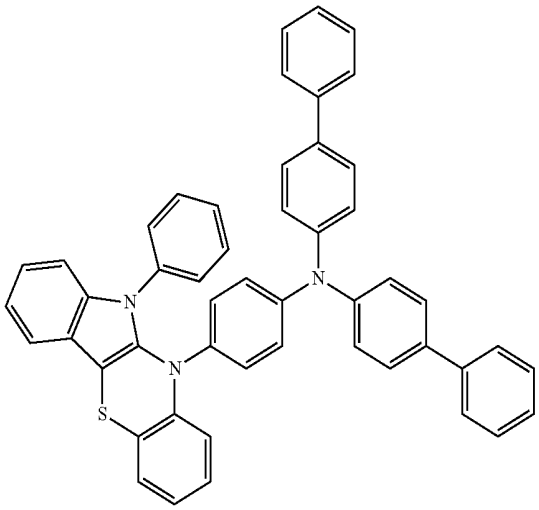


[0086] [Compound Group 3]

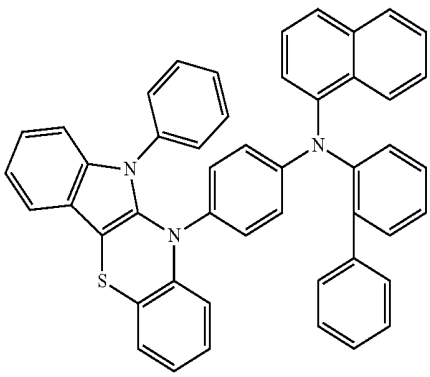
C1



C2

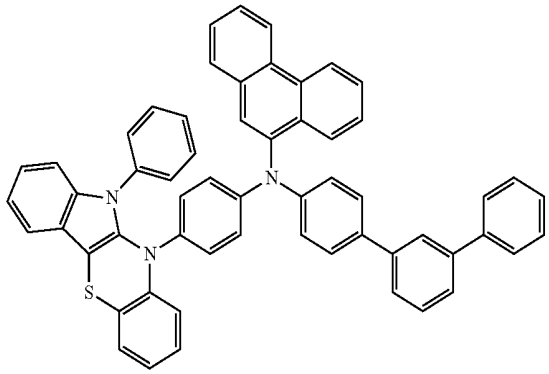


C3

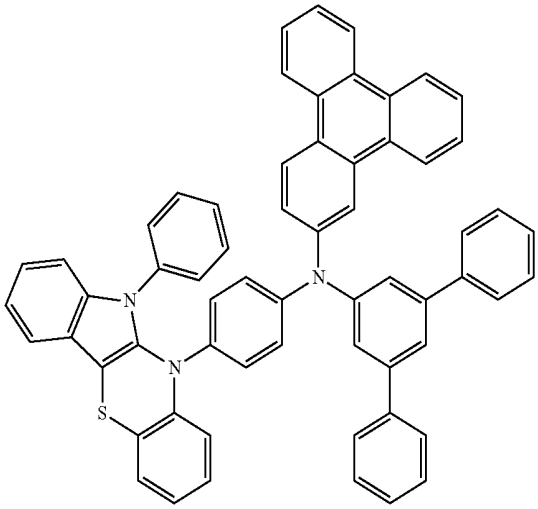


-continued

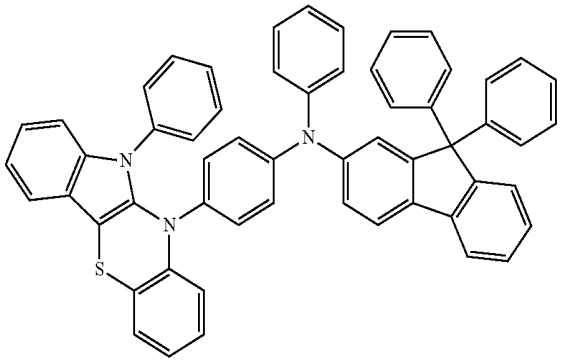
C4



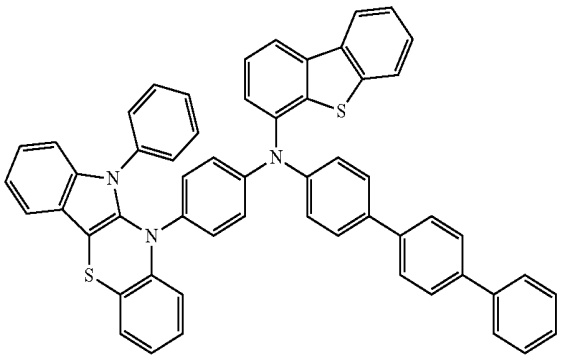
C5



C6

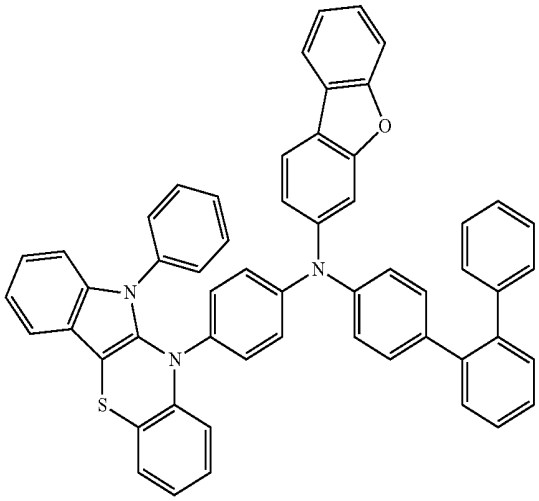


C7

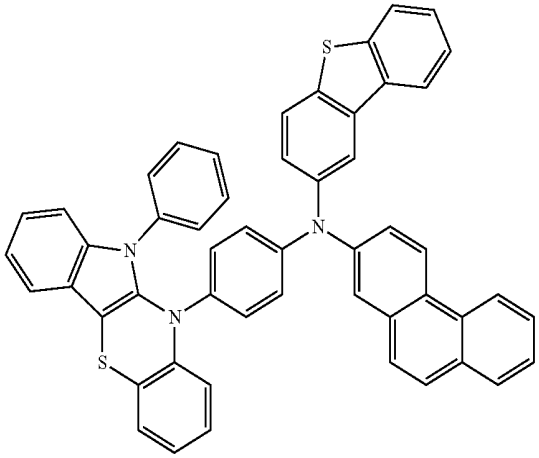


-continued

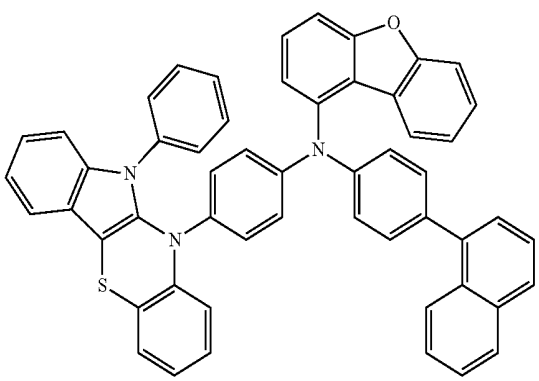
C8



C9

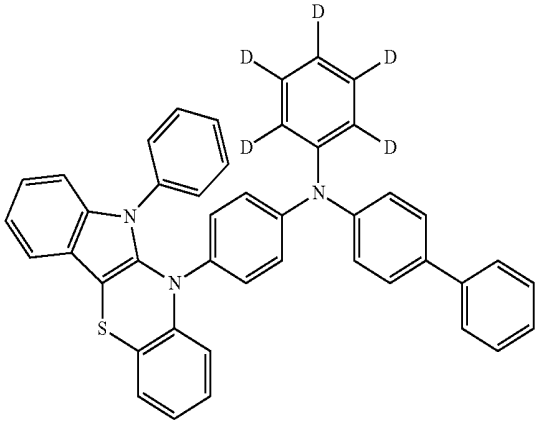


C10

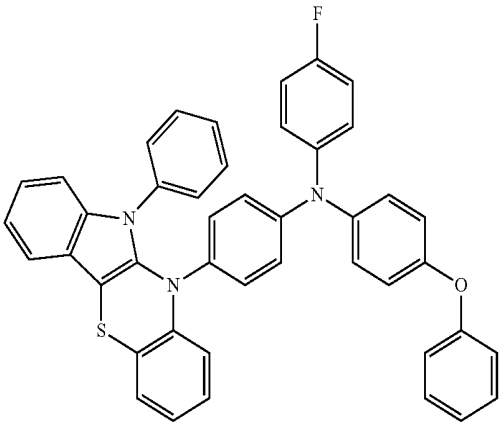


-continued

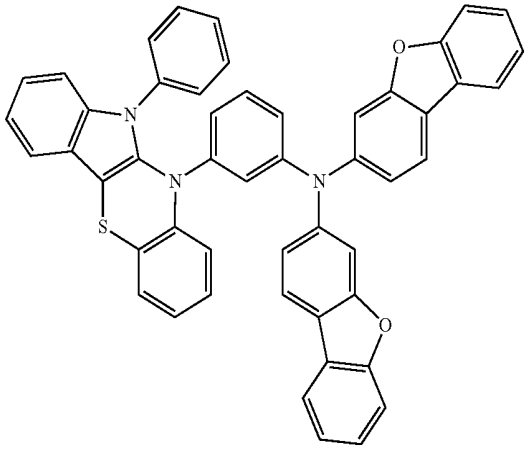
C11



C12

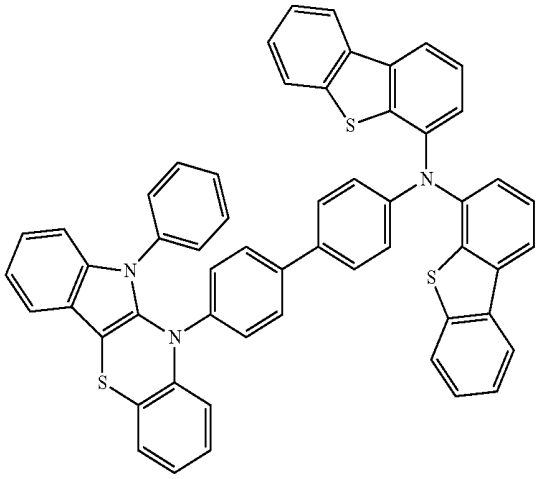


C13

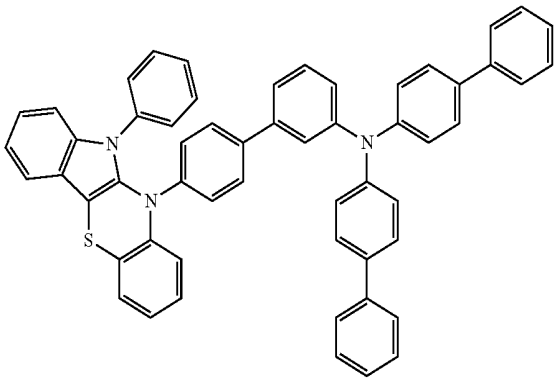


-continued

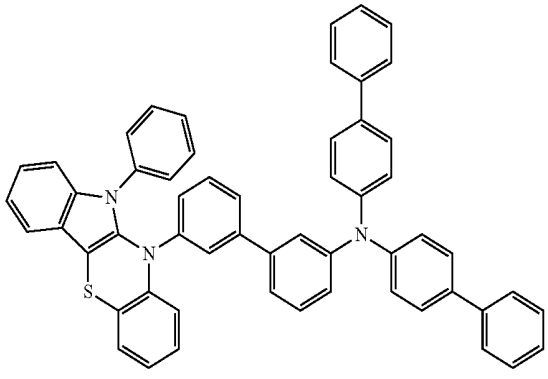
C14



C15

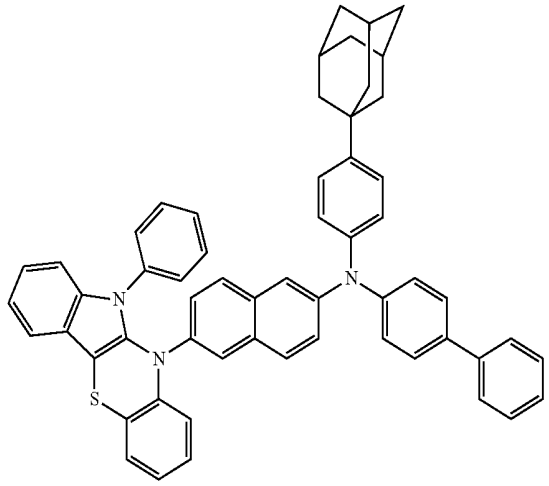


C16

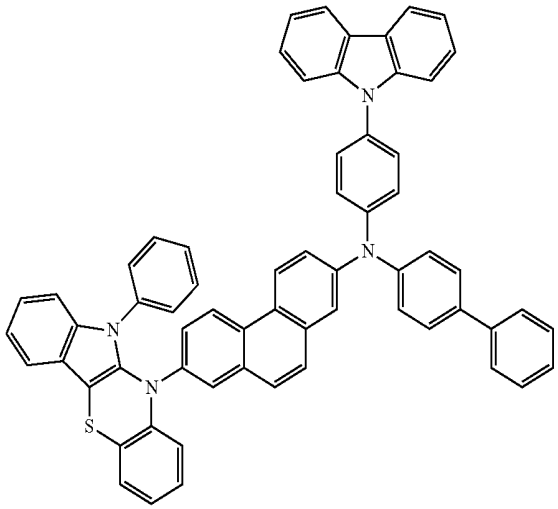


-continued

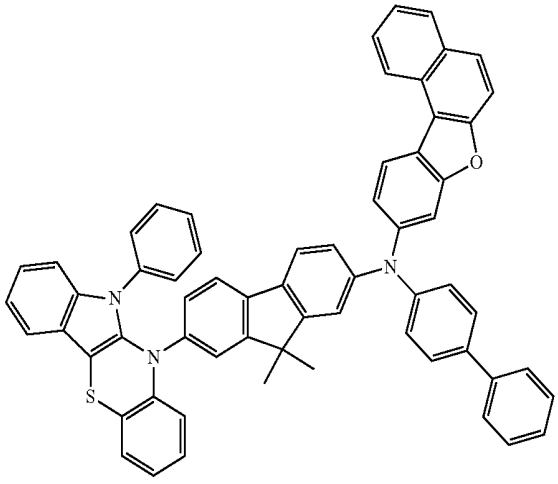
C17



C18

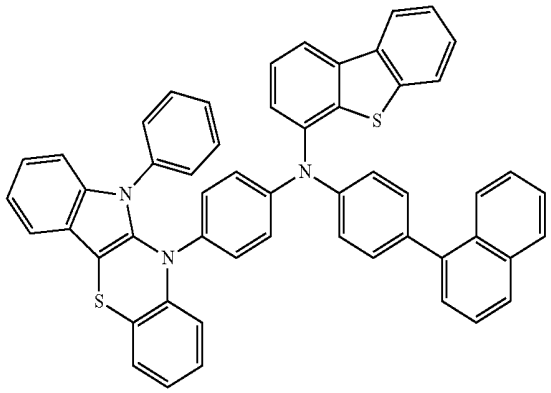


C19

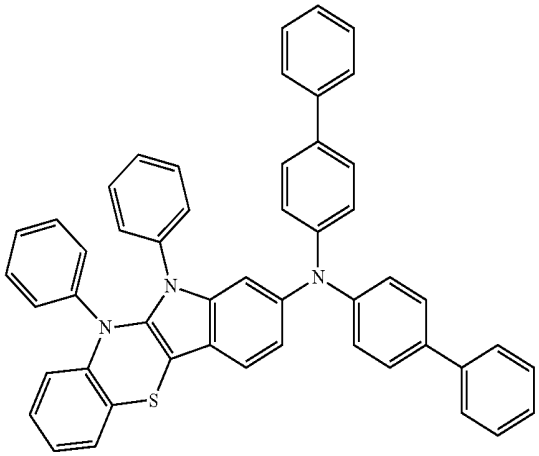


-continued

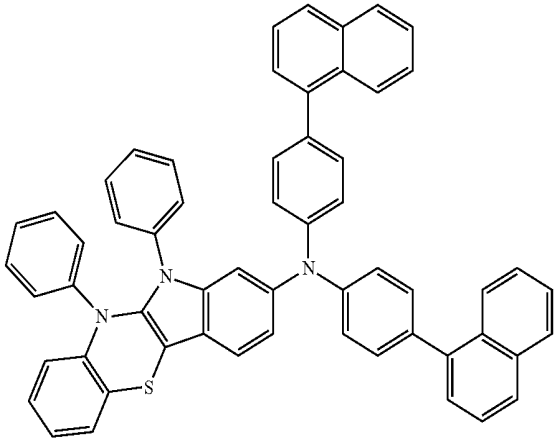
C20



C21

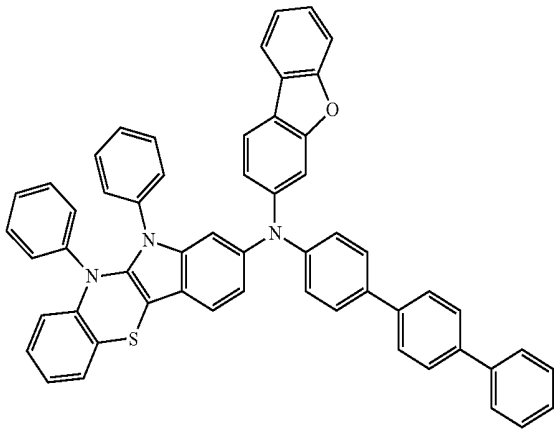


C22

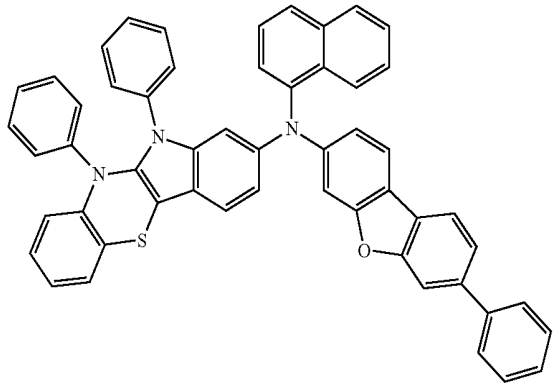


-continued

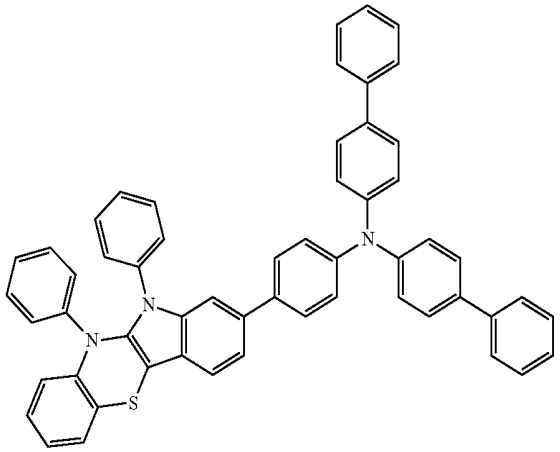
C23



C24

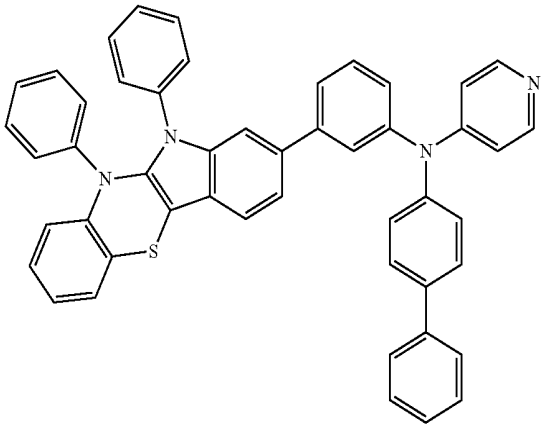


C25

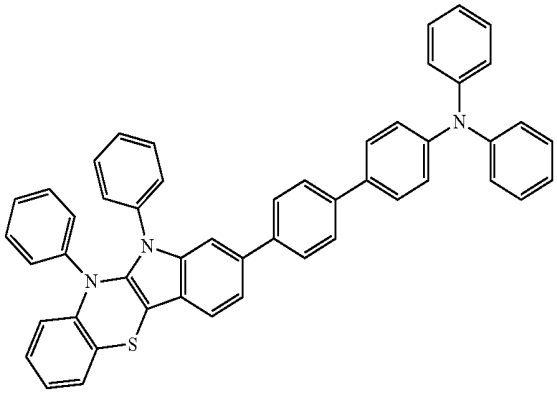


-continued

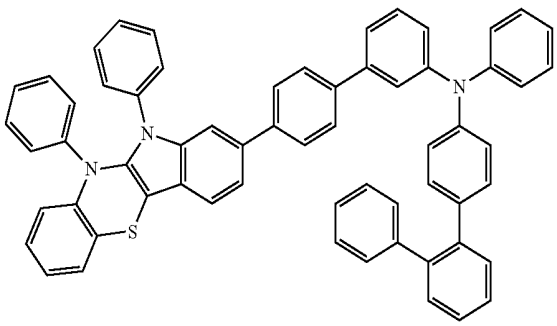
C26



C27

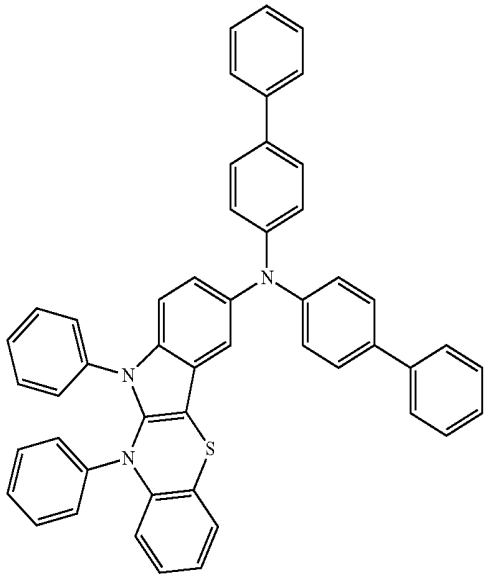


C28

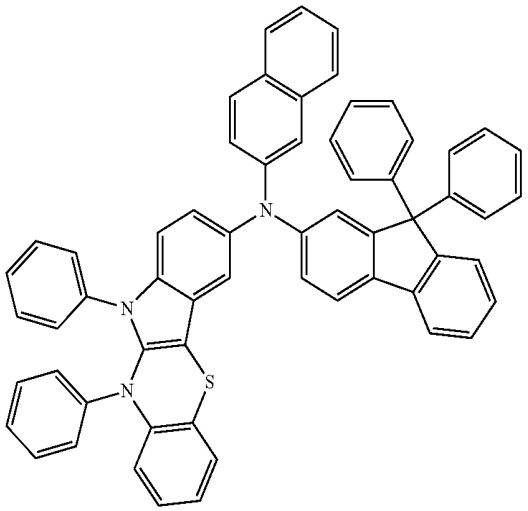


-continued

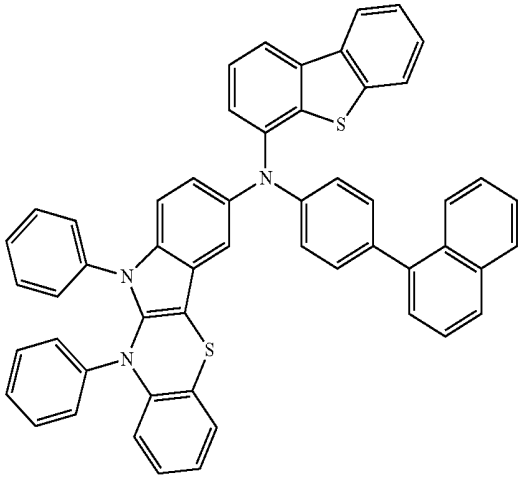
C29



C30

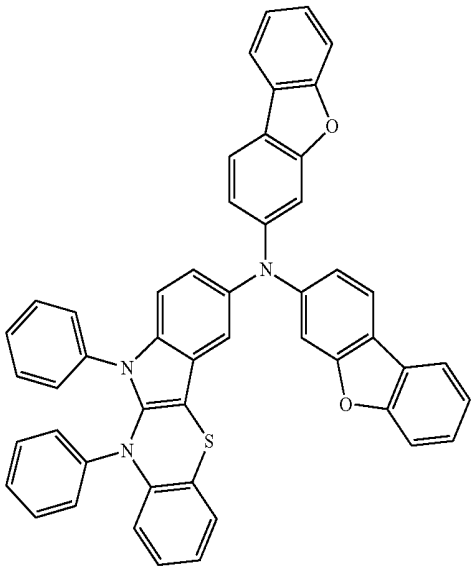


C31

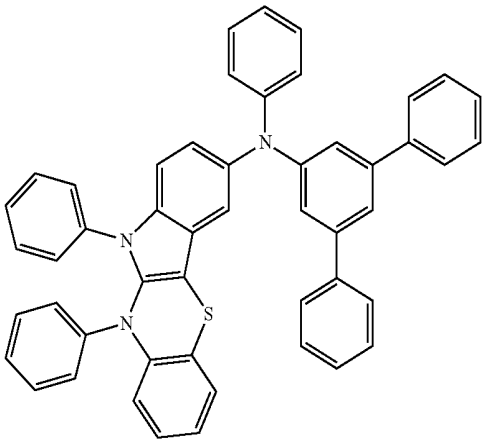


-continued

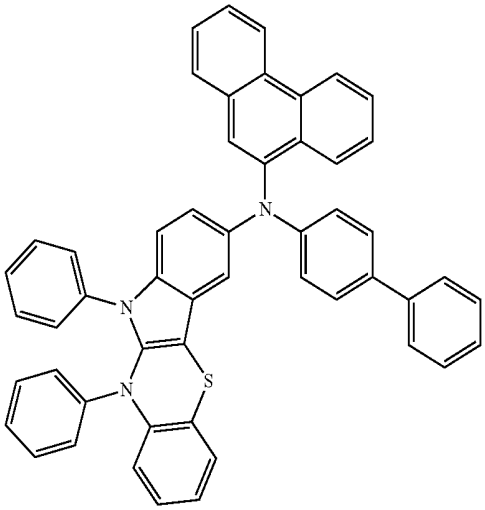
C32



C33

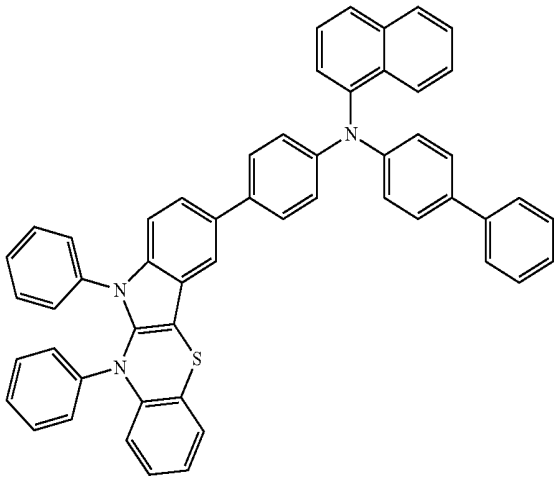


C34

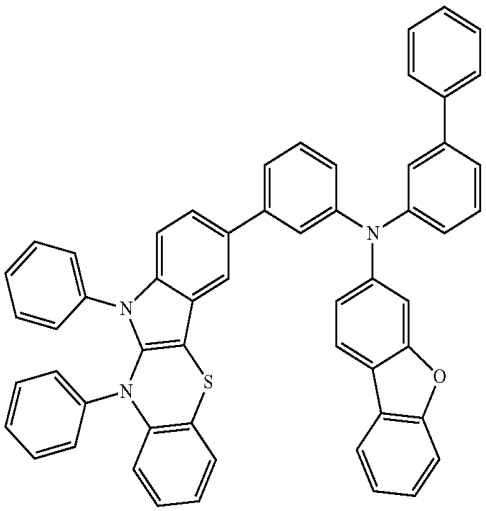


-continued

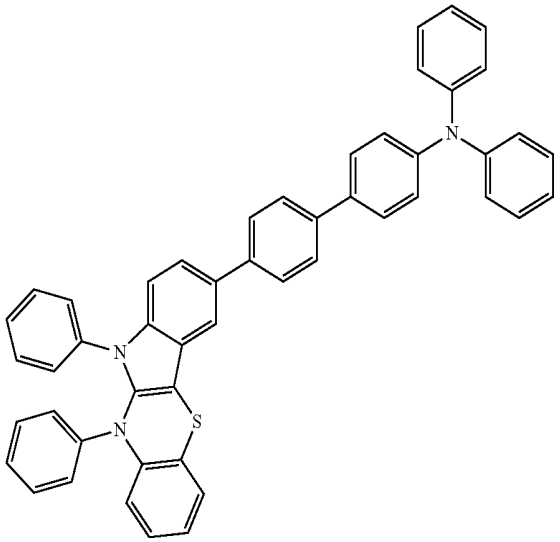
C35



C36

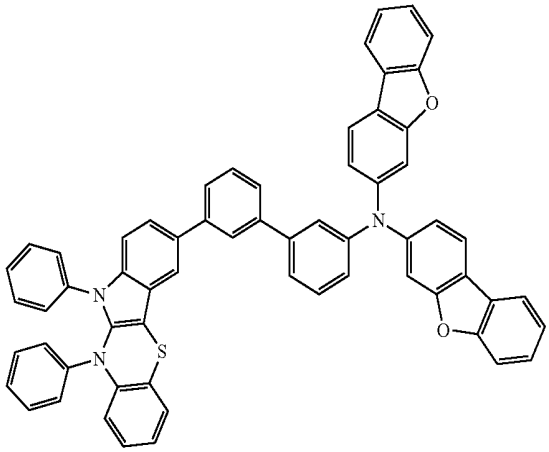


C37

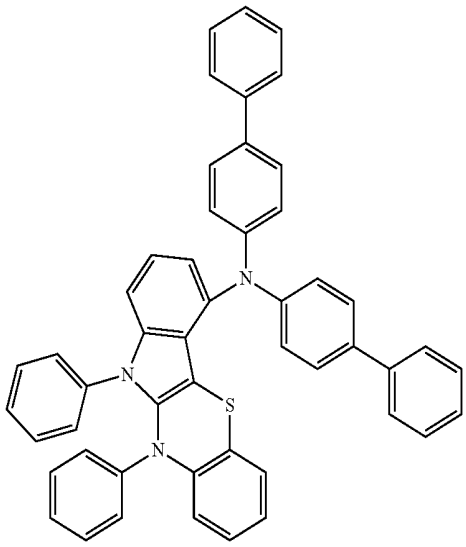


-continued

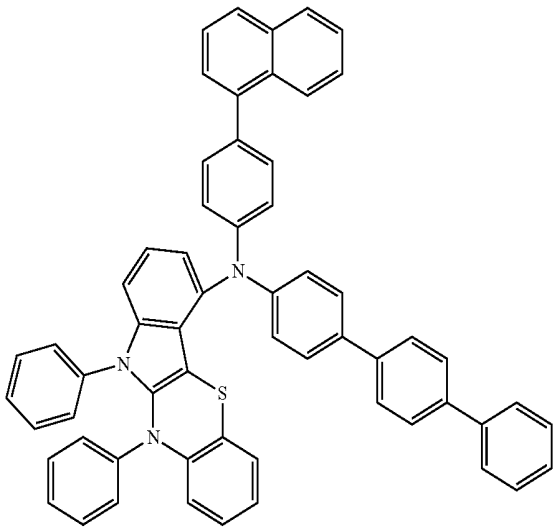
C38



C39

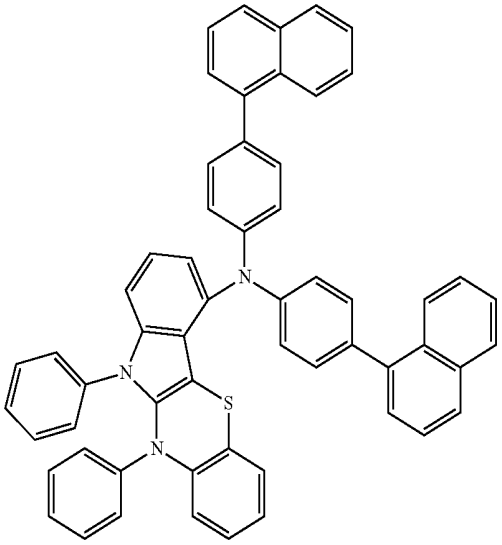


C40

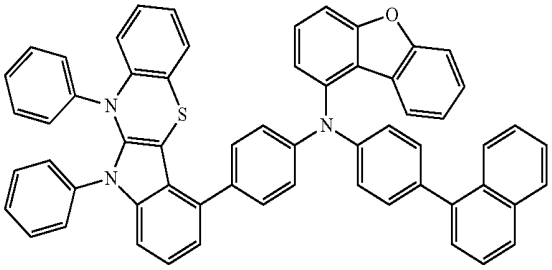


-continued

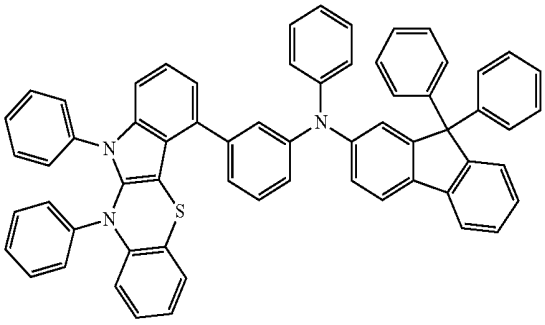
C41



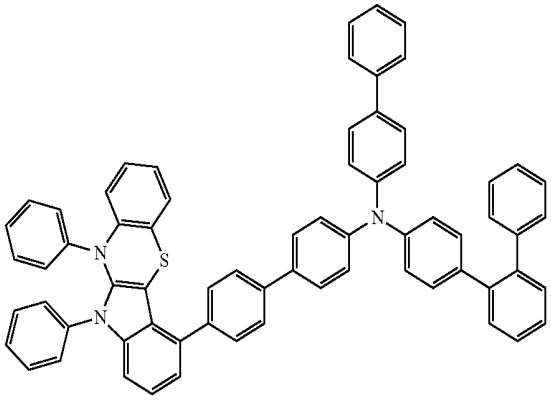
C42



C43

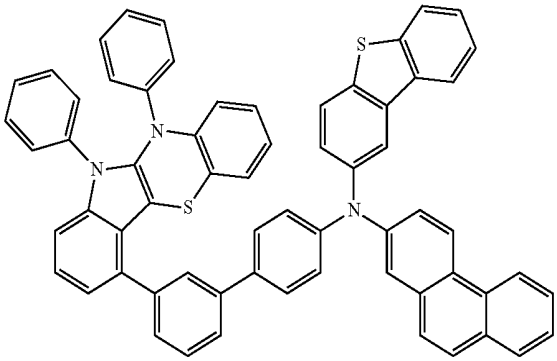


C44

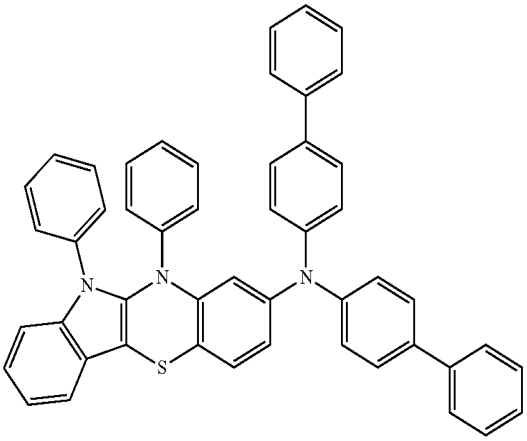


-continued

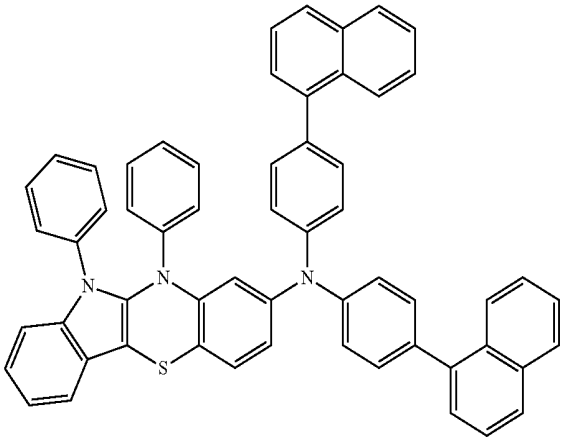
C45



C46

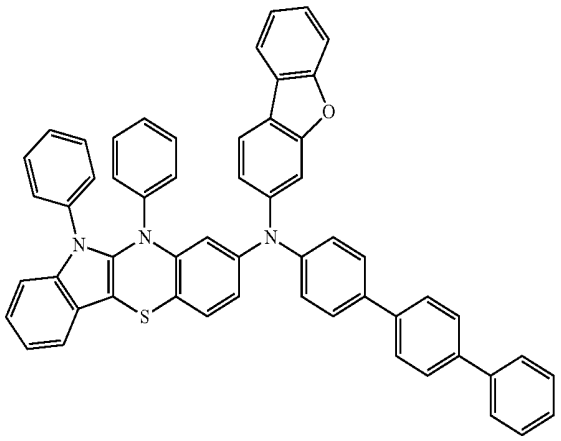


C47

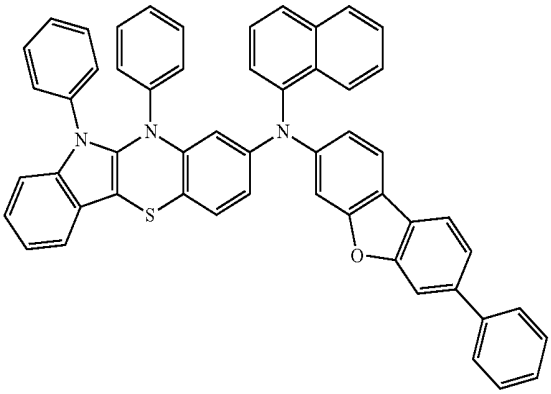


-continued

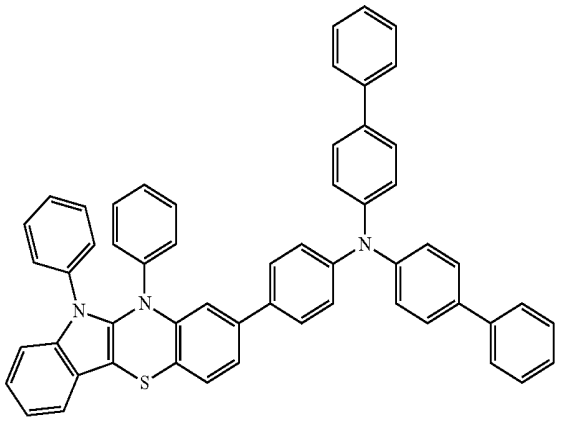
C48



C49

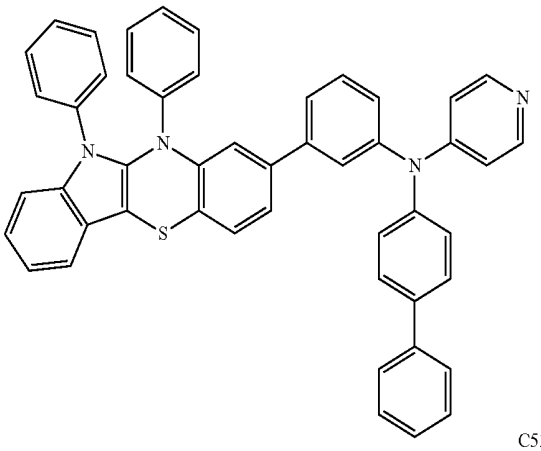


C50

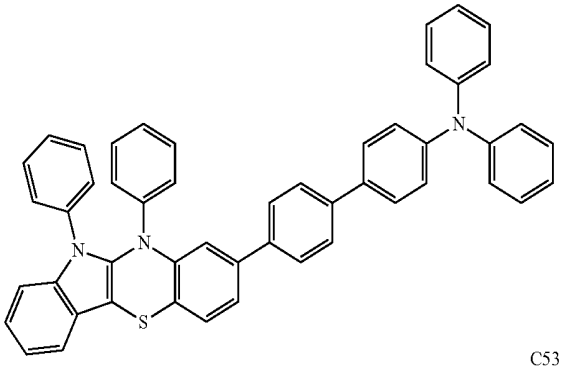


-continued

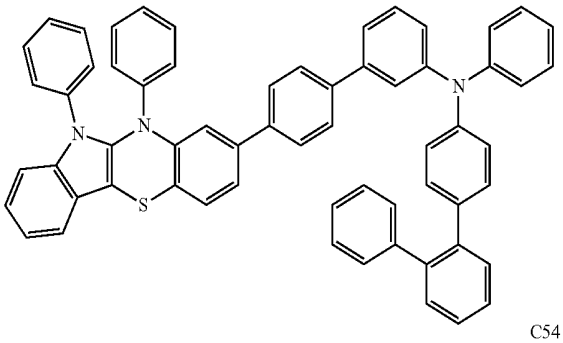
C51



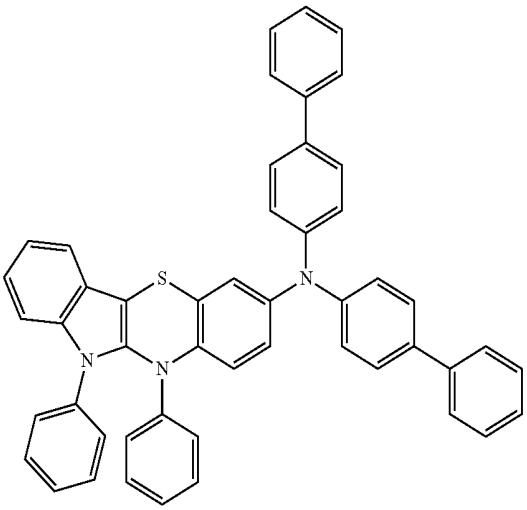
C52



C53

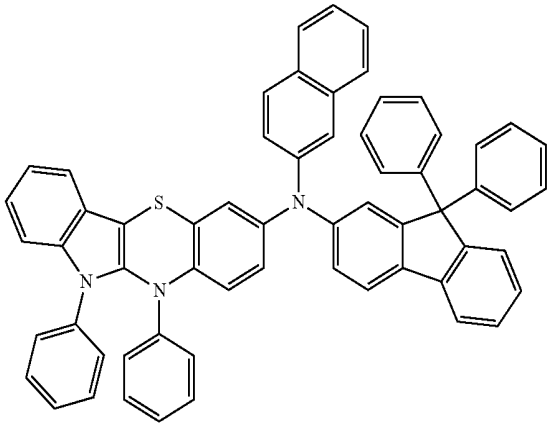


C54

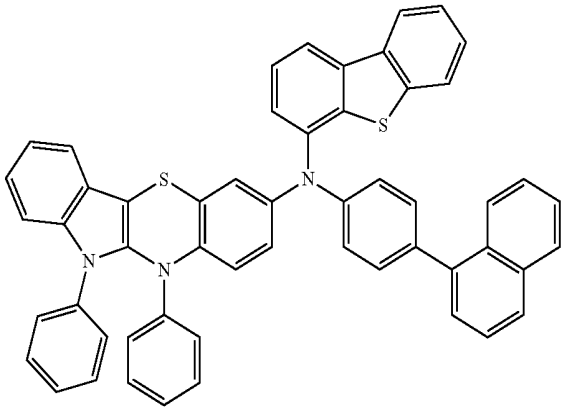


-continued

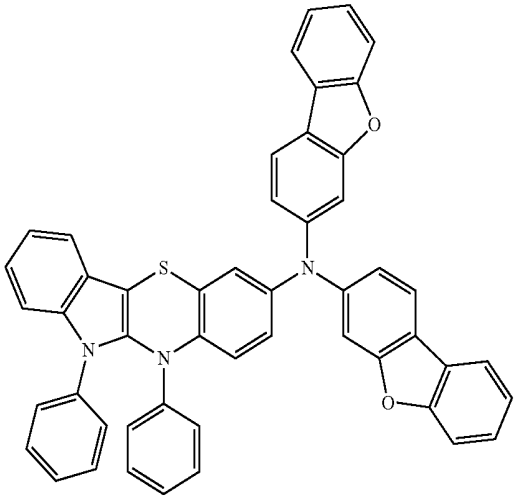
C55



C56

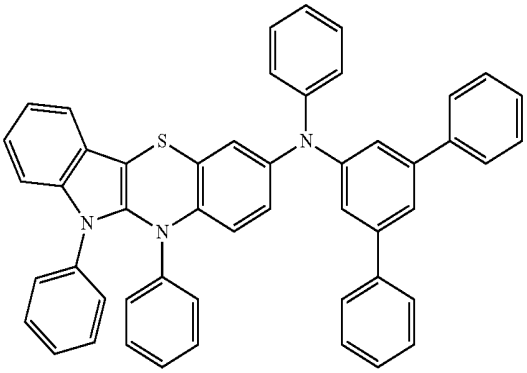


C57

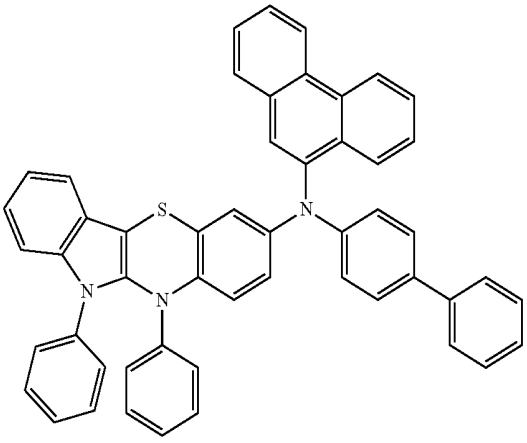


-continued

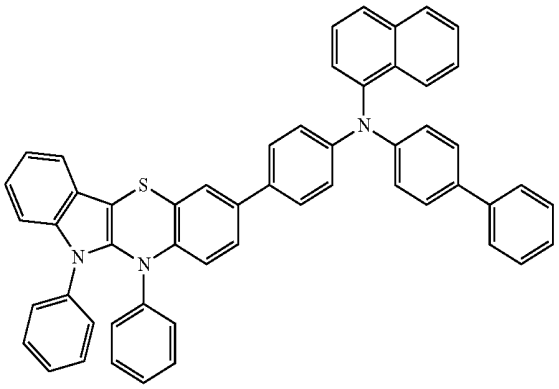
C58



C59

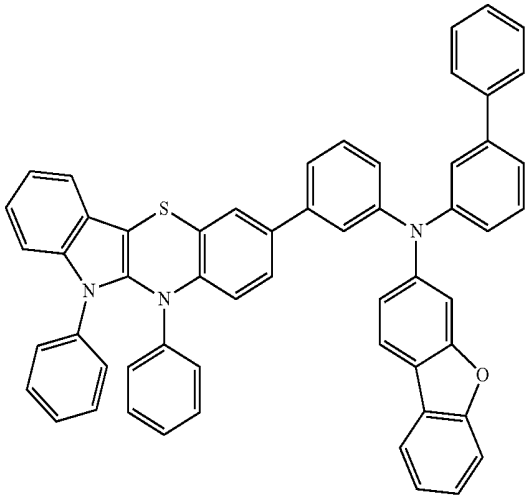


C60

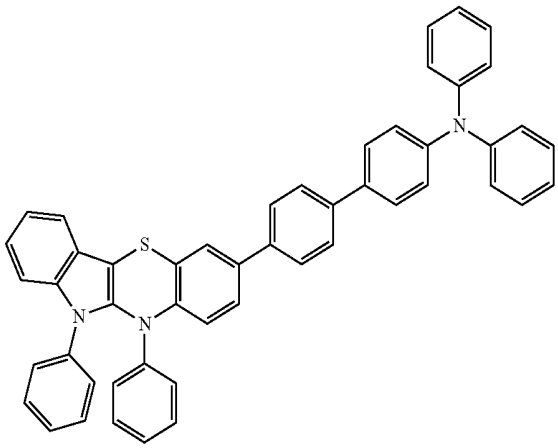


-continued

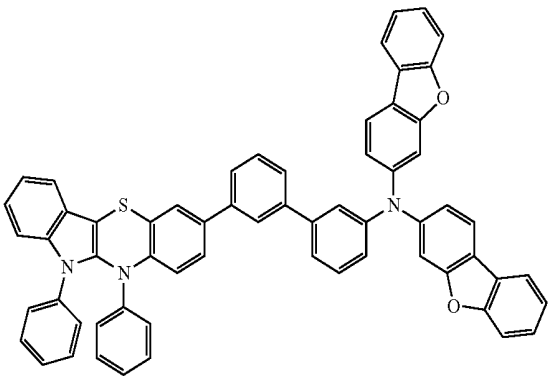
C61



C62

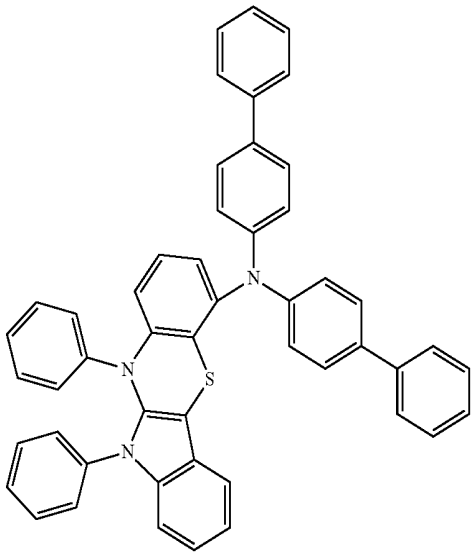


C63

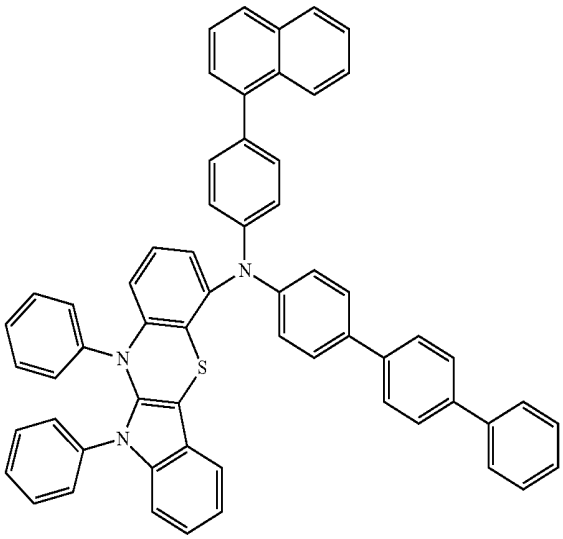


-continued

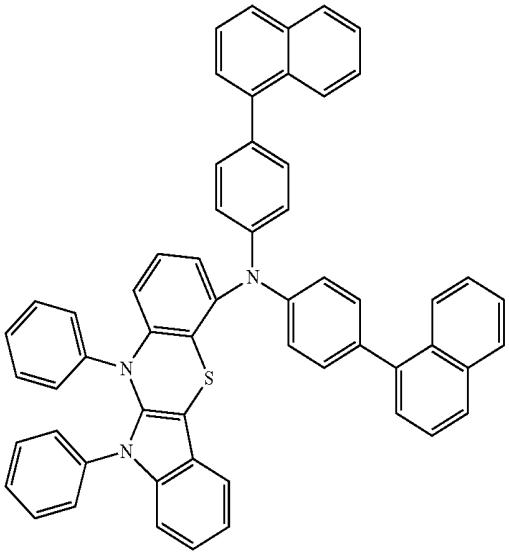
C64



C65

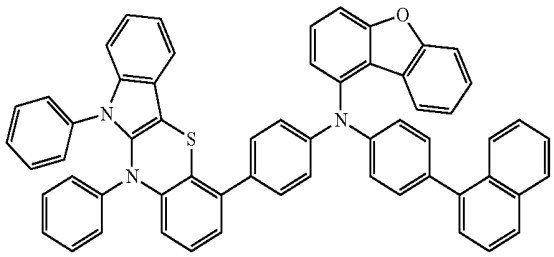


C66

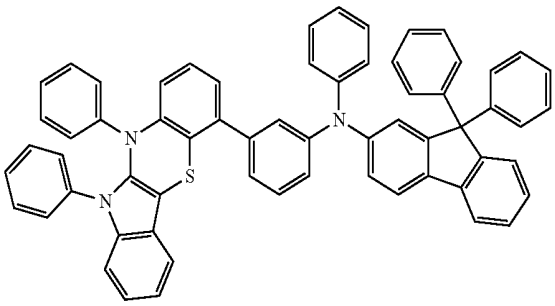


-continued

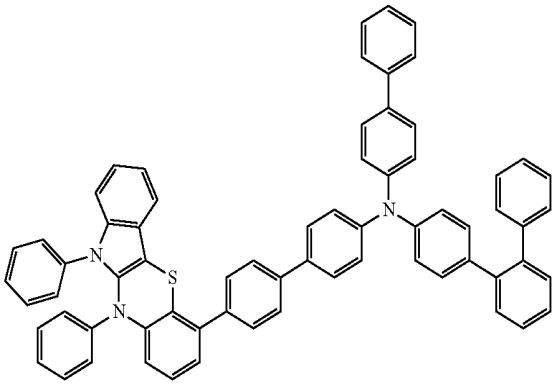
C67



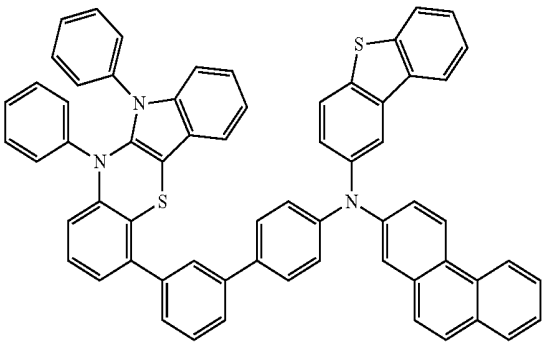
C68



C69

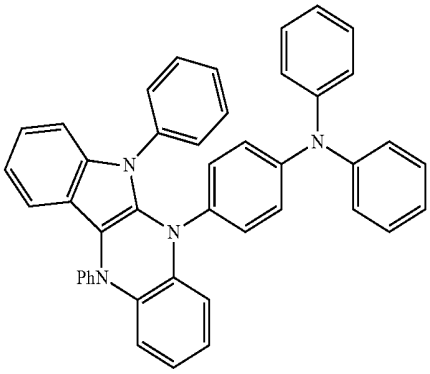


C70

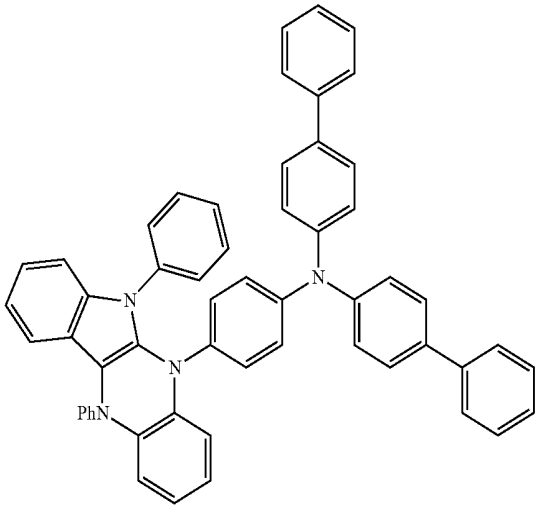


[0087] [Compound Group 4]

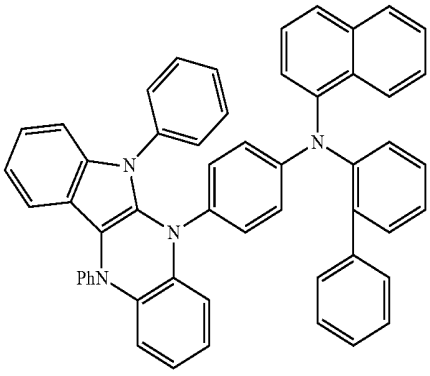
D1



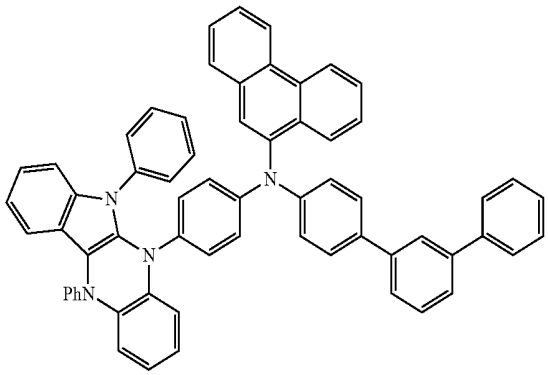
D2



D3

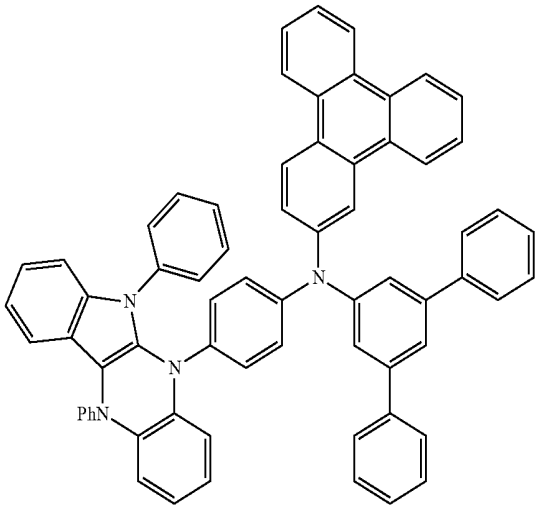


D4

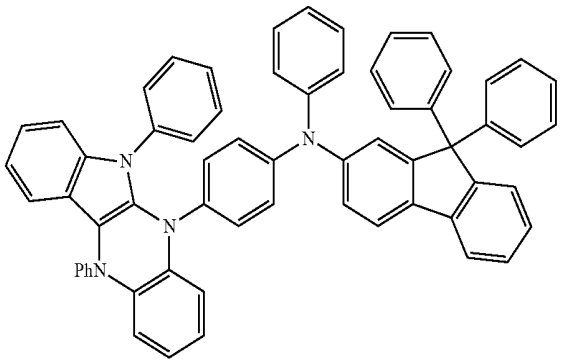


-continued

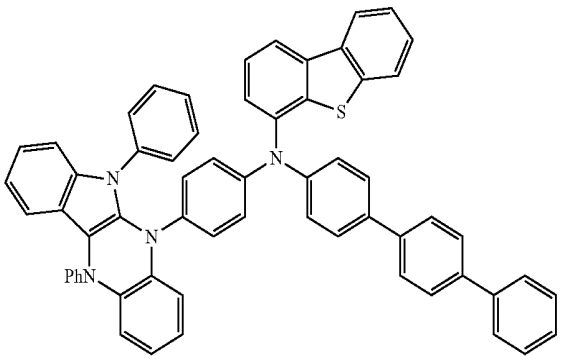
D5



D6

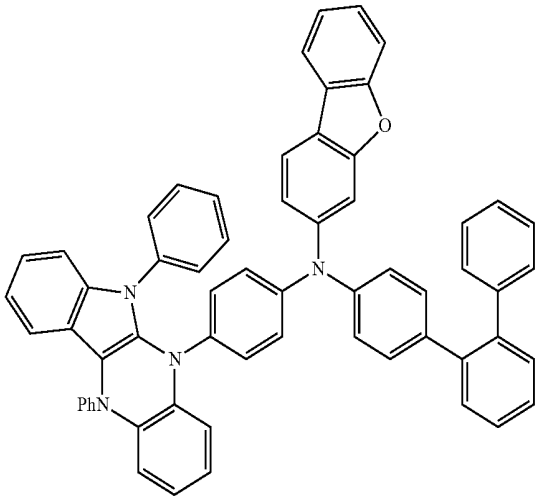


D7

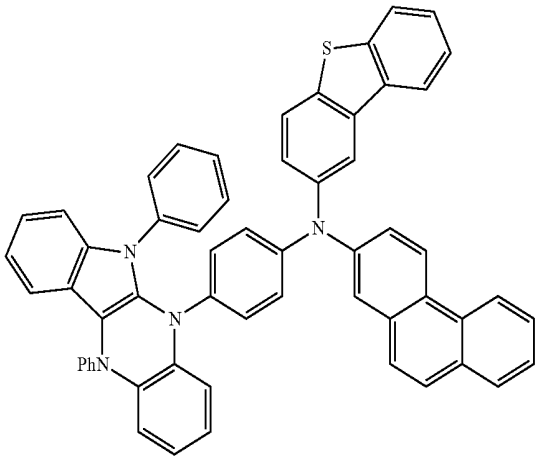


-continued

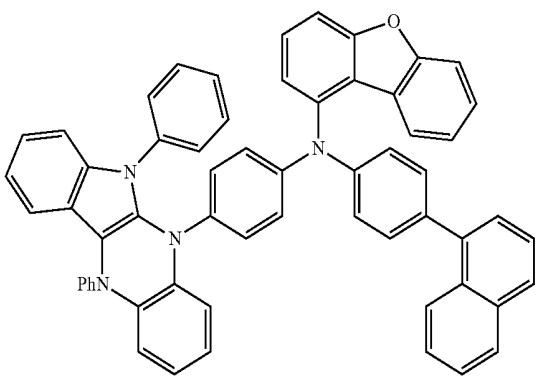
D8



D9

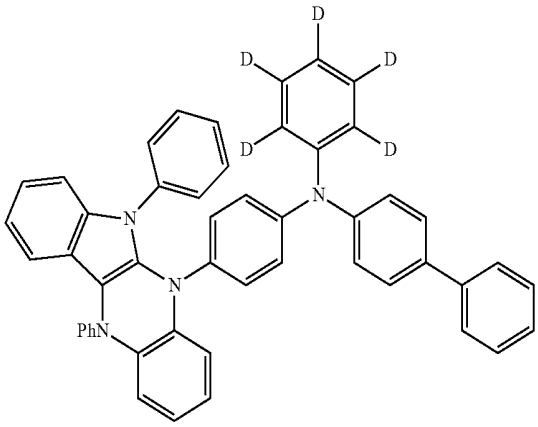


D10

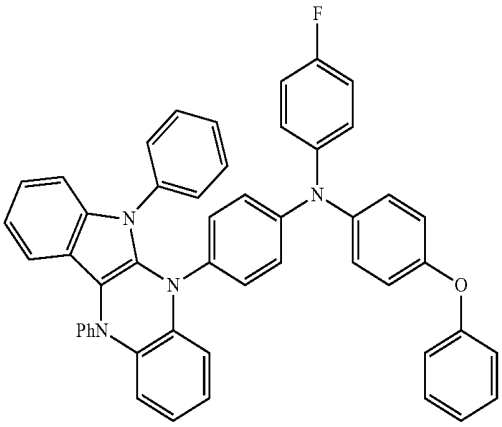


-continued

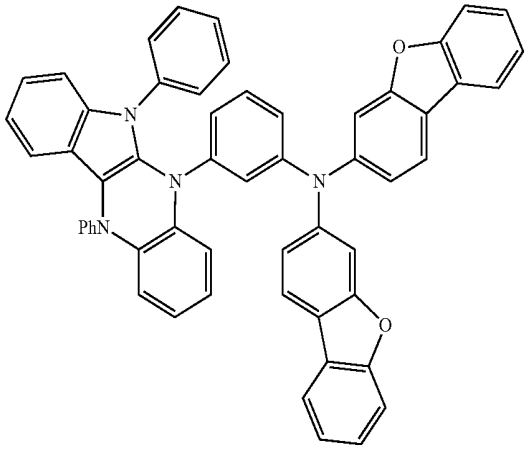
D11



D12

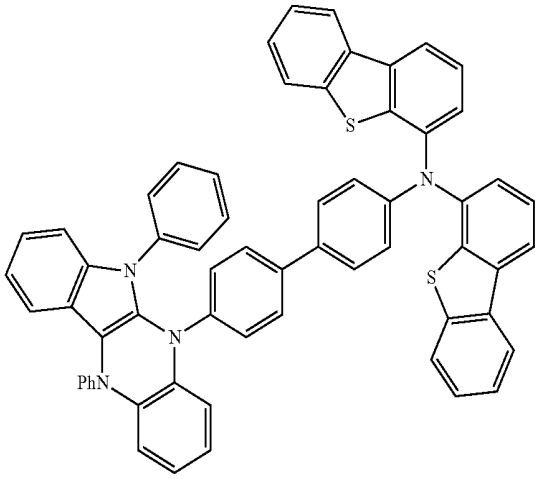


D13

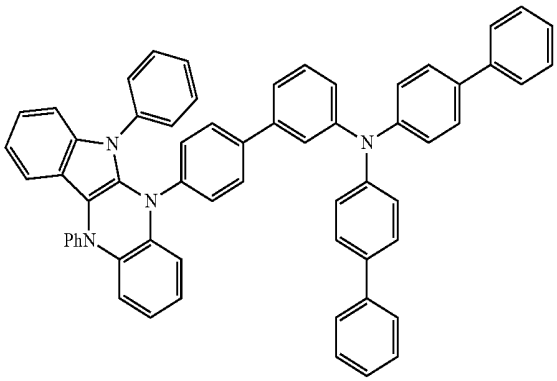


-continued

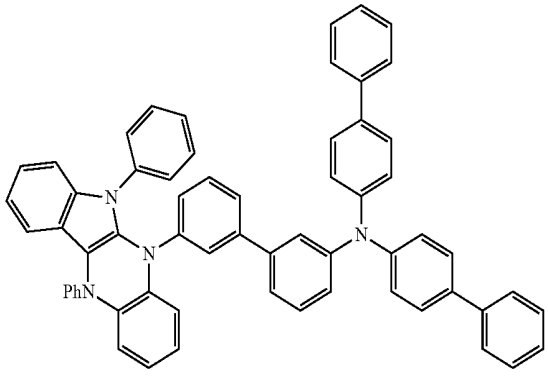
D14



D15

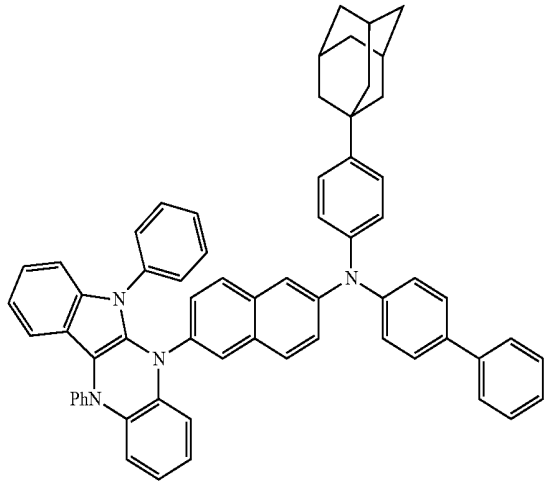


D16

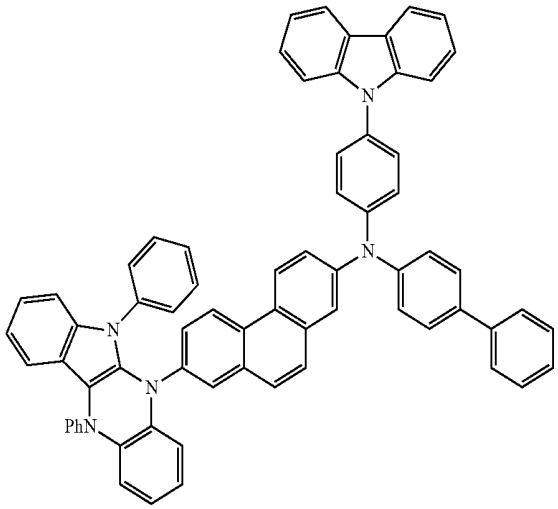


-continued

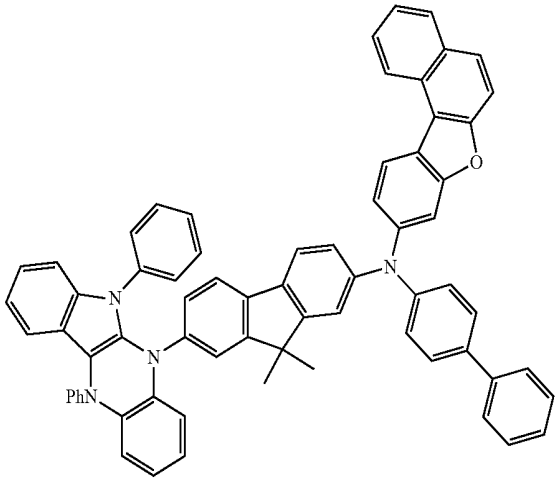
D17



D18

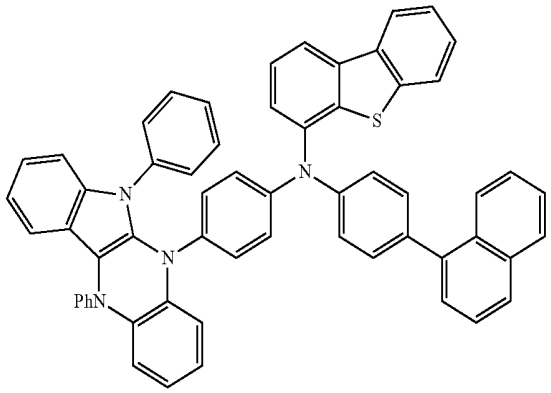


D19

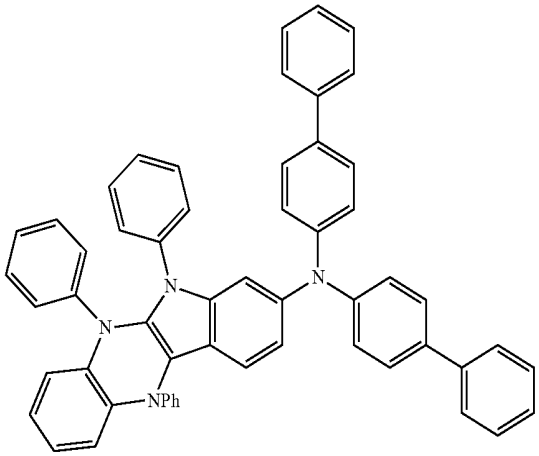


-continued

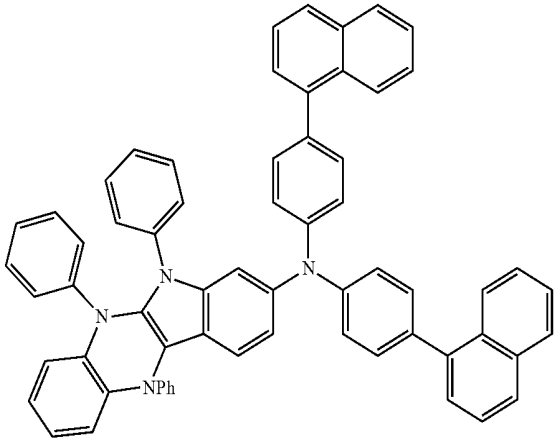
D20



D21

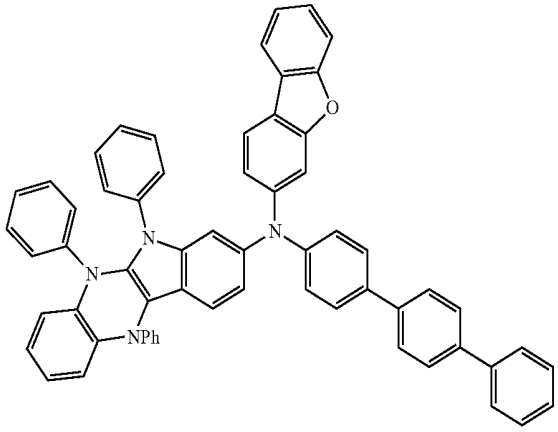


D22

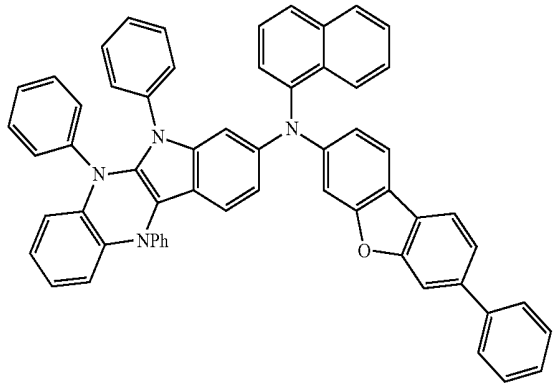


-continued

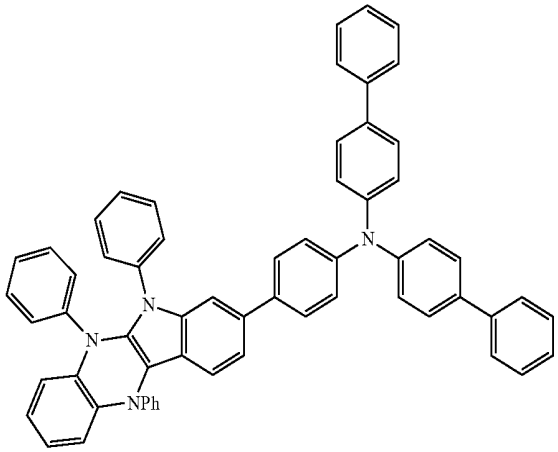
D23



D24

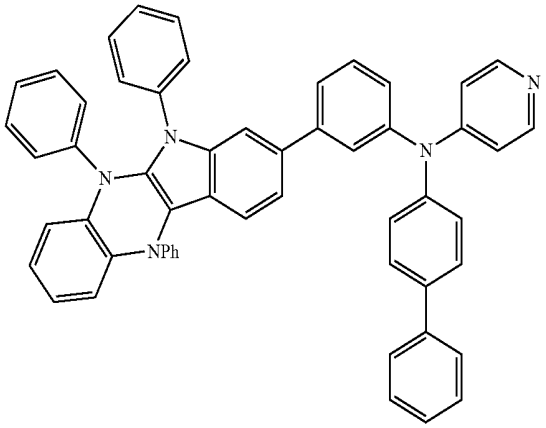


D25

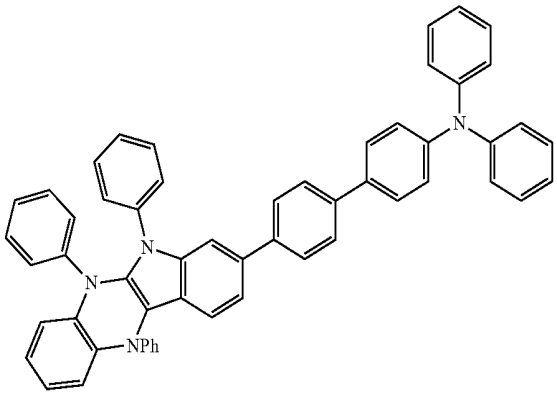


-continued

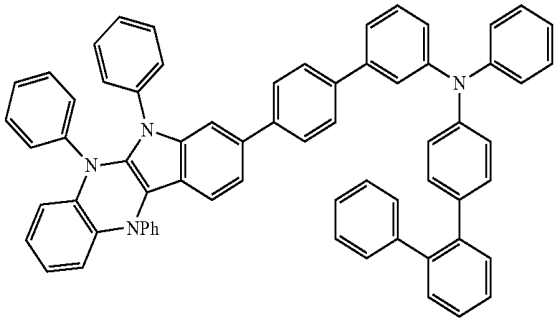
D26



D27

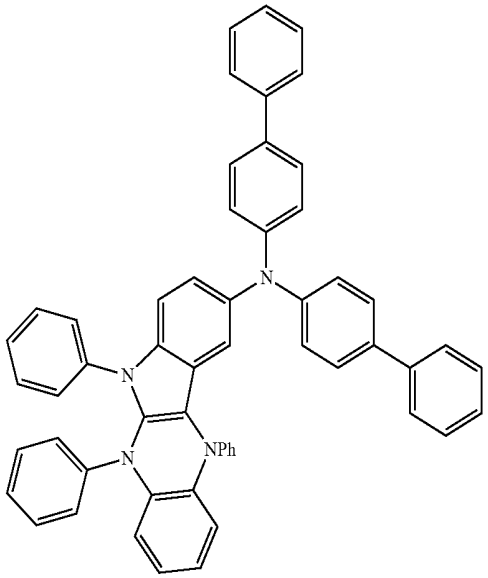


D28

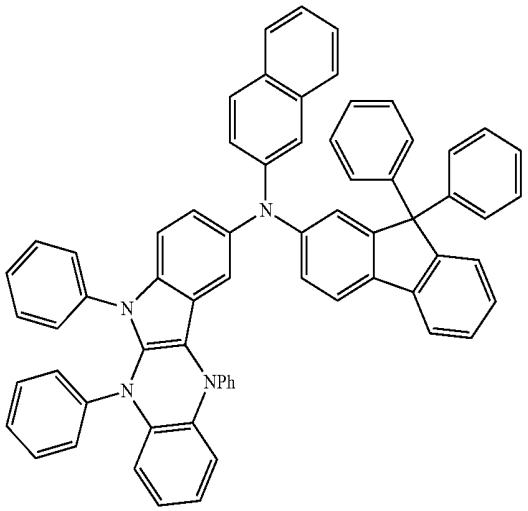


-continued

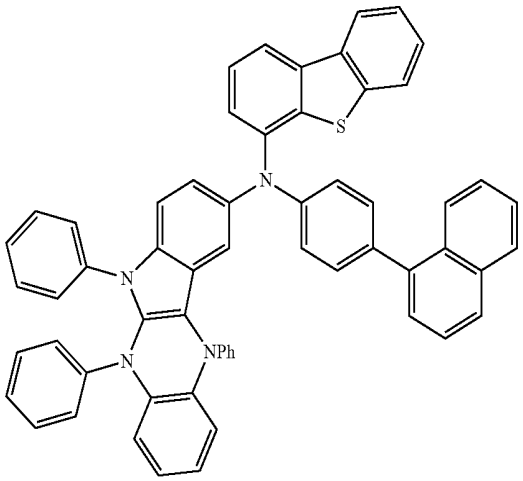
D29



D30

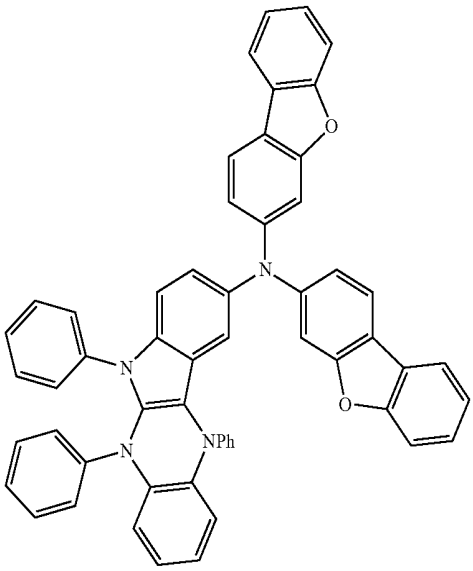


D31

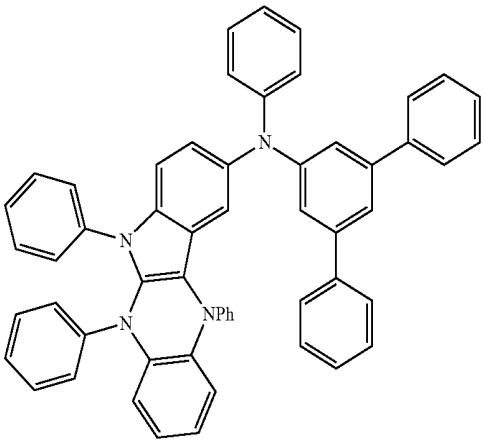


-continued

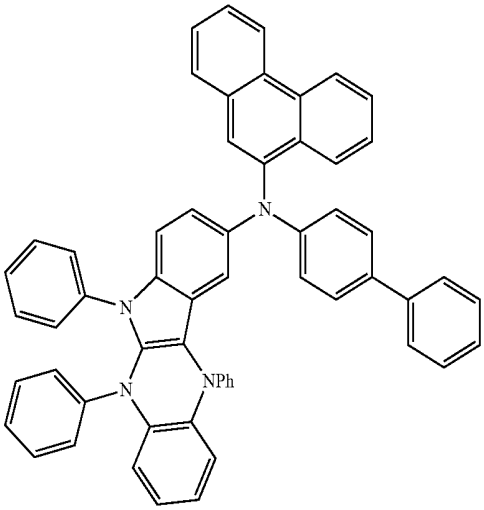
D32



D33

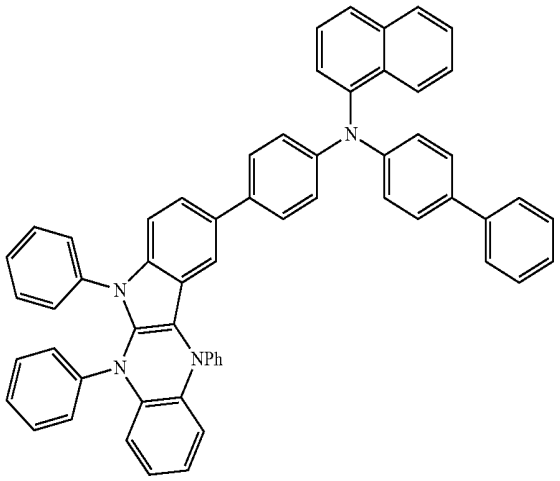


D34

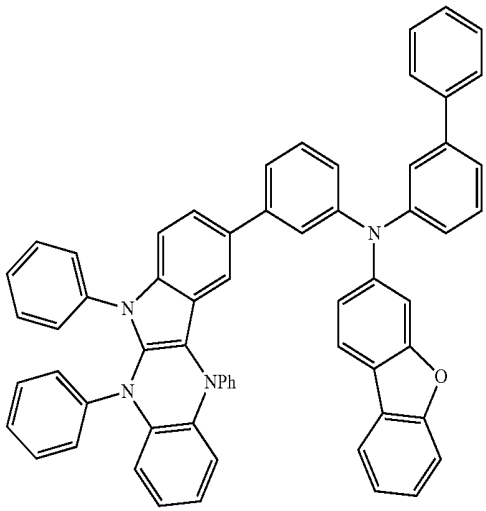


-continued

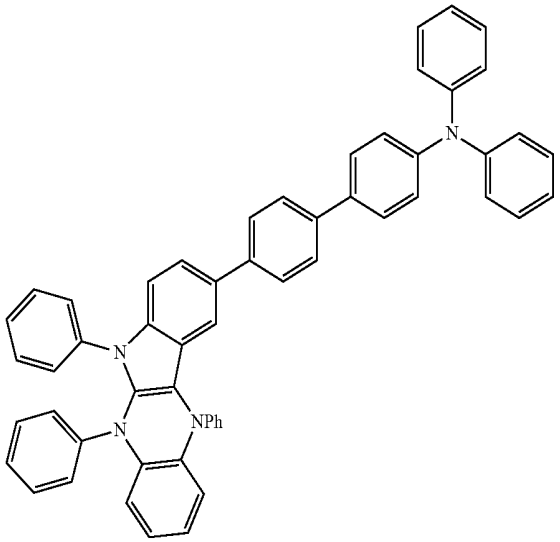
D35



D36

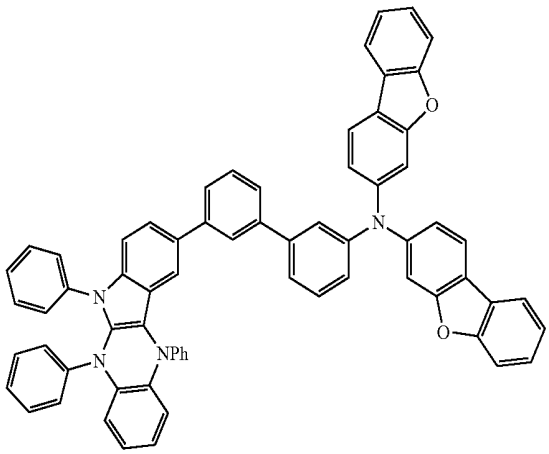


D37

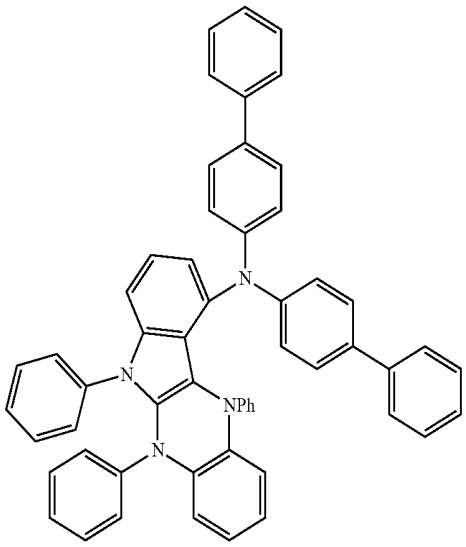


-continued

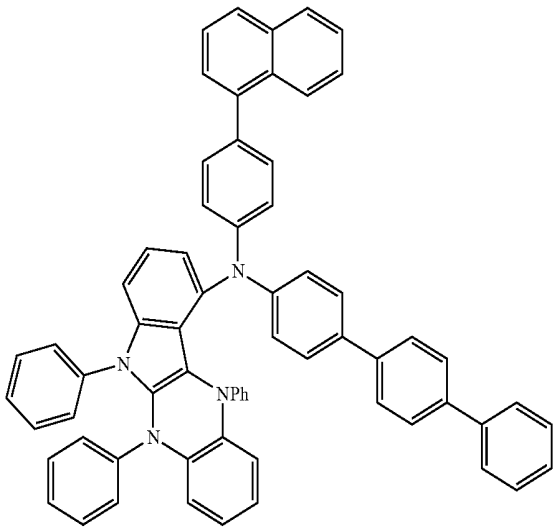
D38



D39

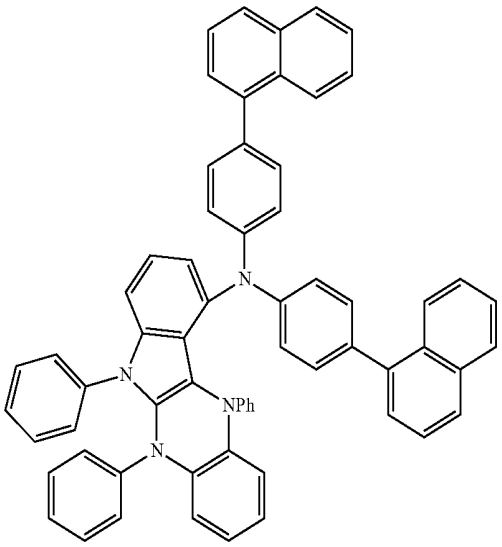


D40

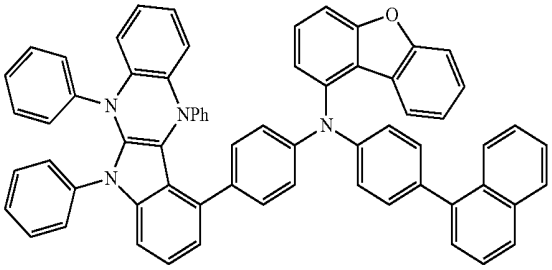


-continued

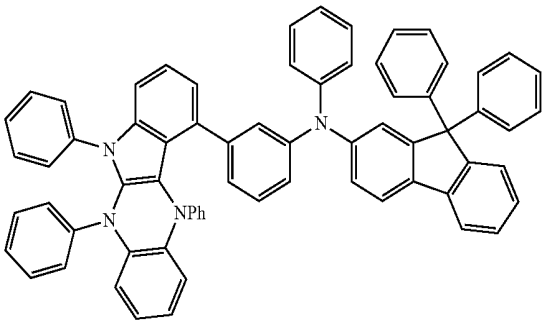
D41



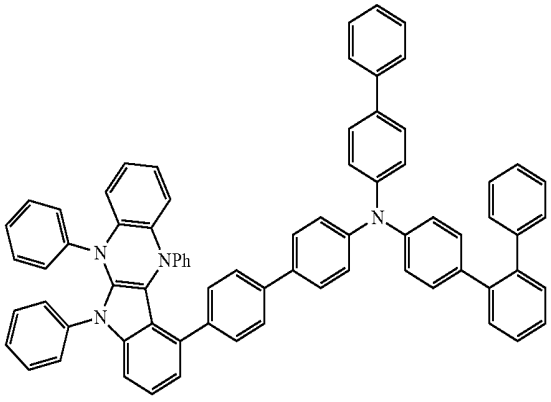
D42



D43

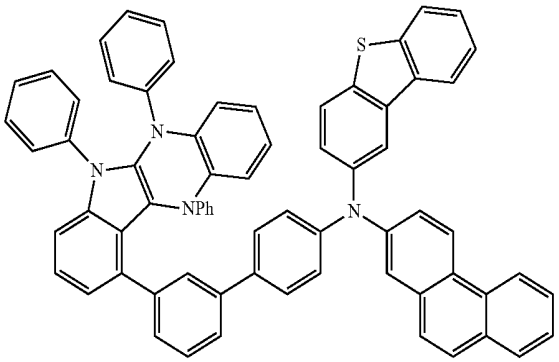


D44

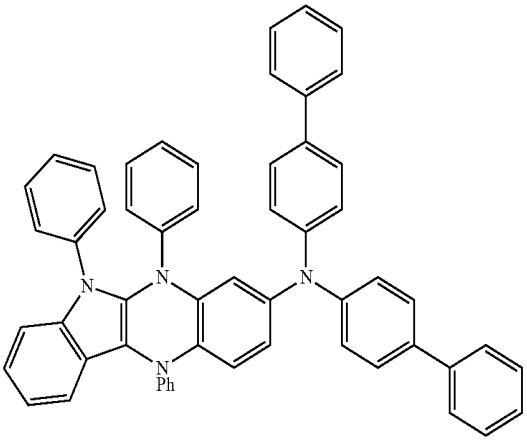


-continued

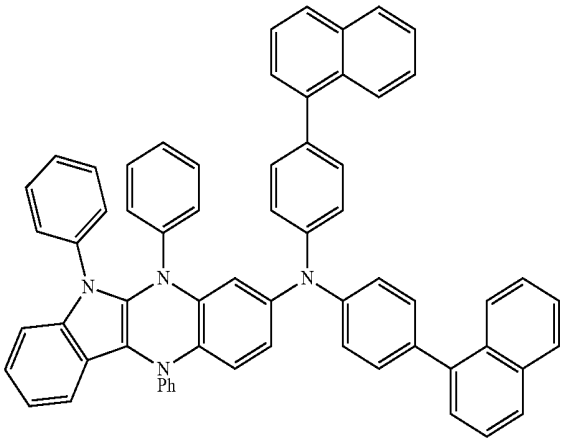
D45



D46

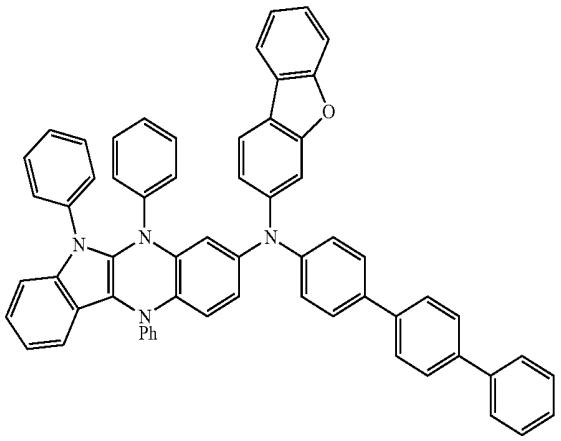


D47

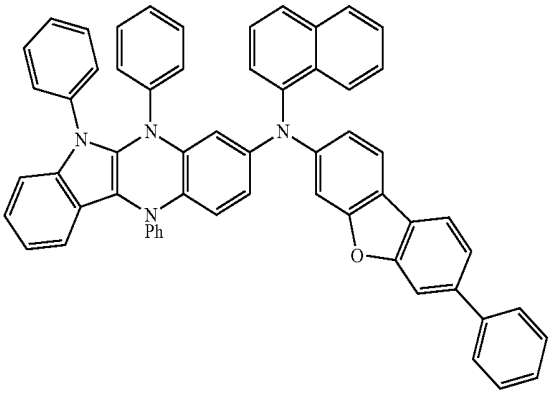


-continued

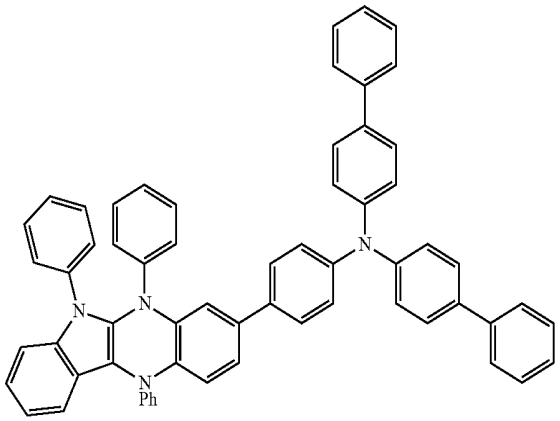
D48



D49

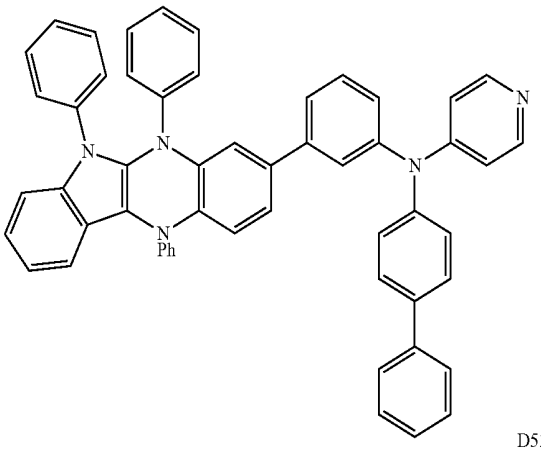


D50

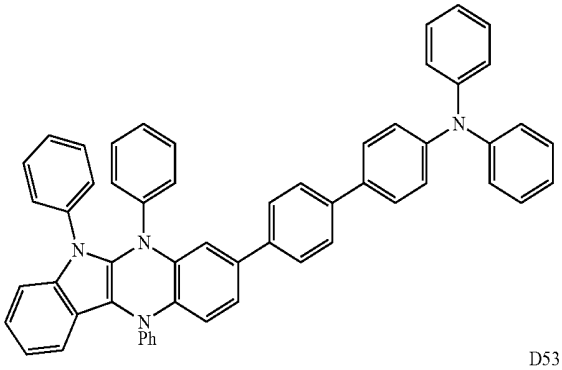


-continued

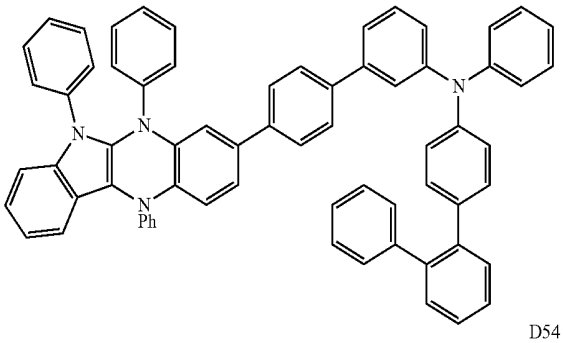
D51



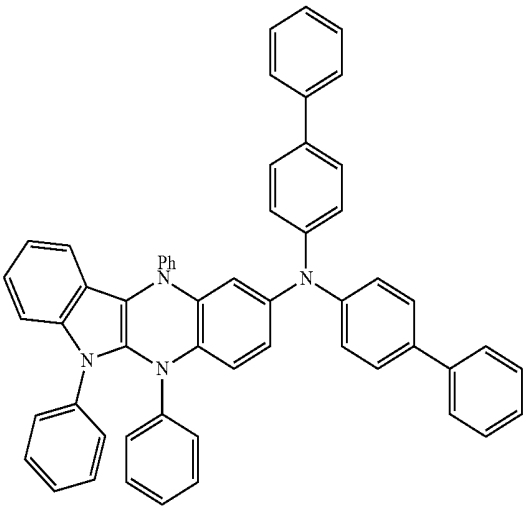
D52



D53

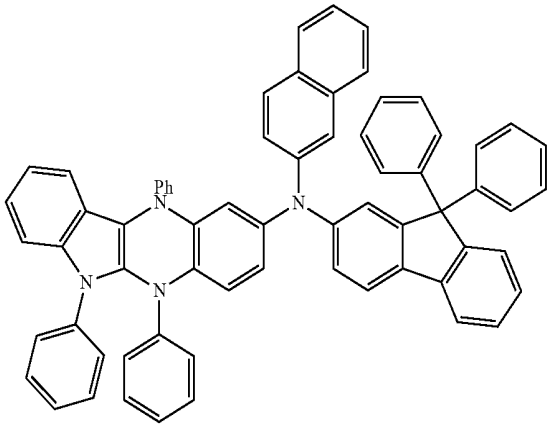


D54

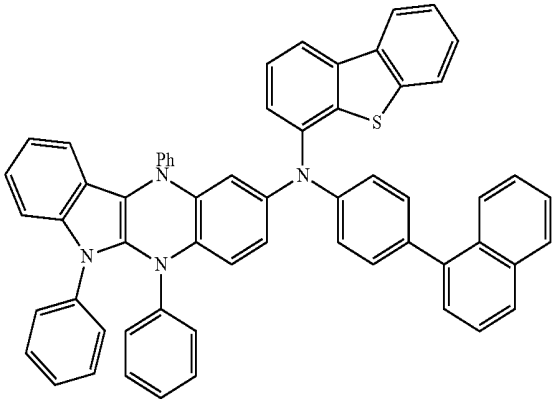


-continued

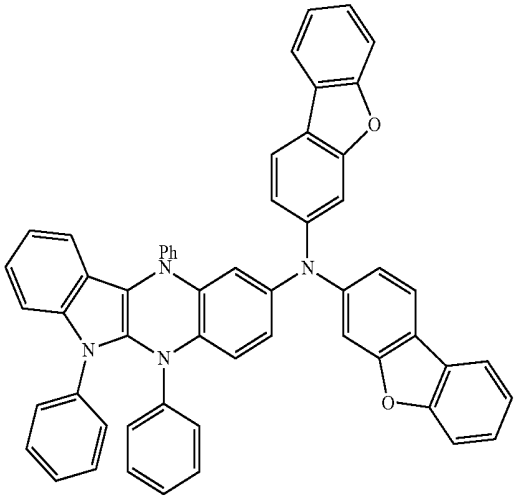
D55



D56

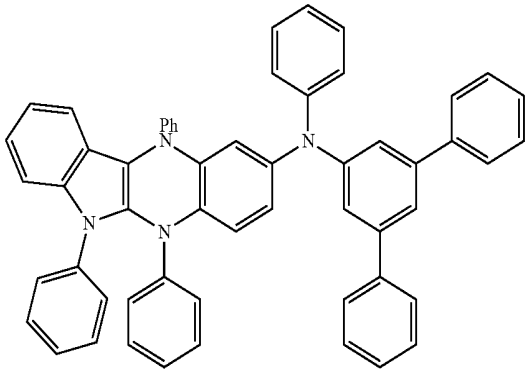


D57

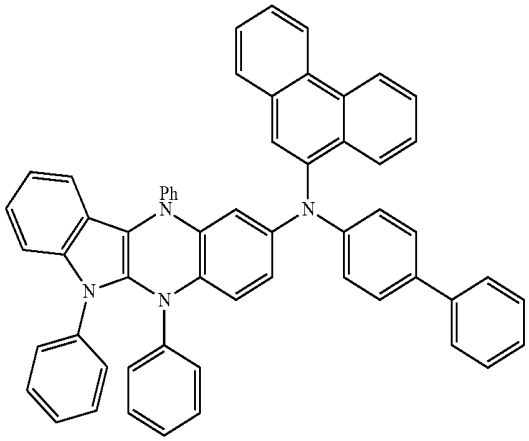


-continued

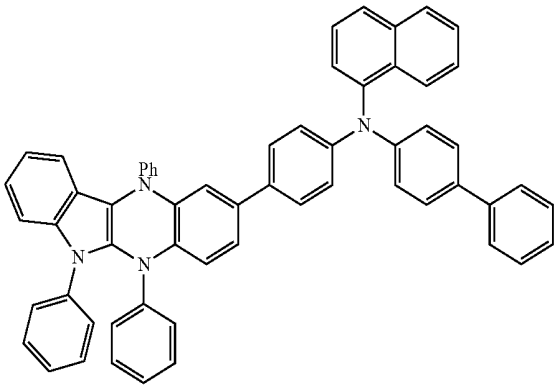
D58



D59

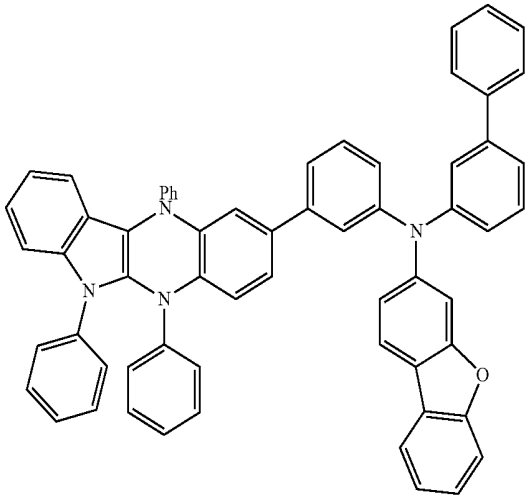


D60

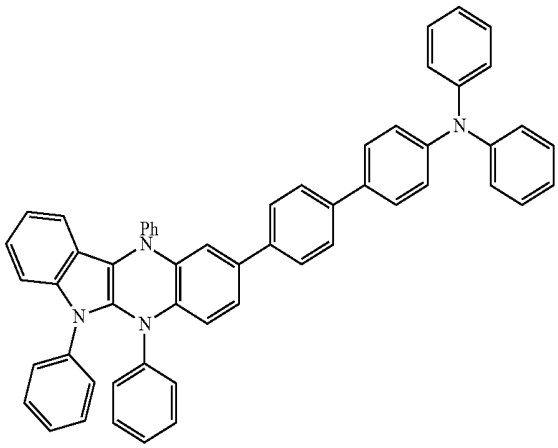


-continued

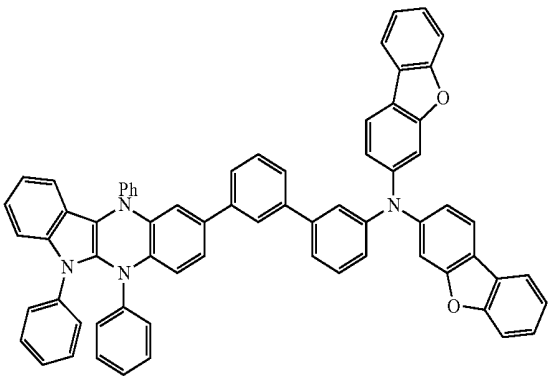
D61



D62

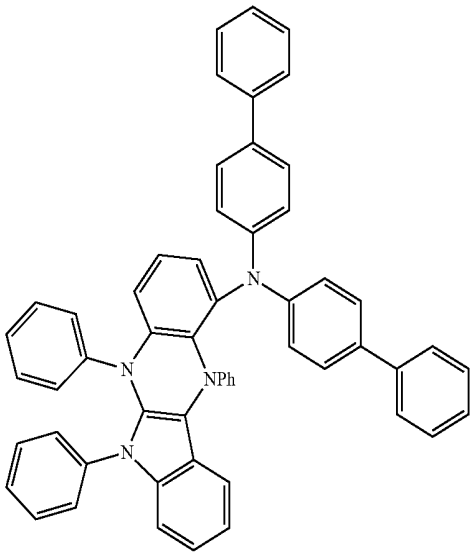


D63

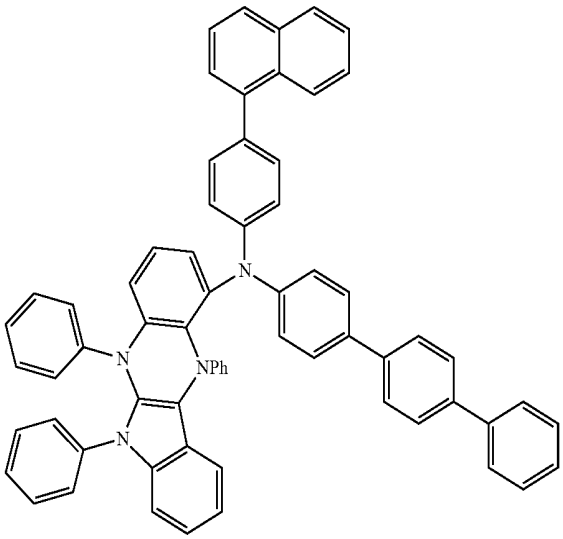


-continued

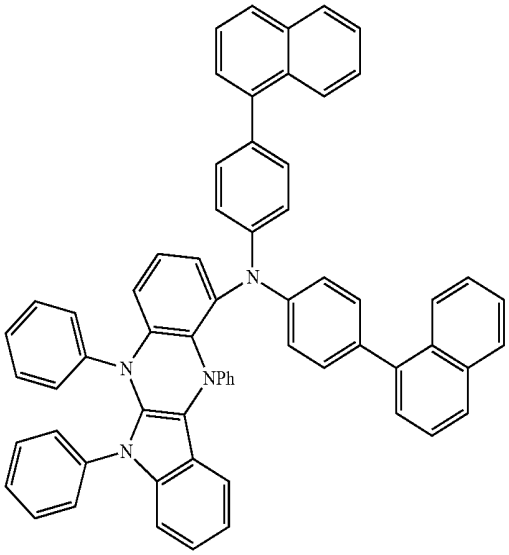
D64



D65

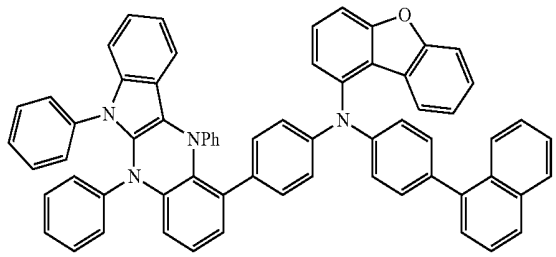


D66

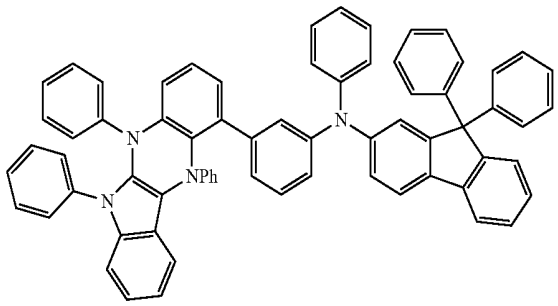


-continued

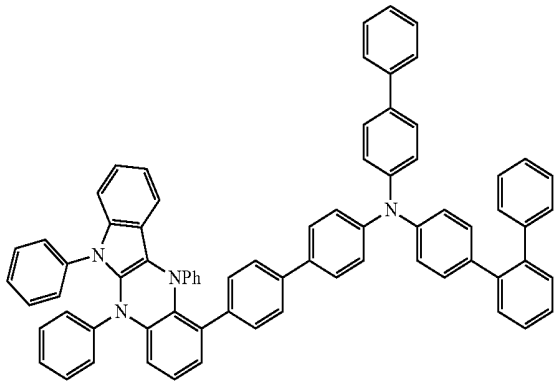
D67



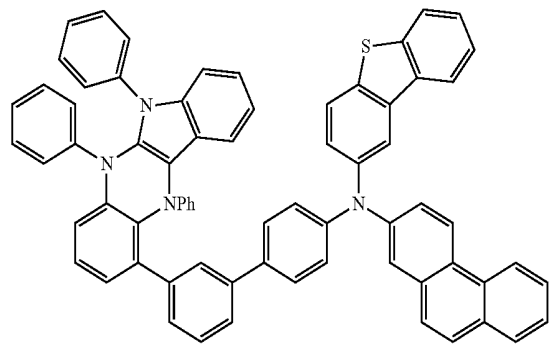
D68



D69

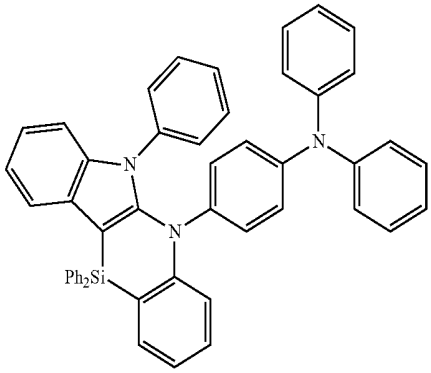


D70

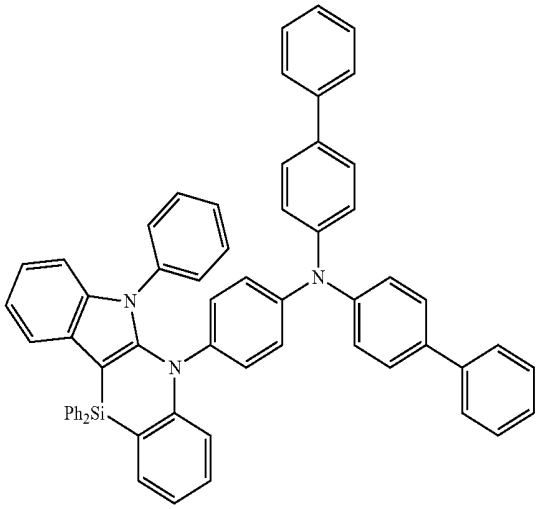


[0088] [Compound Group 5]

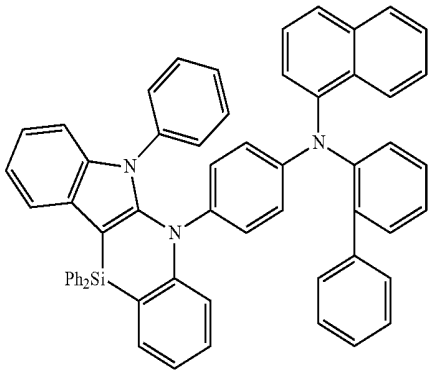
E1



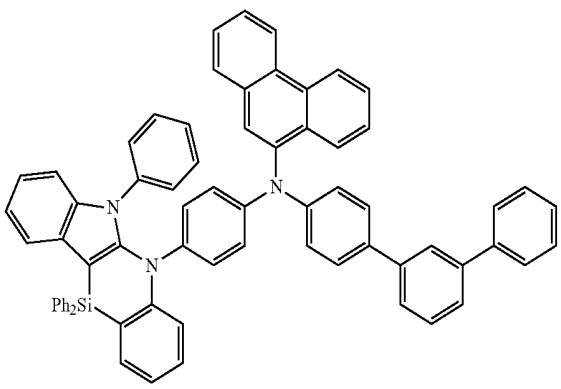
E2



E3

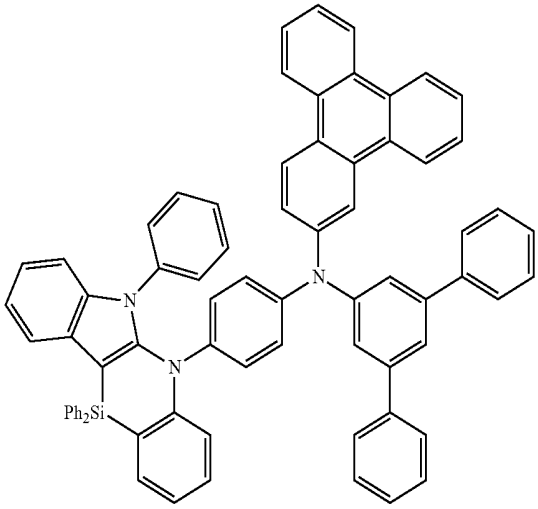


E4

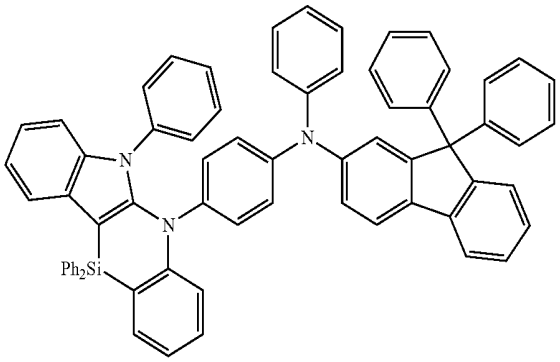


-continued

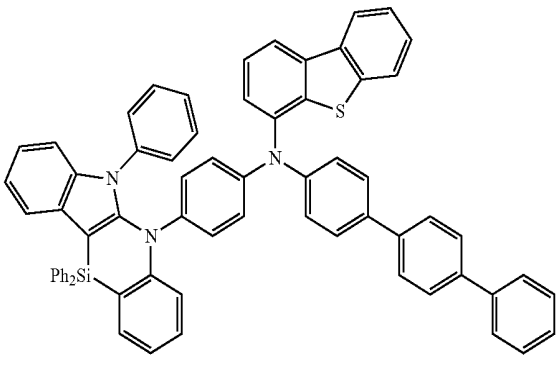
E5



E6

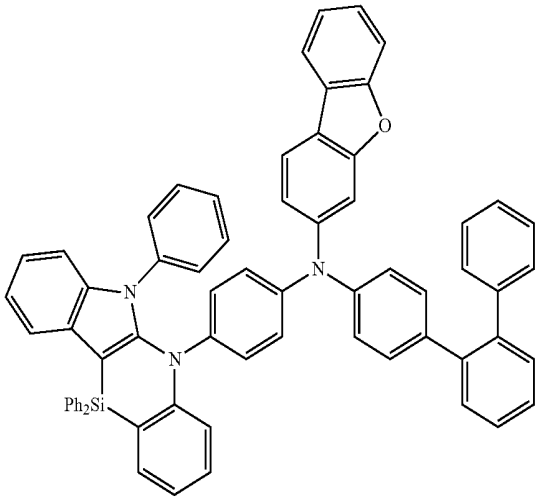


E7

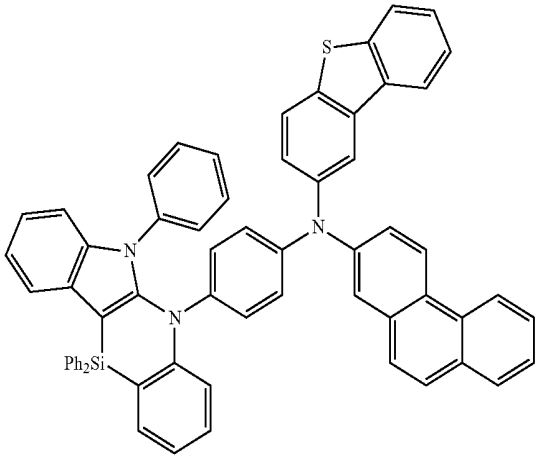


-continued

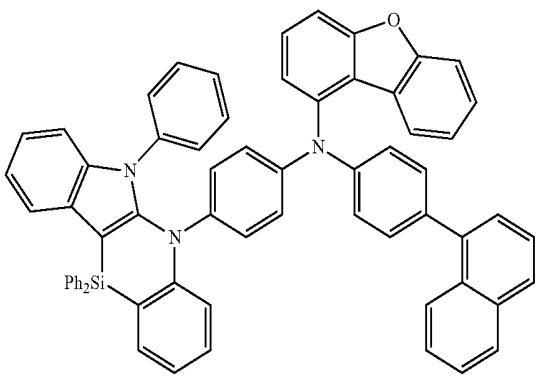
E8



E9

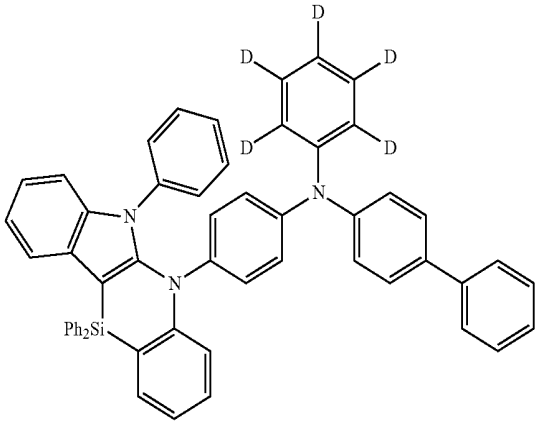


E10

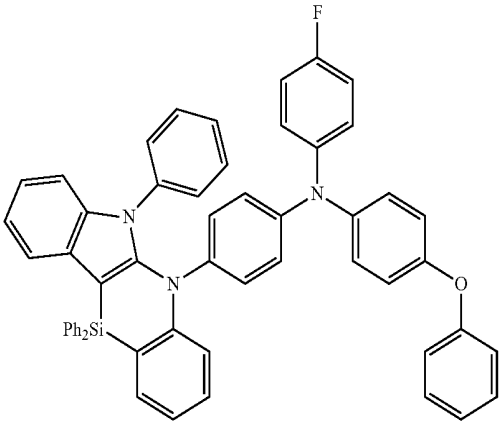


-continued

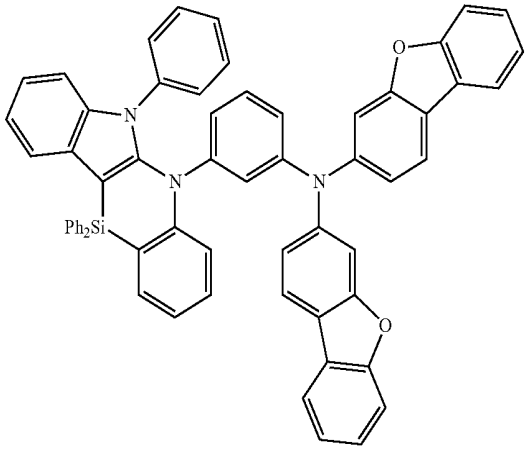
E11



E12

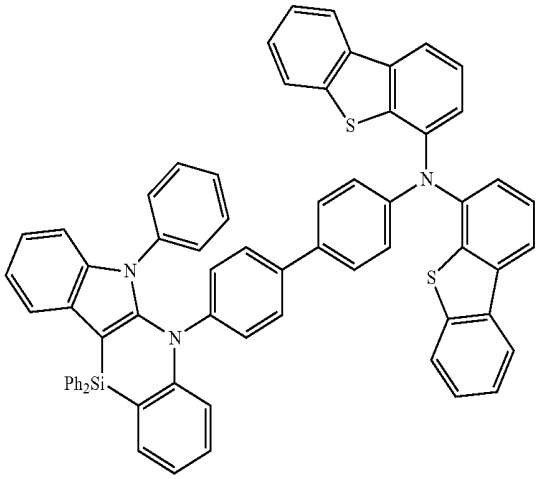


E13

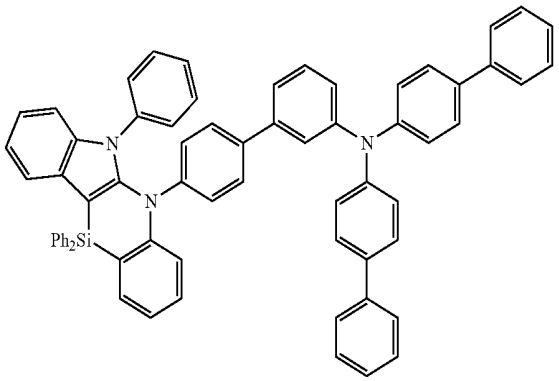


-continued

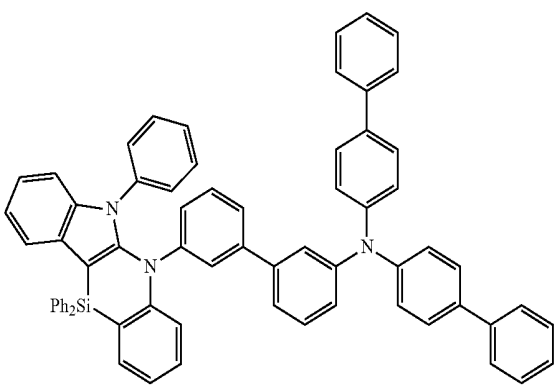
E14



E15

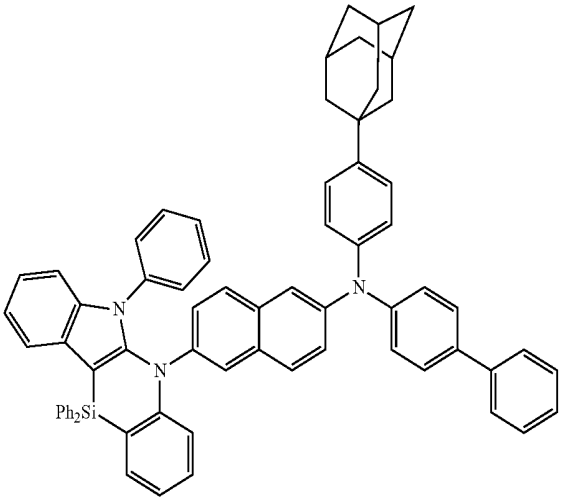


E16

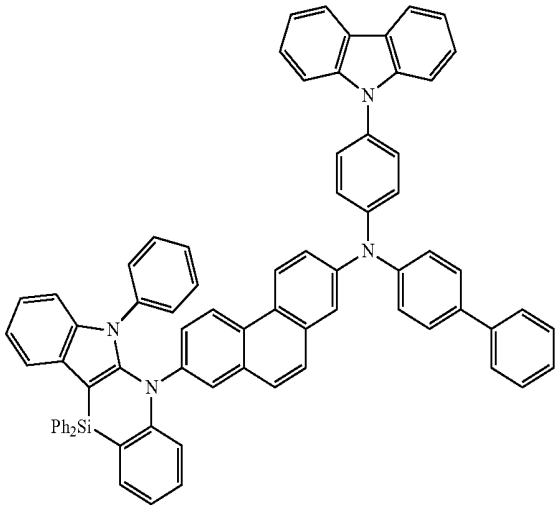


-continued

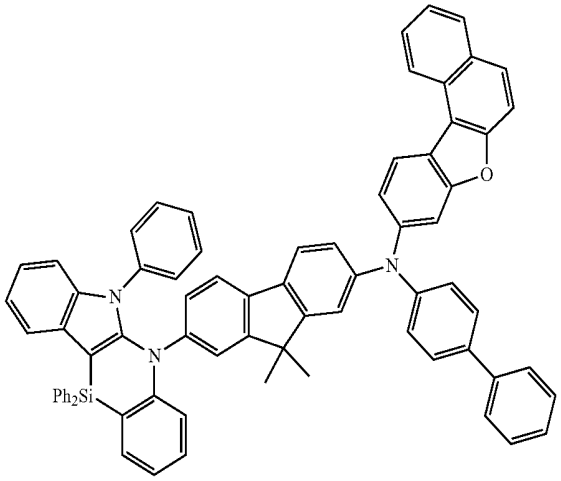
E17



E18

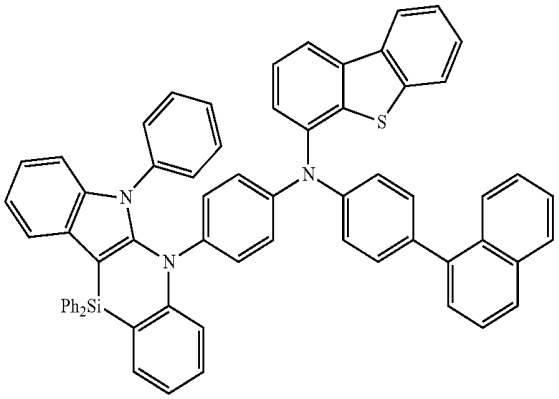


E19

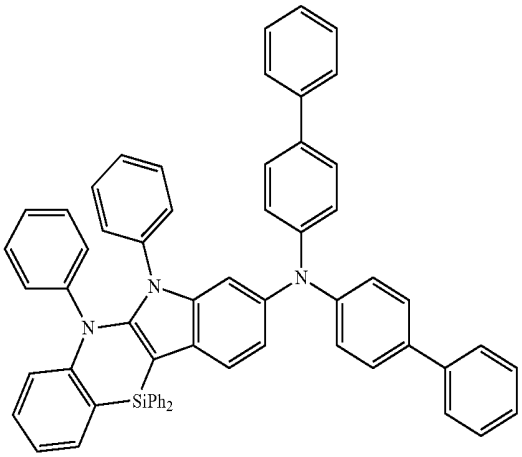


-continued

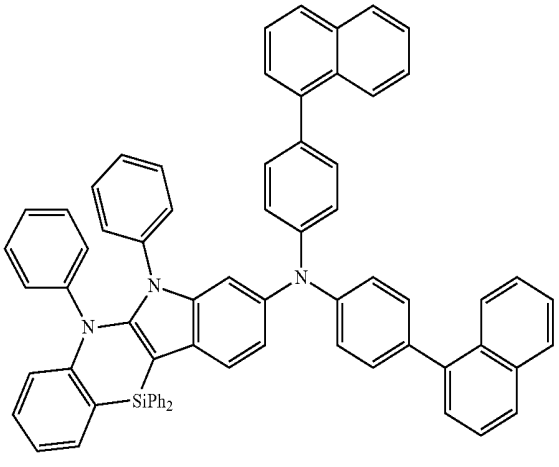
E20



E21

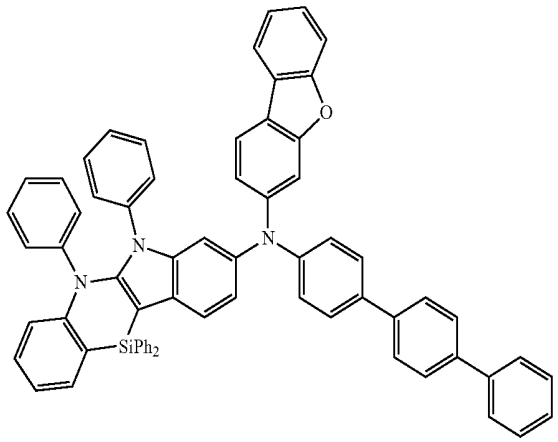


E22

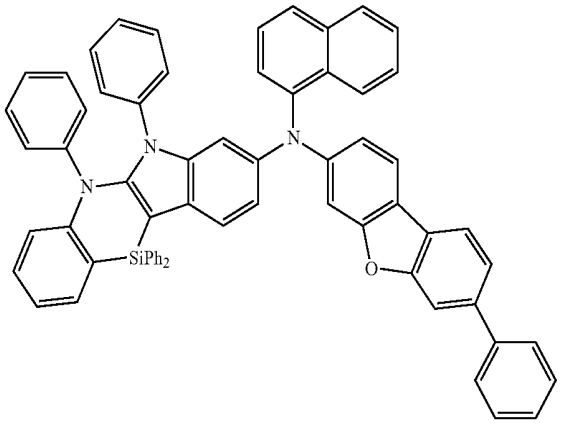


-continued

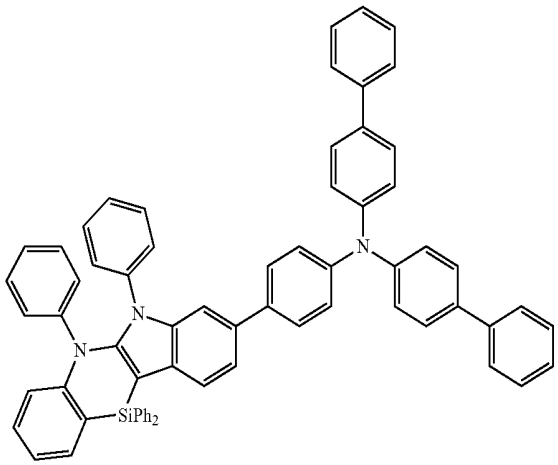
E23



E24

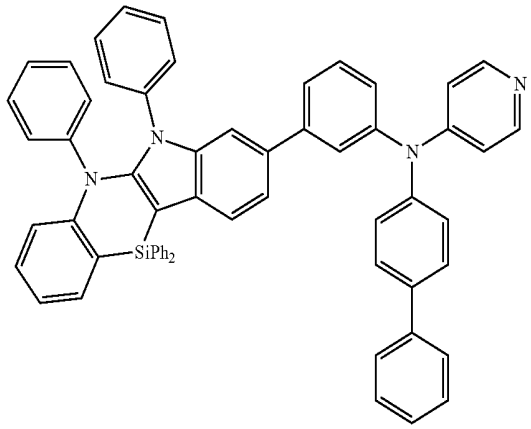


E25

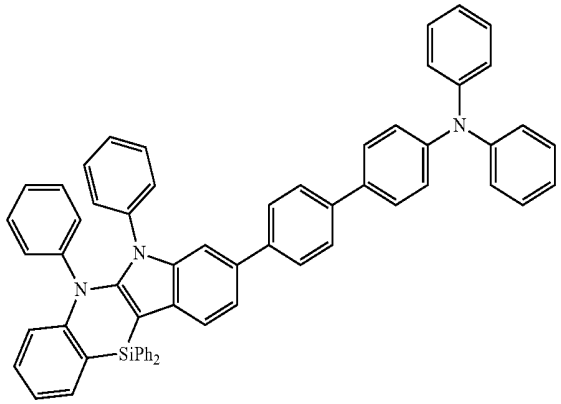


-continued

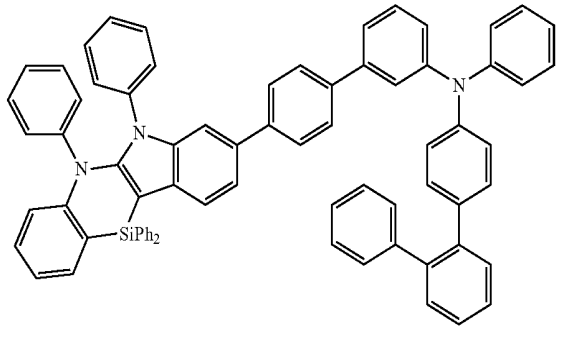
E26



E27

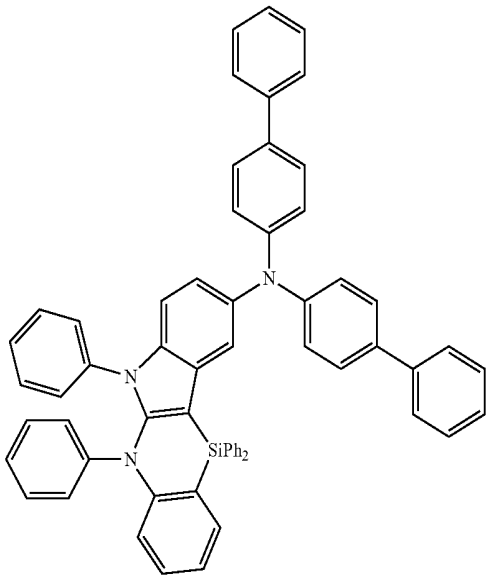


E28

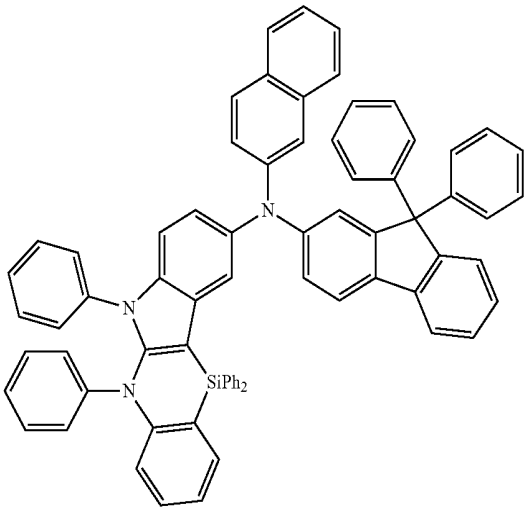


-continued

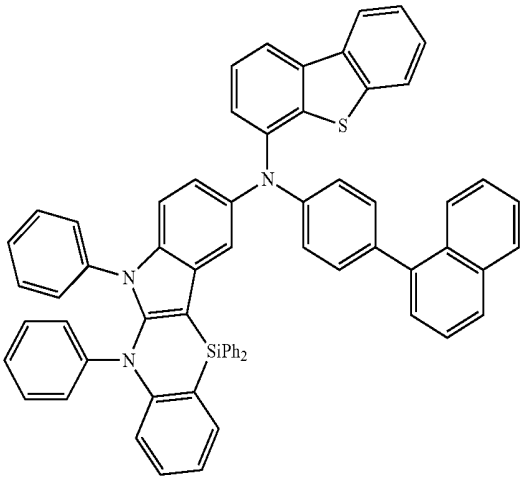
E29



E30

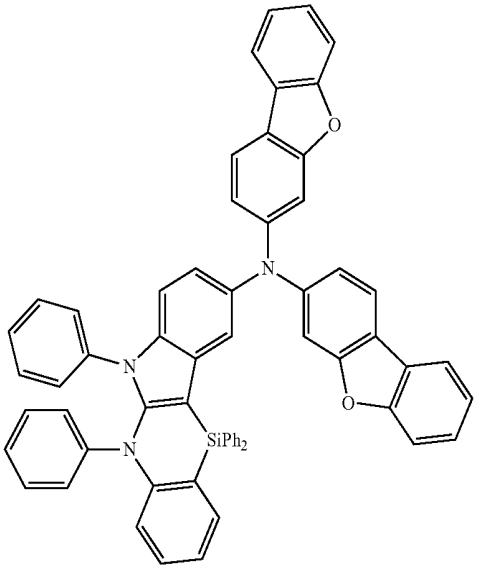


E31

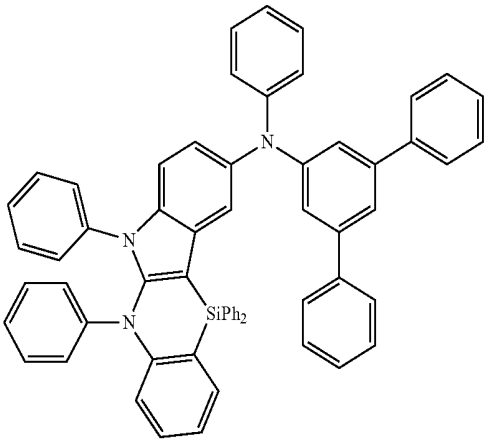


-continued

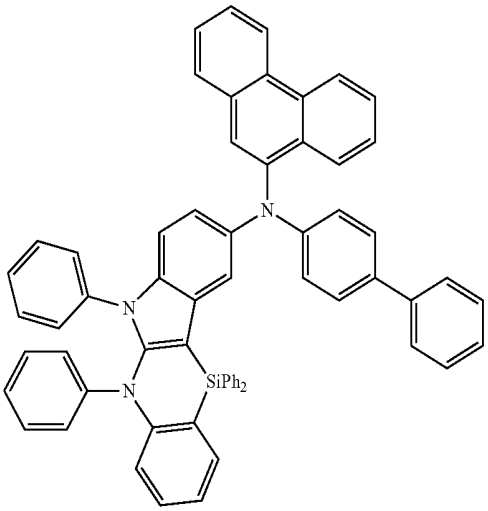
E32



E33

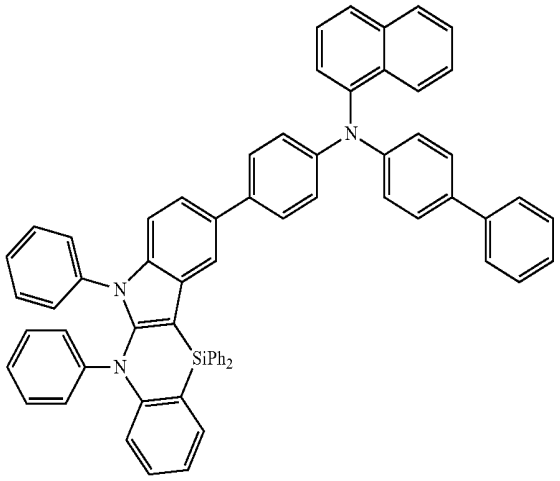


E34

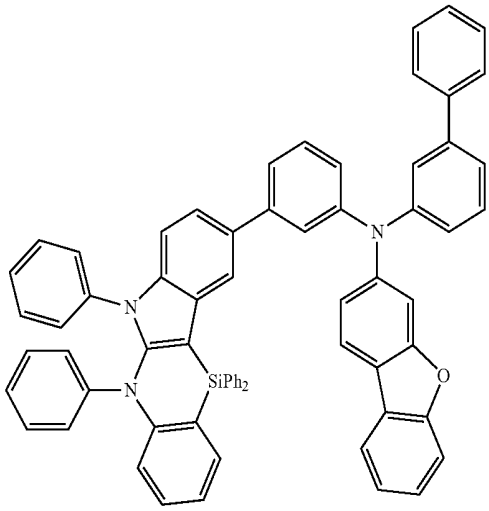


-continued

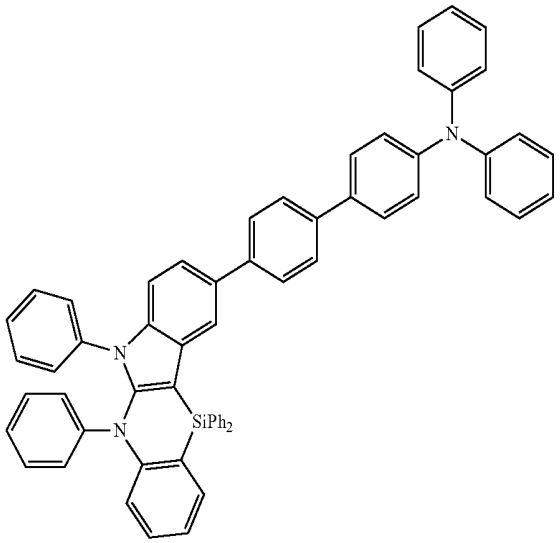
E35



E36

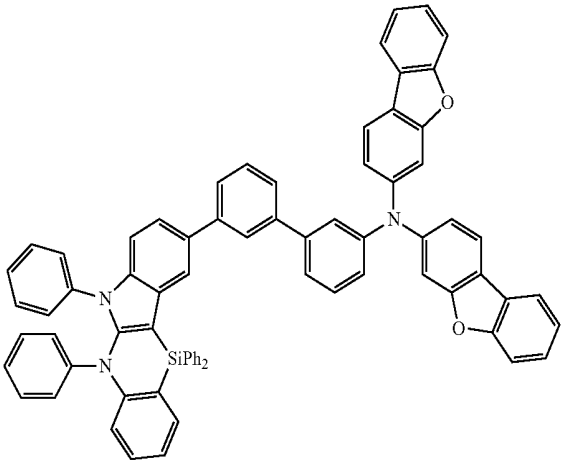


E37

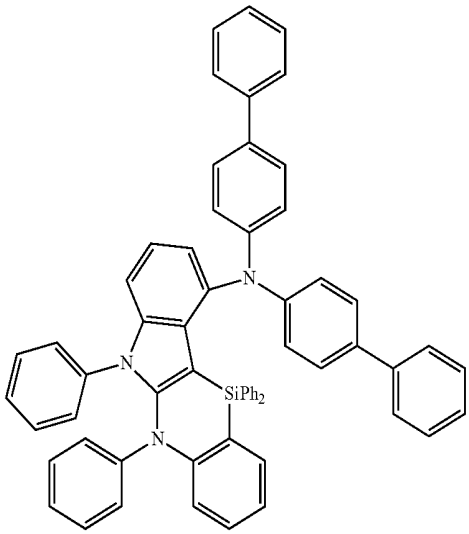


-continued

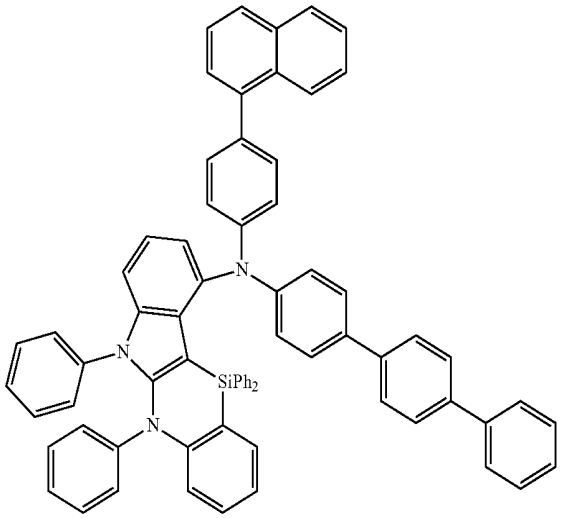
E38



E39

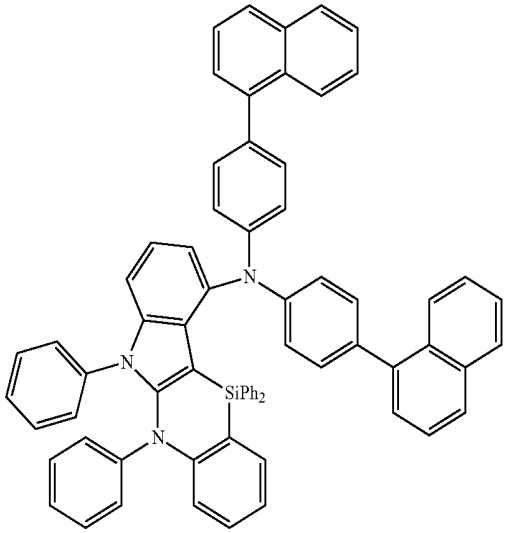


E40

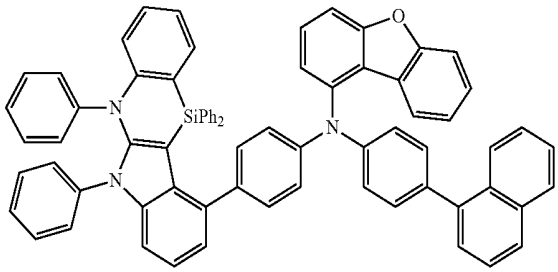


-continued

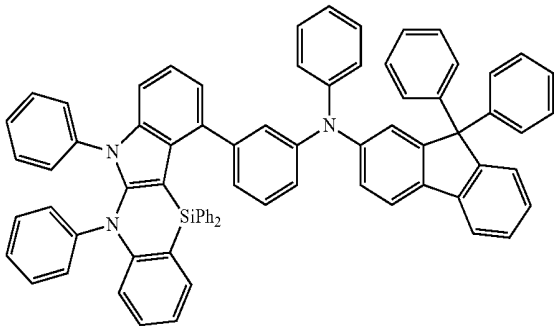
E41



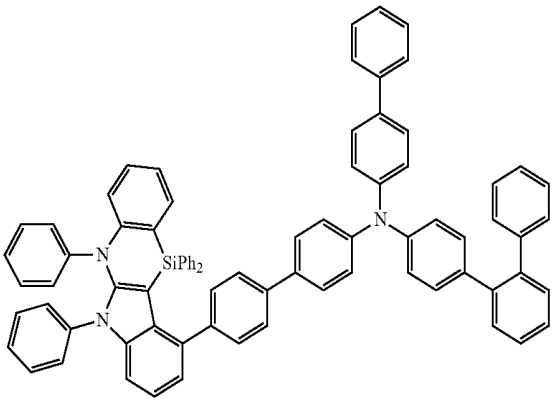
E42



E43

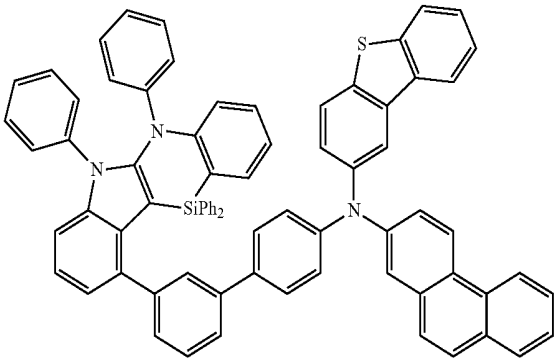


E44

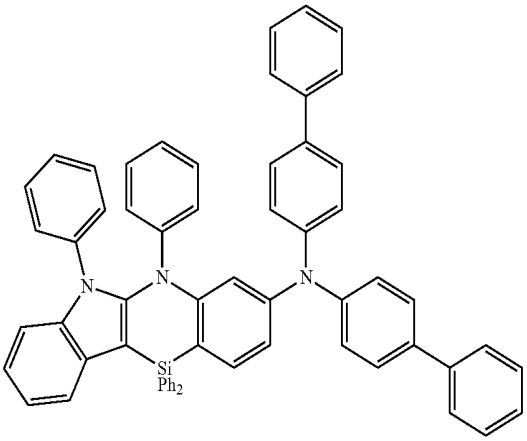


-continued

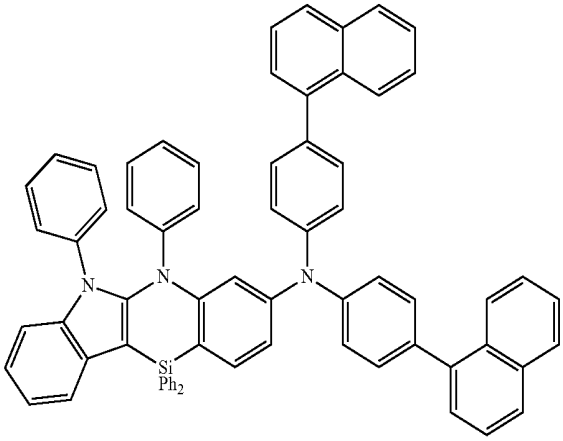
E45



E46

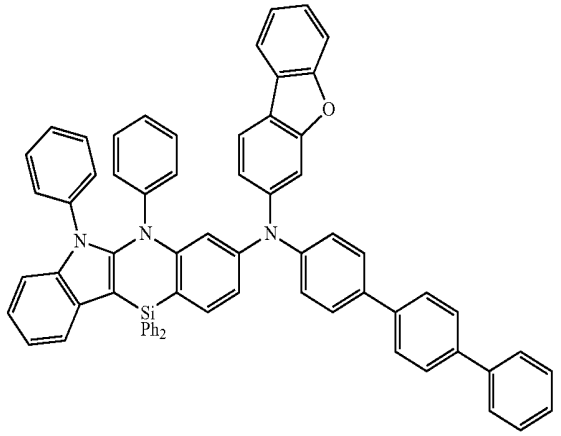


E47

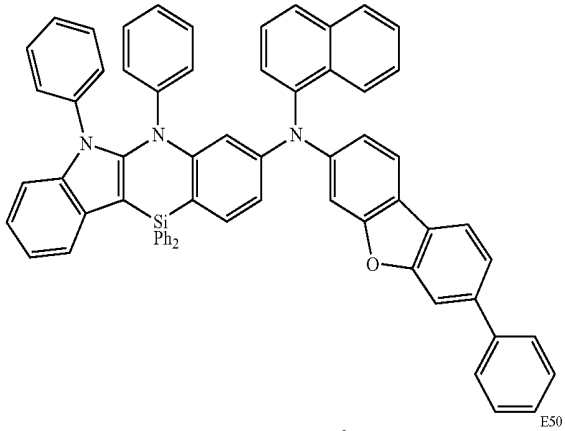


-continued

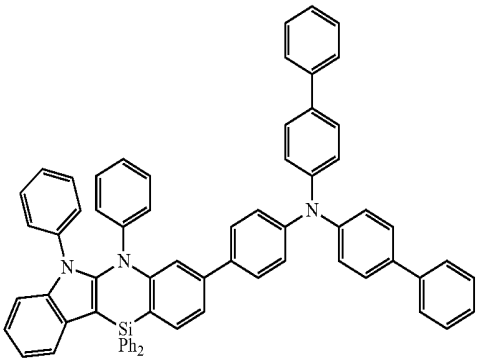
E48



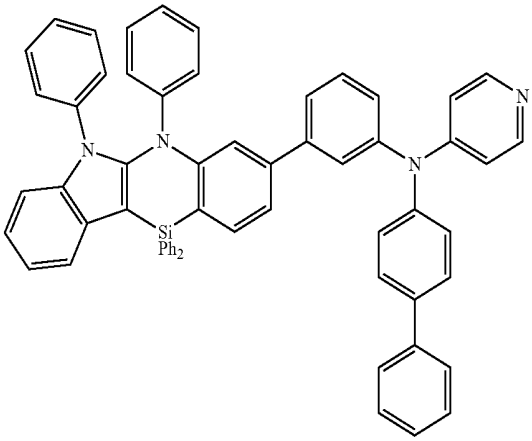
E49



E50

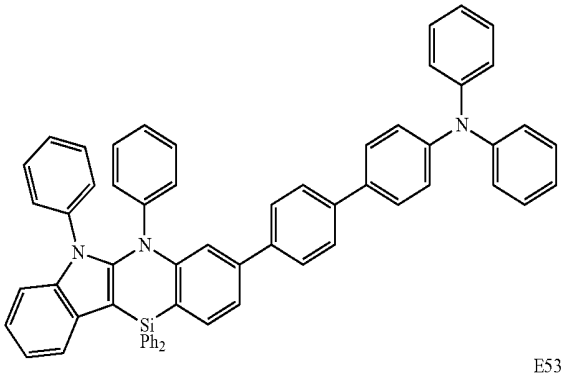


E51

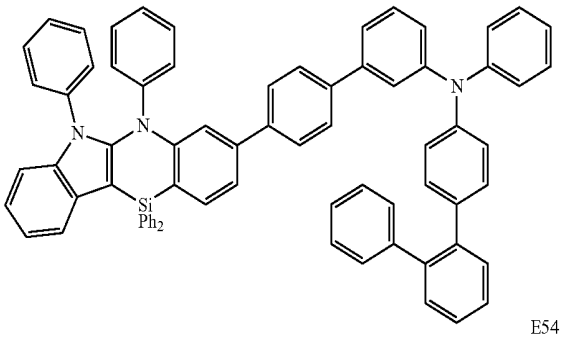


-continued

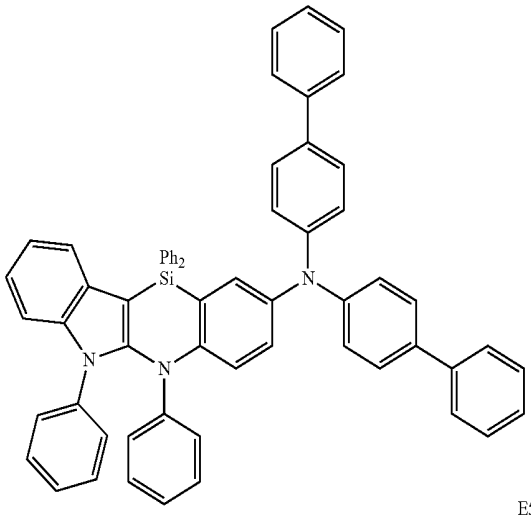
E52



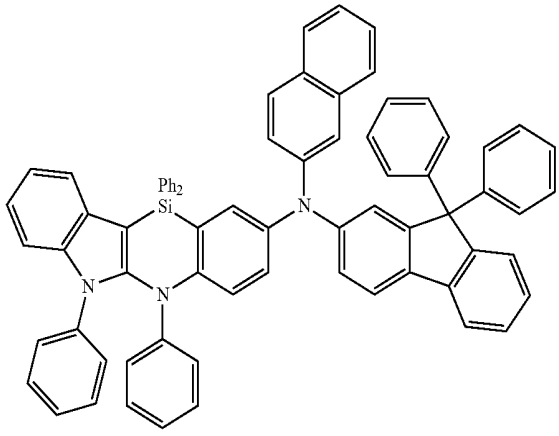
E53



E54

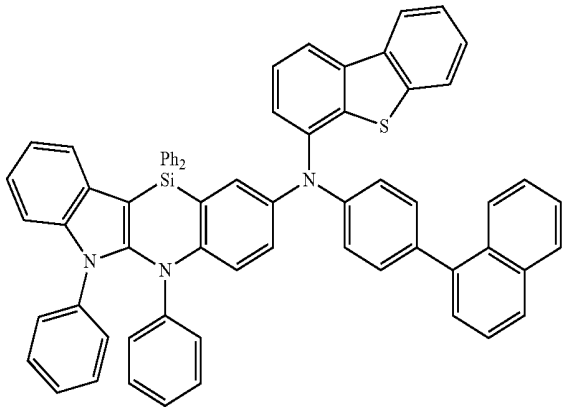


E55

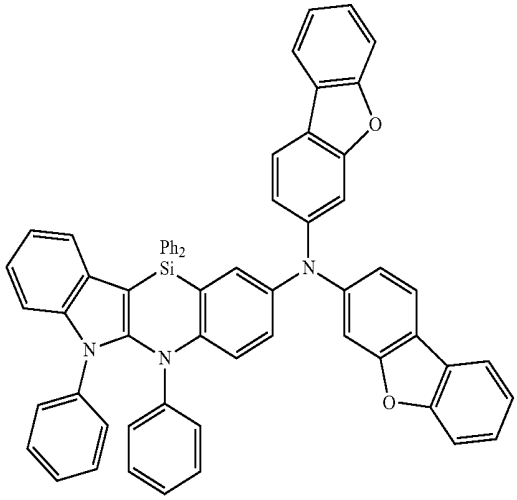


-continued

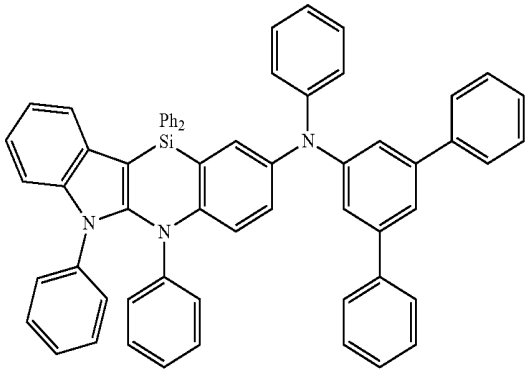
E56



E57

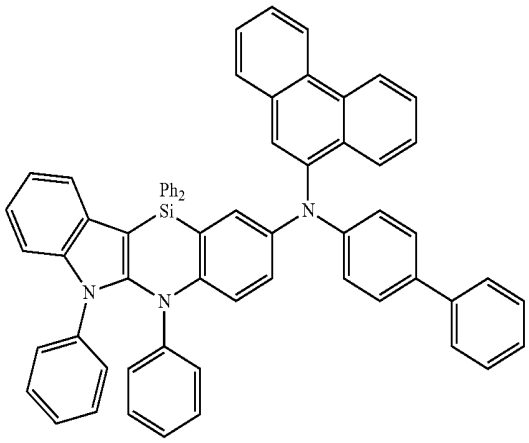


E58

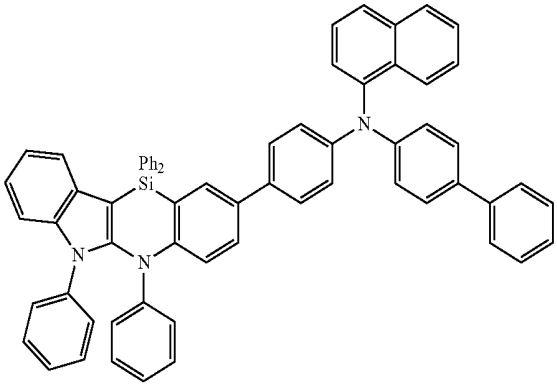


-continued

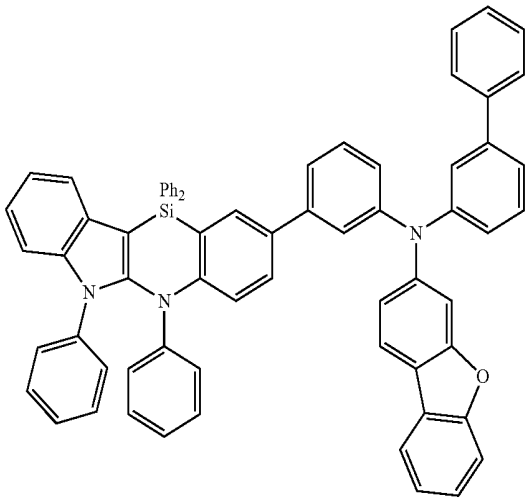
E59



E60

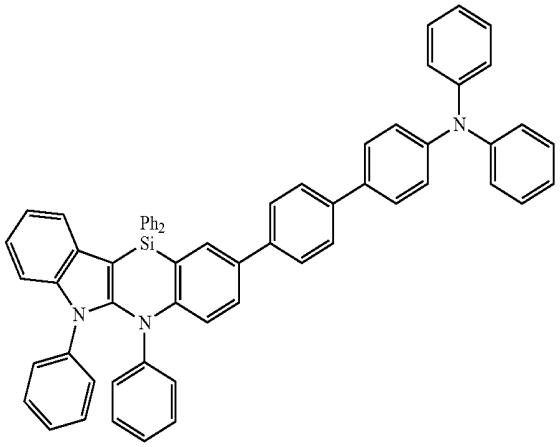


E61

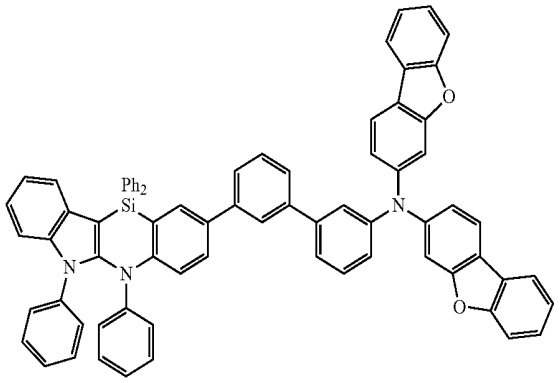


-continued

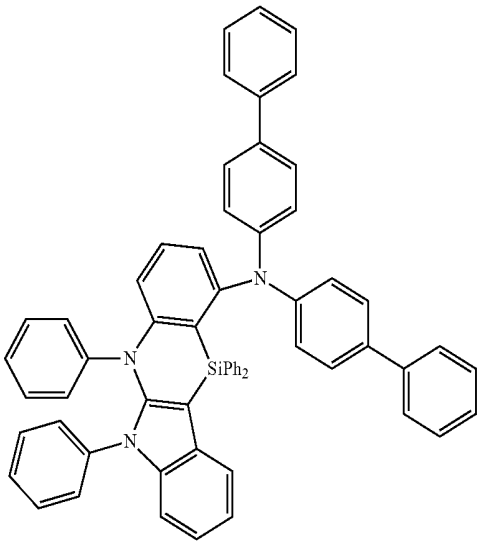
E62



E63

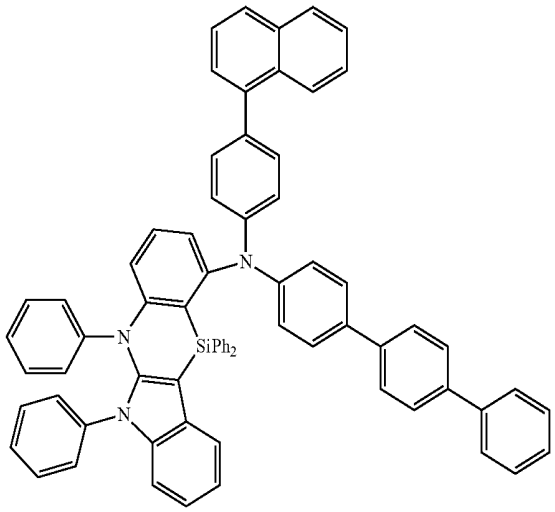


E64

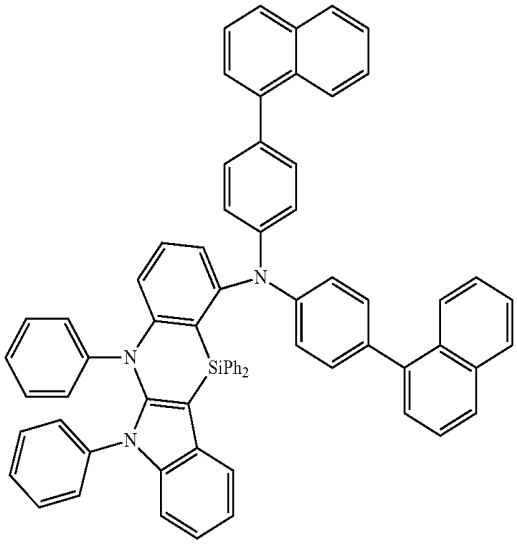


-continued

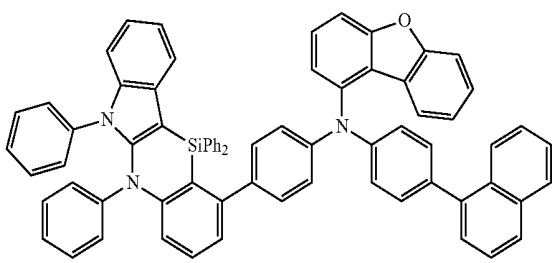
E65



E66

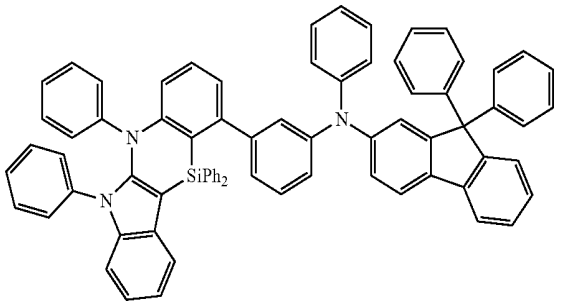


E67

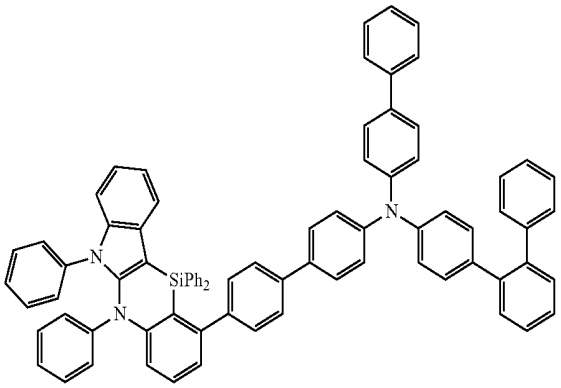


-continued

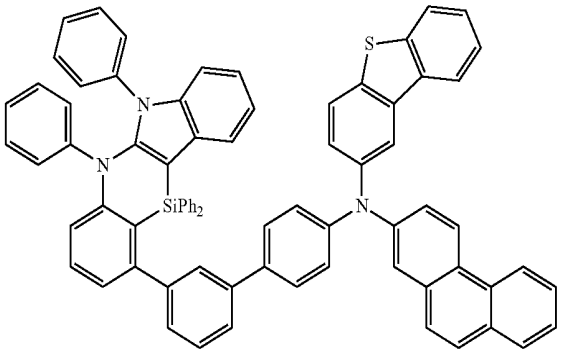
E68



E69



E70



[0089] Referring to FIGS. **2** and **3** again, the hole transport region HTR may have a single layer formed using a single material, a single layer formed using a plurality of different materials, or a multilayer structure including a plurality of layers formed using a plurality of different materials.

[0090] The hole transport region HTR may have a single layer structure of a hole injection layer HIL or a hole transport layer HTL, or may have a single layer structure formed using a hole injection material and a hole transport material. In addition, the hole transport region HTR may have a single layer structure formed using a plurality of different materials, or a laminated structure of hole injection layer HIL/hole transport layer HTL, hole injection layer HIL/hole transport layer HTL/hole buffer layer, hole injection layer HIL/hole buffer layer, hole transport layer HTL/hole buffer layer, or hole injection layer HIL/hole transport layer HTL/electron blocking layer EBL, laminated in order from the first electrode EL**1**, without limitation.

[0091] The hole transport region HTR may be formed using various methods such as a vacuum deposition method, a spin coating method, a cast method, a Langmuir-Blodgett (LB) method, an inkjet printing method, a laser printing method, and a laser induced thermal imaging (LITI) method.

[0092] The hole injection layer HIL may include a phthalocyanine compound such as copper phthalocyanine; N,N'-diphenyl-N,N'-bis-[4-(phenyl-m-tolyl-amino)-phenyl]-biphenyl-4,4'-diamine (DNTPD), 4,4',4"-tris(3-methylphenylphenylamino)triphenylamine (m-MTDATA), 4,4',4"-tris(N,N-diphenylamino)triphenylamine (TDATA), 4,4',4"-tris {N-(2-naphthyl)-N-phenylamino}-triphenylamine (2-TNATA), poly(3,4-ethylenedioxythiophene)/poly(4-styrenesulfonate) (PEDOT/PSS), polyaniline/dodecylbenzenesulfonic acid (PANI/DBSA), polyaniline/camphor sulfonic acid (PANI/CSA), polyaniline/poly(4-styrenesulfonate) (PANI/PSS), N,N'-di(naphthalen-1-yl)-N,N'-diphenyl-benzidine (NPB), triphenylamine-containing polyether ketone (TPAPEK), 4-isopropyl-4'-methyldiphenyliodonium tetrakis(pentafluorophenyl)borate, dipyrazino[2,3-f: 2',3'-h] quinoxaline-2,3,6,7,10,11-hexacarbonitrile (HAT-CN), etc.

[0093] The hole transport layer HTL may include, for example, carbazole derivatives such as N-phenyl carbazole, polyvinyl carbazole, fluorine-based derivatives, N,N'-bis(3-methylphenyl)-N,N'-diphenyl-[1,1-biphenyl]-4,4'-diamine (TPD), triphenylamine-based derivatives such as 4,4',4"-tris (N-carbazolyl)triphenylamine (TCTA), N,N'-di(naphthalen-1-yl)-N,N'-diphenyl-benzidine (NPB), 4,4'-cyclohexylidene bis[N,N-bis(4-methylphenyl)benzenamine](TAPC), 4,4'-bis [N,N'-(3-tolyl)amino]-3,3'-dimethylbiphenyl (HMTPD), 1,3-bis(N-carbazolyl)benzene (mCP), etc.

[0094] The thickness of the hole transport region HTR may be from about 100 Å to about 10,000 Å, for example, from about 100 Å to about 1,000 Å. In case the hole transport region HTR includes both of the hole injection layer HIL and the hole transport layer HTL, the thickness of the hole injection layer HIL may be from about 100 Å to about 10,000 Å, for example, from about 100 Å to about 1,000 Å, and the thickness of the hole transport layer HTL may be from about 30 Å to about 1,000 Å. In case the thicknesses of the hole transport region HTR, the hole injection layer HIL and the hole transport layer HTL satisfy the above-described ranges, satisfactory hole transport properties may be obtained without substantial increase of a driving voltage.

[0095] The hole transport region HTR may further include a charge generating material in addition to the above-described materials to improve conductivity. The charge generating material may be dispersed in the hole transport region HTR uniformly or non-uniformly. The charge generating material may be, for example, a p-dopant. The p-dopant may be one of quinone derivatives, metal oxides, or cyano group-containing compounds, without limitation. For example, non-limiting examples of the p-dopant may include quinone derivatives such as tetracyanoquinodimethane (TCNQ), and 2,3,5,6-tetrafluoro-tetracyanoquinodimethane (F4-TCNQ), metal oxides such as tungsten oxide and molybdenum oxide, without limitation.

[0096] As described above, the hole transport region HTR may further include at least one of a hole buffer layer or an electron blocking layer in addition to the hole injection layer HIL and the hole transport layer HTL. The hole buffer layer may compensate an optical resonance distance according to the wavelength of light emitted from the emission layer EML and increase light emission efficiency. Materials included in the hole transport region HTR may be used as

materials included in the hole buffer layer. The electron blocking layer is a layer preventing electron injection from the electron transport region ETR into the hole transport region HTR.

[0097] In case the hole transport region HTR includes both of the hole injection layer HIL and the hole transport layer HTL, and also includes the above-described condensed cyclic compound, the condensed cyclic compound may be included in the hole transport layer HTL.

[0098] In case the hole transport layer HTL consists of a plurality of organic layers, the condensed cyclic compound may be included in an organic layer adjacent to the emission layer EML.

[0099] In case the hole transport region HTR includes the condensed cyclic compound, the hole transport region HTR may further include a known material in addition to the condensed cyclic compound.

[0100] The emission layer EML is disposed on the hole transport region HTR. The thickness of the emission layer EML may be, for example, from about 100 Å to about 1,000 Å, or from about 100 Å to about 300 Å. The emission layer EML may have a single layer formed using a single material, a single layer formed using a plurality of different materials, or a multilayer structure having a plurality of layers formed using a plurality of different materials.

[0101] The emission layer EML may be a fluorescence emission layer or a phosphorescence emission layer. The emission layer EML may include a host and a dopant.

[0102] The emission layer EML may employ any host material commonly used without specific limitation. For example, the emission layer EML may include at least one of bis[2-(diphenylphosphino)phenyl] ether oxide (DPEPO), 4,4'-bis(carbazol-9-yl)biphenyl (CBP), 1,3-bis(carbazol-9-yl)benzene (mCP), 2,8-bis(diphenylphosphoryl)dibenzo[b,d] furan (PPF), 4,4',4"-tris(carbazol-9-yl)-triphenylamine (TcTa) or 1,3,5-tris(N-phenylbenzimidazole-2-yl)benzene (TPBi). However, an embodiment of the inventive concept is not limited thereto. For example, the emission layer EML may include, as a host material, tris(8-hydroxyquinolino) aluminum (Alq3), 4,4'-bis(N-carbazolyl)-1,1'-biphenyl (CBP), poly(N-vinylcarbazole) (PVK), 9,10-di(naphthalen-2-yl)anthracene (ADN), 4,4',4"-tris(carbazol-9-yl)-triphenylamine (TCTA), 1,3,5-tris(N-phenylbenzimidazol-2-yl) benzene (TPBi), 3-tert-butyl-9,10-di(naphth-2-yl) anthracene (TBADN), distyrylarylene (DSA), 4,4'-bis(9-carbazolyl)-2,2'-dimethyl-biphenyl (CDBP), 2-methyl-9,10-bis(naphthalen-2-yl)anthracene (MADN), bis[2-(diphenylphosphino)phenyl]ether oxide (DPEPO), hexaphenyl cyclotriphosphazene (CP1), 1,4-bis(triphenylsilyl)benzene (UGH2), hexaphenylcyclotrisiloxane ($DPSiO_3$), octaphenylcyclotetrasiloxane ($DPSiO_4$), 2,8-bis(diphenylphosphoryl)dibenzofuran (PPF), etc.

[0103] For example, the emission layer EML may further include, as a dopant material, at least one of N,N,N',N'-tetraphenyl-pyrene-1,6-diamine (TPD), 4,4'-bis(2-(9-ethyl-9H-carbazol-3-yl)vinyl)-1,1'-biphenyl (BCzVBi), 4,4'-bis (9-ethyl-3-carbazovinylene)-1,1'-biphenyl, 10-phenyl-10H, 10'H-spiro[acridine-9,9'-anthracene]-10'-one (ACRSA), 3,4,5,6-tetra-9H-carbazol-9-yl-1,2-benzenedicarbonitrile (4CzPN), 2,4,5,6-tetra-9H-carbazol-9-yl-isophthalonitrile (4CzIPN), bis[4-(9,9-dimethyl-9,10-dihydroacridine)phenyl]sulfone (DMAC-DPS), or 2-phenoxazine-4,6-diphenyl-1,3,5-triazine (PSZ-TRZ). The emission layer EML may further include, as a known dopant material, styryl derivatives (for example, 1,4-bis[2-(3-N-ethylcarbazolyl)vinyl] benzene (BCzVB), 4-(di-p-tolylamino)-4'-[(di-p-tolylamino)styryl] stilbene (DPAVB), N-(4-((E)-2-(6-((E)-4-(diphenylamino)styryl)naphthalen-2-yl)vinyl)phenyl)-N-phenylbenzenamine (N-BDAVBi)), perylene and the derivatives thereof (for example, 2,5,8,11-tetra-t-butylperylene (TBP)), pyrene and the derivatives thereof (for example, 1,1-dipyrene, 1,4-dipyrenylbenzene, 1,4-bis(N,N-diphenylamino)pyrene), etc.

[0104] The emission layer EML may emit blue light. The emission layer EML may emit light having a wavelength range of about 510 nm or shorter, or about 480 nm or shorter. The emission layer EML may be a phosphorescence emission layer emitting phosphorescence light.

[0105] The electron transport region ETR is disposed on the emission layer EML. The electron transport region ETR may include at least one of a hole blocking layer, an electron transport layer ETL or an electron injection layer EIL, without limitation.

[0106] The electron transport region ETR may have a single layer formed using a single material, a single layer formed using a plurality of different materials, or a multilayer structure having a plurality of layers formed using a plurality of different materials.

[0107] For example, the electron transport region ETR may have a single layer structure of an electron injection layer EIL or an electron transport layer ETL, or a single layer structure formed using an electron injection material and an electron transport material. In addition, the electron transport region ETR may have a single layer structure having a plurality of different materials, or a laminated structure of electron transport layer ETL/electron injection layer EIL, or hole blocking layer/electron transport layer ETL/electron injection layer EIL, laminated in order from the emission layer EML, without limitation. The thickness of the electron transport region ETR may be, for example, from about 1,000 Å to about 1,500 Å.

[0108] The electron transport region ETR may be formed using various methods such as a vacuum deposition method, a spin coating method, a cast method, a Langmuir-Blodgett (LB) method, an inkjet printing method, a laser printing method, and a laser induced thermal imaging (LITI) method.

[0109] In case the electron transport region ETR includes the electron transport layer ETL, the electron transport region ETR may include anthracene derivatives. However, an embodiment of the inventive concept is not limited thereto. The electron transport region may include, for example, tris(8-hydroxyquinolinato)aluminum (Alq_3), 1,3,5-tri[(3-pyridyl)-phen-3-yl]benzene, 2,4,6-tris(3'-(pyridin-3-yl)biphenyl-3-yl)-1,3,5-triazine, 2-(4-(N-phenylbenzoimidazolyl-1-ylphenyl)-9,10-dinaphthylanthracene, 1,3,5-tri(1-phenyl-1H-benzo[d]imidazol-2-yl)phenyl (TPBi), 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP), 4,7-diphenyl-1,10-phenanthroline (Bphen), 3-(4-biphenylyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole (TAZ), 4-(naphthalen-1-yl)-3,5-diphenyl-4H-1,2,4-triazole (NTAZ), 2-(4-biphenylyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole (tBu-PBD), bis(2-methyl-8-quinolinolato-N1,O8)-(1,1'-Biphenyl-4-olato)aluminum (BAlq), berylliumbis (benzoquinolin-10-olate) ($Bebq_2$), 9,10-di(naphthalen-2-yl) anthracene (ADN) and a mixture thereof. The thickness of the electron transport layer ETL may be from about 100 Å to about 1,000 Å, for example, from about 150 Å to about 500 Å. If the thickness of the electron transport layer ETL

satisfies the above-described range, satisfactory electron transport properties may be obtained without substantial increase of a driving voltage.

[0110] When the electron transport region ETR includes the electron injection layer EIL, the electron transport region ETR may use LiF, lithium quinolate (LIQ), Li_2O, BaO, NaCl, CsF, a metal in lanthanoides such as Yb, or a metal halide such as RbCl and RbI. However, an embodiment of the inventive concept is not limited thereto. The electron injection layer EIL also may be formed using a mixture material of an electron transport material and an insulating organo metal salt. The organo metal salt may be a material having an energy band gap of about 4 eV or more. Particularly, the organo metal salt may include, for example, a metal acetate, a metal benzoate, a metal acetoacetate, a metal acetylacetonate, or a metal stearate. The thickness of the electron injection layer EIL may be from about 1 Å to about 100 Å, for example, from about 3 Å to about 90 Å. In case the thickness of the electron injection layer EIL satisfies the above described range, satisfactory electron injection properties may be obtained without inducing the substantial increase of a driving voltage.

[0111] The electron transport region ETR may include a hole blocking layer, as described above. The hole blocking layer may include, for example, at least one of 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline (BCP) or 4,7-diphenyl-1,10-phenanthroline (Bphen), without limitation.

[0112] The second electrode EL**2** is disposed on the electron transport region ETR. The second electrode EL**2** may be a common electrode or a cathode. The second electrode EL**2** may be a transmissive electrode, a transflective electrode or a reflective electrode. In case the second electrode EL**2** is the transmissive electrode, the second electrode EL**2** may be formed using transparent metal oxides, for example, ITO, IZO, ZnO, ITZO, etc.

[0113] In case the second electrode EL**2** is the transflective electrode or the reflective electrode, the second electrode EL**2** may include Ag, Mg, Cu, Al, Pt, Pd, Au, Ni, Nd, Ir, Cr, Li, Ca, LiF/Ca, LiF/Al, Mo, Ti, a compound thereof, or a mixture thereof (for example, a mixture of Ag and Mg). The second electrode EL**2** may have a multilayer structure including a reflective layer or a transflective layer formed using the above-described materials and a transparent conductive layer formed using ITO, IZO, ZnO, ITZO, etc.

[0114] Even not shown, the second electrode EL**2** may be connected with an auxiliary electrode. In case the second electrode EL**2** is connected with the auxiliary electrode, the resistance of the second electrode EL**2** may decrease.

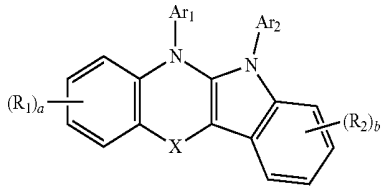
[0115] In the organic electroluminescence device **10**, according to the application of a voltage to each of the first electrode EL**1** and the second electrode EL**2**, holes injected from the first electrode EL**1** may move via the hole transport region HTR to the emission layer EML, and electrons injected from the second electrode EL**2** may move via the electron transport region ETR to the emission layer EML. The electrons and the holes are recombined in the emission layer EML to generate excitons, and light may be emitted via the transition of the excitons from an excited state to a ground state.

[0116] In case the organic electroluminescence device **10** is a top emission type, the first electrode EL**1** may be a reflective electrode, and the second electrode EL**2** may be a transmissive electrode or a transflective electrode. In case the organic electroluminescence device **10** is a bottom emission type, the first electrode EL**1** may be a transmissive electrode or a transflective electrode, and the second electrode EL**2** may be a reflective electrode.

[0117] The organic electroluminescence device **10** according to an embodiment of the inventive concept includes the above-described condensed cyclic compound as a material for the hole transport region HTR, thereby securing enhanced efficiency and device life.

[0118] An embodiment of the inventive concept provides a condensed cyclic compound represented by the following Formula 1.

[Formula 1]



[0119] In Formula 1, X may be a direct linkage, O, S, NR_5, or SiR_6R_7.

[0120] In Formula 1, each of Ar_1 and Ar_2 may independently be a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring.

[0121] In Formula 1, each of R_1 and R_2 may independently be a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms.

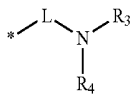
[0122] In Formula 1, a and b may be each independently an integer of 0 to 4. In case a is an integer of 2 or more, a plurality of R_1 may be the same or different from each other. In case b is an integer of 2 or more, a plurality of R_2 may be the same or different from each other.

[0123] In Formula 1, each of R_5, R_6, and R_7 may independently be a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

[0124] In Formula 1, the substituted ones may be substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

[0125] In Formula 1, any one of Ar_1, R_1 or R_2 is represented by the following Formula 2.

[Formula 2]



[0126] In Formula 2, L may be a substituted or unsubstituted arylene group having 6 to 40 carbon atoms for forming a ring.

[0127] In Formula 2, each of R_3 and R_4 may independently be a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

[0128] In R_3 and R_4, the substituted ones may be substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted cycloalkyl group having 3 to 40 carbon atoms for forming a ring, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

[0129] The explanation on the condensed cyclic compound described in the above particular explanation on the organic electroluminescence device according to an embodiment of the inventive concept may be applied to the condensed cyclic compound represented by Formula 1 according to an embodiment of the inventive concept.

[0130] The condensed cyclic compound according to an embodiment of the inventive concept may be any one selected from the group consisting of compounds represented in the above Compound Groups 1 to 5.

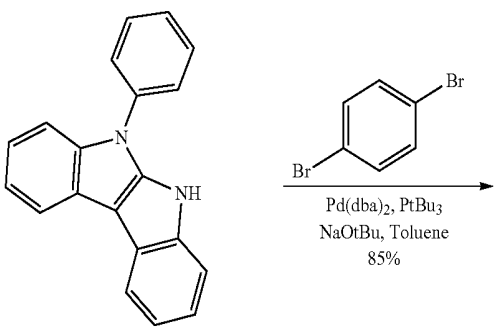
[0131] Hereinafter, the inventive concept will be explained in more detail with reference to specific embodiments and comparative embodiments. The following embodiments are illustrated only for assisting the understanding of the inventive concept, and the scope of the inventive concept is not limited thereto.

SYNTHESIS EXAMPLES

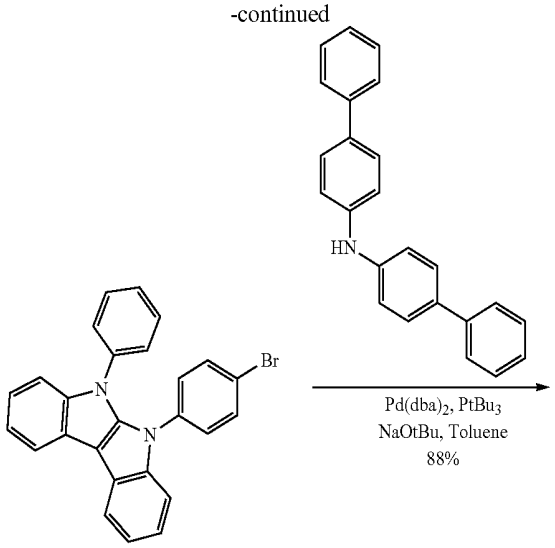
[0132] The condensed cyclic compound according to an embodiment of the inventive concept may be synthesized, for example, as follows. However, the synthetic method of the condensed cyclic compound according to an embodiment of the inventive concept is not limited thereto.

1. Synthesis of Compound A2

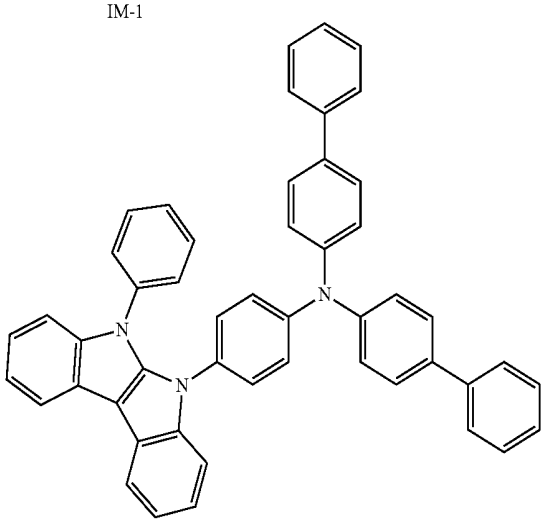
[0133] Compound A2, the condensed cyclic compound according to an embodiment of the inventive concept, may be synthesized, for example, as follows.



-continued



IM-1



A2

(Synthesis of Intermediate IM-1)

[0134] In an Ar atmosphere, 5-phenyl-5,6-dihydroindolo [2,3-b]indole (5.00 g, 17.7 mmol), $Pd(dba)_2$ (0.31 g, 0.03 equiv, 0.5 mmol), NaOtBu (11.65 g, 1.0 equiv, 1.70 mmol), toluene (88 mL), 1,4-dibromobenzene (4.60 g, 1.1 equiv, 19.5 mmol) and tBu_3P (0.36 g, 0.1 equiv, 1.8 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-1 (6.58 g, yield 85%).

[0135] Intermediate IM-1 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=437.

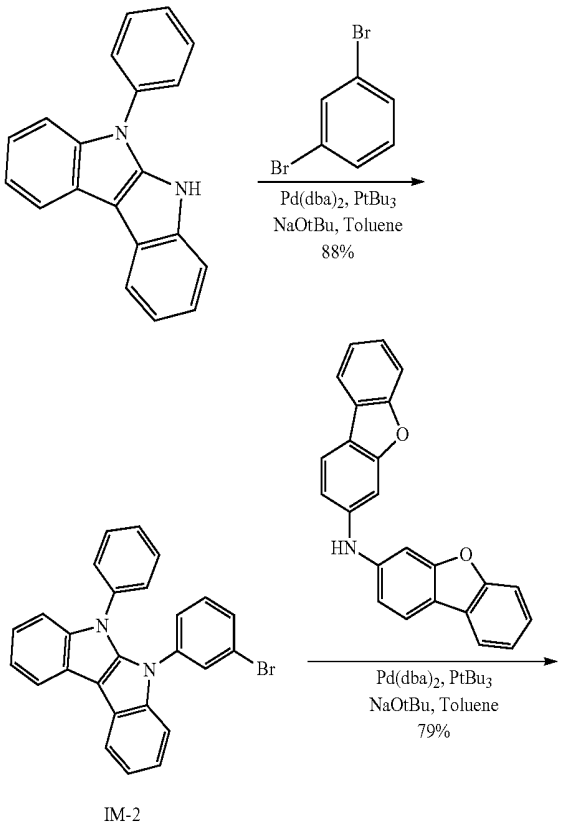
(Synthesis of Compound A2)

[0136] In an Ar atmosphere, IM-1 (5.00 g, 11.4 mmol), $Pd(dba)_2$ (0.20 g, 0.03 equiv, 0.3 mmol), NaOtBu (2.20 g, 2.0 equiv, 22.8 mmol), toluene (57 mL), bis(4-biphenyl) amine (4.04 g, 1.1 equiv, 12.6 mmol) and tBu_3P (0.23 g, 0.1 equiv, 1.1 mmol) were added sequentially into a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Compound A2 (6.82 g, yield 88%) as a solid.

[0137] Compound A2 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=677.

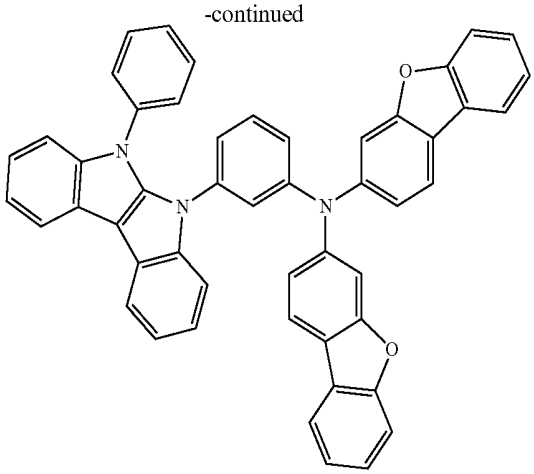
2. Synthesis of Compound A13

[0138] Compound A13, the condensed cyclic compound according to an embodiment of the inventive concept, may be synthesized, for example, as follows.



IM-2

-continued



A13

(Synthesis of Intermediate IM-2)

[0139] In an Ar atmosphere, 5-phenyl-5,6-dihydroindolo [2,3-b]indole (5.00 g, 17.7 mmol), $Pd(dba)_2$ (0.31 g, 0.03 equiv, 0.5 mmol), NaOtBu (11.65 g, 1.0 equiv, 1.70 mmol), toluene (88 mL), 1,3-dibromobenzene (4.60 g, 1.1 equiv, 19.5 mmol) and tBu_3P (0.36 g, 0.1 equiv, 1.8 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-2 (6.82 g, yield 88%).

[0140] Intermediate IM-2 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=437.

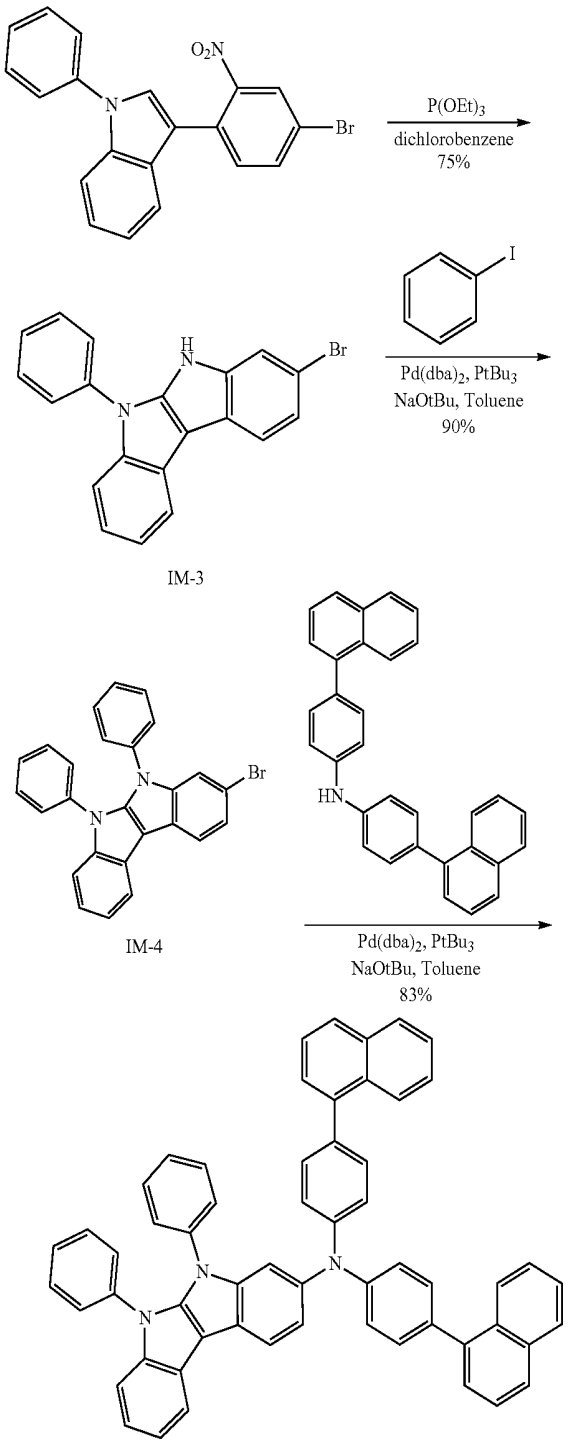
(Synthesis of Compound A13)

[0141] In an Ar atmosphere, IM-2 (5.00 g, 11.4 mmol), $Pd(dba)_2$ (0.20 g, 0.03 equiv, 0.3 mmol), NaOtBu (2.20 g, 2.0 equiv, 22.8 mmol), toluene (57 mL), bis(4-biphenyl-3-yl)amine (4.40 g, 1.1 equiv, 12.6 mmol) and tBu_3P (0.23 g, 0.1 equiv, 1.1 mmol) were added sequentially into a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Compound A13 (6.37 g, yield 79%) as a solid.

[0142] Compound A13 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=705.

3. Synthesis of Compound A22

[0143]



(Synthesis of Intermediate IM-3)

[0144] In an Ar atmosphere, 3-(4-bromo-2-nitrophenyl)-1-phenyl-1H-indole (15.00 g, 38.1 mmol), o-dichlorobenzene (76.3 mL) and $P(OEt)_3$ (25.35 g, 4 equiv, 152.6 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated at about 160° C. for about 24 hours. After cooling in the air to room temperature, reaction solvent was evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-3 (10.33 g, yield 75%).

[0145] Intermediate IM-3 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=361.

(Synthesis of Intermediate IM-4)

[0146] In an Ar atmosphere, IM-3 (7.00 g, 19.4 mmol), $Pd(dba)_2$ (0.33 g, 0.03 equiv, 0.6 mmol), NaOtBu (1.86 g, 1.0 equiv, 19.4 mmol), toluene (97 mL), iodobenzene (4.28 g, 1.1 equiv, 21.3 mmol) and tBu_3P (0.39 g, 0.1 equiv, 1.9 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-4 (7.63 g, yield 90%).

[0147] Intermediate IM-4 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=437.

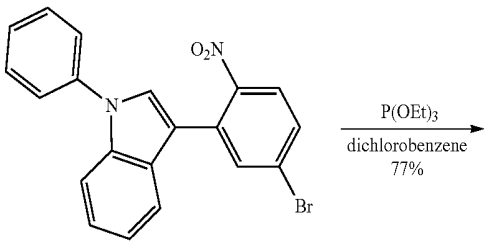
(Synthesis of Compound A22)

[0148] In an Ar atmosphere, IM-4 (5.00 g, 11.4 mmol), $Pd(dba)_2$ (0.20 g, 0.03 equiv, 0.3 mmol), NaOtBu (2.20 g, 2.0 equiv, 22.8 mmol), toluene (57 mL), bis[4-(naphthalen-1-yl)phenyl]amine (5.30 g, 1.1 equiv, 12.6 mmol) and tBu_3P (0.23 g, 0.1 equiv, 1.1 mmol) were added sequentially into a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Compound A22 (7.38 g, yield 83%) as a solid.

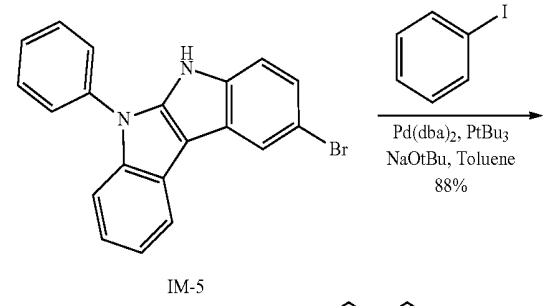
[0149] Compound A22 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=777.

4. Synthesis of Compound A35

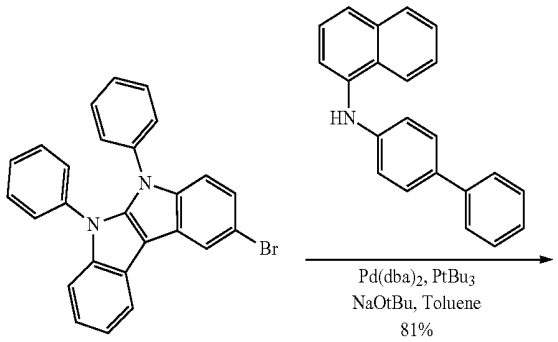
[0150]



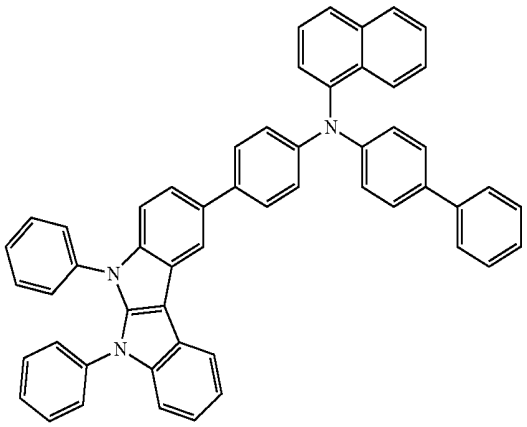
-continued



IM-5



IM-6



A35

(Synthesis of Intermediate IM-5)

[0151] In an Ar atmosphere, 3-(5-bromo-2-nitrophenyl)-1-phenyl-1H-indole (15.00 g, 38.1 mmol), o-dichlorobenzene (76.3 mL) and $P(OEt)_3$ (25.35 g, 4 equiv, 152.6 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated at about 160° C. for about 24 hours. After cooling in the air to room temperature, reaction solvent was evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-5 (10.61 g, yield 77%).

[0152] Intermediate IM-5 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=361.

(Synthesis of Intermediate IM-6)

[0153] In an Ar atmosphere, IM-5 (7.00 g, 19.4 mmol), $Pd(dba)_2$ (0.33 g, 0.03 equiv, 0.6 mmol), NaOtBu (1.86 g, 1.0 equiv, 19.4 mmol), toluene (97 mL), iodobenzene (4.28 g, 1.1 equiv, 21.3 mmol) and tBu_3P (0.39 g, 0.1 equiv, 1.9 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-6 (7.46 g, yield 88%).

[0154] Intermediate IM-6 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=437.

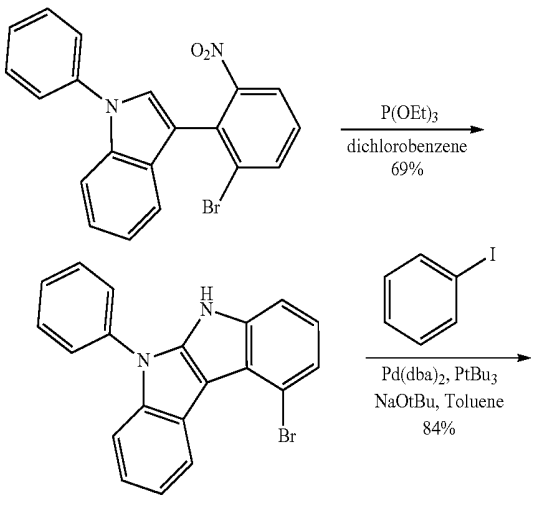
(Synthesis of Compound A35)

[0155] In an Ar atmosphere, IM-6 (5.00 g, 11.4 mmol), $Pd(dba)_2$ (0.20 g, 0.03 equiv, 0.3 mmol), NaOtBu (2.20 g, 2.0 equiv, 22.8 mmol), toluene (57 mL), N-[(1,1'-biphenyl)-4-yl]naphthalen-1-amine (3.71 g, 1.1 equiv, 12.6 mmol) and tBu_3P (0.23 g, 0.1 equiv, 1.1 mmol) were added sequentially to a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Compound A35 (6.74 g, yield 81%) as a solid.

[0156] Compound A35 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=727.

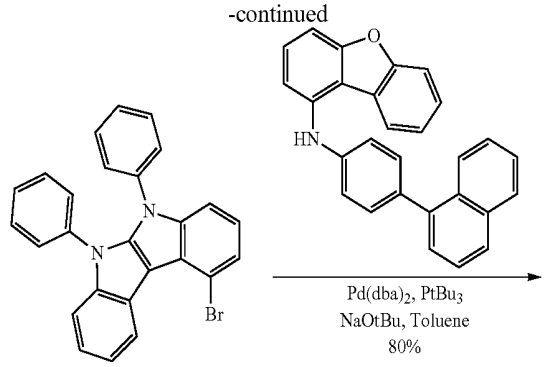
5. Synthesis of Compound A42

[0157]

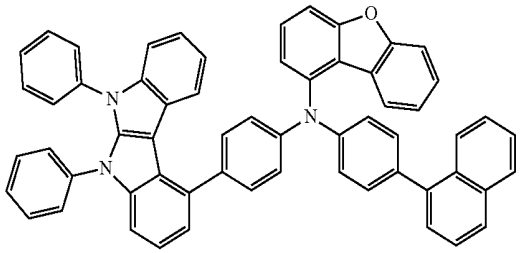


IM-7

-continued



IM-8



A42

(Synthesis of Intermediate IM-7)

[0158] In an Ar atmosphere, 3-(2-bromo-6-nitrophenyl)-1-phenyl-1H-indole (15.00 g, 38.1 mmol), o-dichlorobenzene (76.3 mL) and $P(OEt)_3$ (25.35 g, 4 equiv, 152.6 mmol) were added sequentially to a 300 mL three neck flask, and the mixture was stirred and heated at about 160° C. for about 24 hours. After cooling in the air to room temperature, reaction solvent was evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-7 (9.51 g, yield 69%).

[0159] Intermediate IM-7 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=361.

(Synthesis of Intermediate IM-8)

[0160] In an Ar atmosphere, IM-7 (7.00 g, 19.4 mmol), $Pd(dba)_2$ (0.33 g, 0.03 equiv, 0.6 mmol), NaOtBu (1.86 g, 1.0 equiv, 19.4 mmol), toluene (97 mL), iodobenzene (4.28 g, 1.1 equiv, 21.3 mmol) and tBu_3P (0.39 g, 0.1 equiv, 1.9 mmol) were added sequentially to a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-8 (7.12 g, yield 84%).

[0161] Intermediate IM-8 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=437.

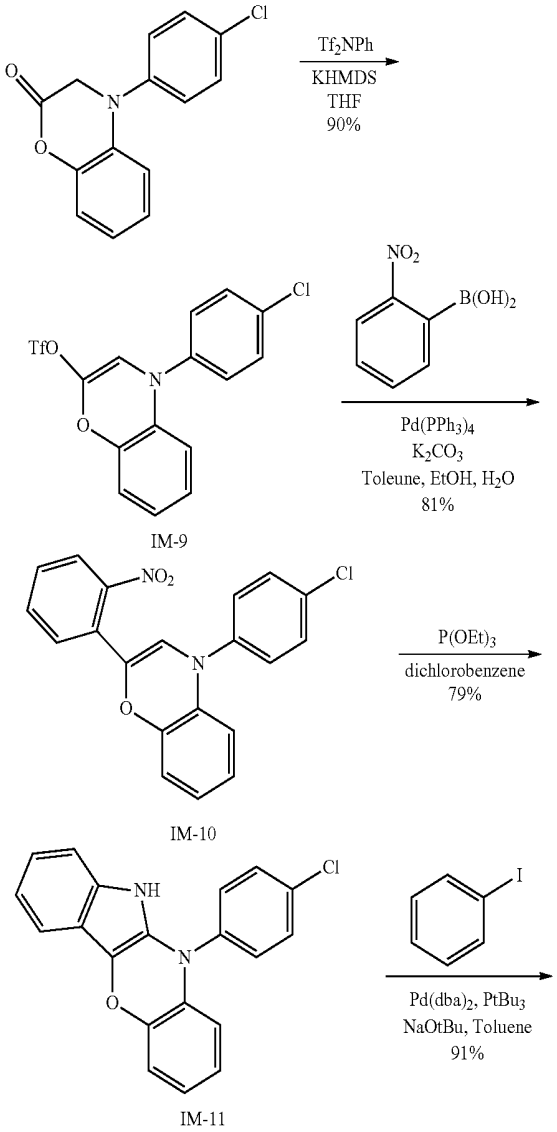
(Synthesis of Compound A42)

[0162] In an Ar atmosphere, IM-8 (5.00 g, 11.4 mmol), $Pd(dba)_2$ (0.20 g, 0.03 equiv, 0.3 mmol), NaOtBu (2.20 g, 2.0 equiv, 22.8 mmol), toluene (57 mL), N-[4-(naphthalen-1-yl)phenyl]dibenzofuran-1-amine (4.85 g, 1.1 equiv, 12.6 mmol) and tBu_3P (0.23 g, 0.1 equiv, 1.1 mmol) were added sequentially into a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Compound A42 (7.48 g, yield 80%) as a solid.

[0163] Compound A42 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=817.

6. Synthesis of Compound B6

[0164]

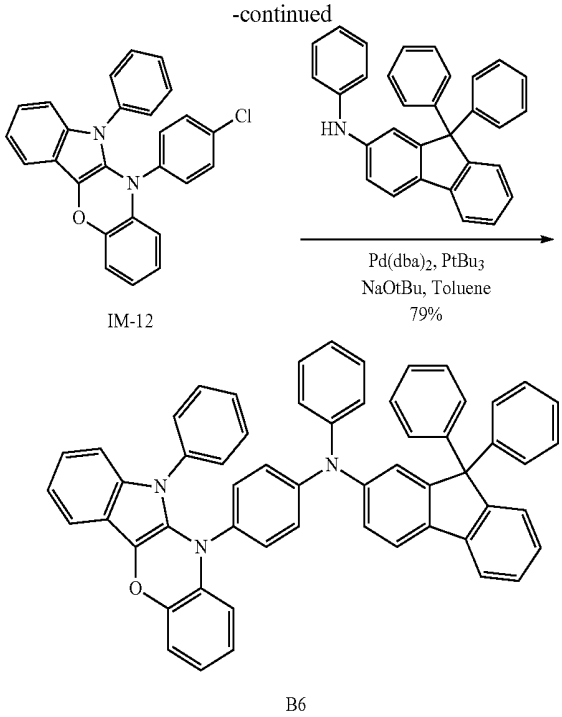


IM-9

IM-10

IM-11

-continued



(Synthesis of Intermediate IM-9)

[0165] In an Ar atmosphere, 4-(4-chlorophenyl)-3,4-dihydro-2H-benzoxazin-2-one (15.00 g, 57.8 mmol) and THF (193 mL, 0.3 M) were added to a 500 mL three neck flask. While stirring the resulting mixture at about −78° C., KHMDS/THF solution (63.5 mL, 1.1 equiv, 1.0 mol) was added dropwise thereto, followed by stirring at the same temperature for about 1 hour. N,N'-bis(trifluoromethanesulfonyl)aniline (24.76 g, 1.2 equiv, 69.3 mmol) and THF solution (17.3 mL, 1 mol/L) were added dropwise thereto, followed by stirring at the same temperature for about 30 minutes. The temperature was elevated to room temperature and the stirring was conducted for about 2 hours. 10% NaOH aqueous solution was added thereto, and then the reaction solution was extracted with AcOEt. After removing aqueous layer, an organic layer was washed with sodium bicarbonate aqueous solution and saturated saline in order, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product IM-9 (20.37 g, yield 90%) thus obtained was used in the next step without purification.

[0166] Intermediate IM-9 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=391.

(Synthesis of Intermediate IM-10)

[0167] In an Ar atmosphere, IM-9 (17.00 g, 43.4 mmol), 2-nitrophenylboronic acid (7.97 g, 1.1 equiv, 47.7 mmol), K_2CO_3 (17.99 g, 3.0 equiv, 130.2 mmol), $Pd(PPh_3)_4$ (2.51 g, 0.05 eq, 2.2 mmol), and a mixture solution of toluene/EtOH/H_2O (4/2/1) (303 mL) were added sequentially into a 500 mL three neck flask, and the mixture was stirred and heated at about 80° C. for about 5 hours. After cooling in the air to room temperature, the reaction solution was extracted with toluene. After removing aqueous layer, an organic layer was washed with saturated saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-10 (12.82 g, yield 81%).

[0168] Intermediate IM-10 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=364.

(Synthesis of Intermediate IM-11)

[0169] In an Ar atmosphere, IM-10 (12.00 g, 30.5 mmol), o-dichlorobenzene (66 mL) and $P(OEt)_3$ (21.86 g, 4 equiv, 131.6 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated at about 160° C. for about 24 hours. After cooling in the air to room temperature, the reaction solution was evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-11 (8.65 g, yield 79%).

[0170] Intermediate IM-11 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=332.

(Synthesis of Intermediate IM-12)

[0171] In an Ar atmosphere, IM-11 (7.00 g, 21.0 mmol), $Pd(dba)_2$ (0.36 g, 0.03 equiv, 0.6 mmol), NaOtBu (4.04 g, 2.0 equiv, 42.1 mmol), toluene (105 mL), iodobenzene (4.72 g, 1.1 equiv, 23.1 mmol) and tBu_3P (0.43 g, 0.1 equiv, 2.1 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-12 (7.83 g, yield 91%).

[0172] Intermediate IM-12 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=408.

(Synthesis of Compound B6)

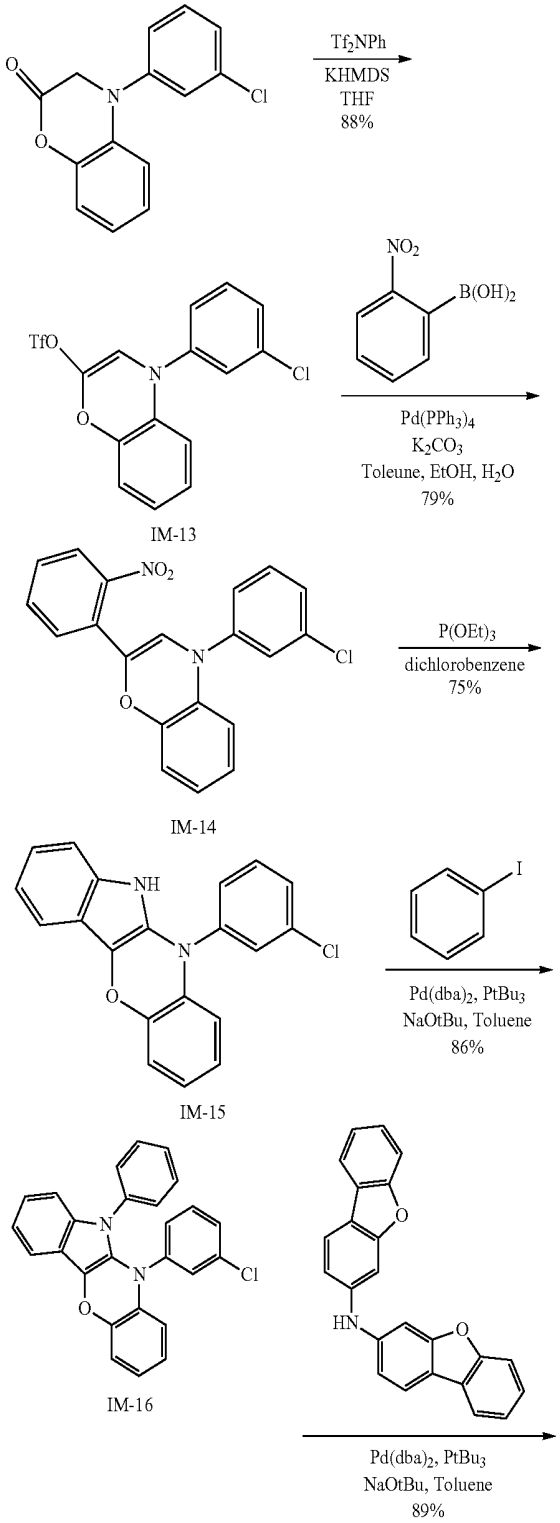
[0173] In an Ar atmosphere, IM-12 (5.00 g, 12.2 mmol), $Pd(dba)_2$ (0.21 g, 0.03 equiv, 0.4 mmol), NaOtBu (2.35 g, 2.0 equiv, 24.5 mmol), toluene (61 mL), N,9,9-triphenyl-9H-fluoren-2-amine (5.51 g, 1.1 equiv, 13.5 mmol) and tBu_3P (0.25 g, 0.1 equiv, 1.2 mmol) were added sequentially into a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and

toluene as developing solvent) to obtain Compound B6 (7.55 g, yield 79%) as a solid.

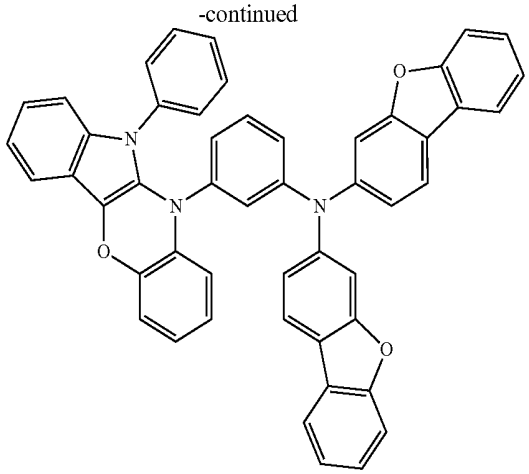
[0174] Compound B6 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=781.

7. Synthesis of Compound B13

[0175]



-continued



B13

(Synthesis of Intermediate IM-13)

[0176] Under an Ar atmosphere, 4-(3-chlorophenyl)-3,4-dihydro-2H-benzoxazin-2-one (15.00 g, 57.8 mmol) and THF (193 mL, 0.3 M) were added to a 500 mL three neck flask. While stirring the resulting mixture at about −78° C., KHMDS/THF solution (63.5 mL, 1.1 equiv, 1.0 mol) was added dropwisely thereto, followed by stirring at the same temperature for about 1 hour. N,N'-bis(trifluoromethanesulfonyl)aniline (24.76 g, 1.2 equiv, 69.3 mmol) and THF solution (17.3 mL, 1 mol/L) were added dropwise thereto, followed by stirring at the same temperature for about 30 minutes. The temperature was elevated to room temperature and the stirring was conducted for about 2 hours. 10% NaOH aqueous solution was added thereto, and then the reaction solution was extracted with AcOEt. After removing aqueous layer, an organic layer was washed with sodium bicarbonate aqueous solution and saturated saline in order, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product IM-13 (19.91 g, yield 88%) thus obtained was used in the next step without purification.

[0177] Intermediate IM-13 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=391.

(Synthesis of Intermediate IM-14)

[0178] In an Ar atmosphere, IM-13 (17.00 g, 43.4 mmol), 2-nitrophenylboronic acid (7.97 g, 1.1 equiv, 47.7 mmol), K_2CO_3 (17.99 g, 3.0 equiv, 130.2 mmol), $Pd(PPh_3)_4$ (2.51 g, 0.05 eq, 2.2 mmol), and a mixture solution of toluene/EtOH/H_2O (4/2/1) (303 mL) were added sequentially into a 500 mL three neck flask, and the mixture was stirred and heated at about 80° C. for about 5 hours. After cooling in the air to room temperature, the reaction solution was extracted with toluene. After removing aqueous layer, an organic layer was washed with saturated saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-14 (12.50 g, yield 79%).

[0179] Intermediate IM-14 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=364.

(Synthesis of Intermediate IM-15)

[0180] In an Ar atmosphere, IM-14 (12.00 g, 30.5 mmol), o-dichlorobenzene (66 mL) and $P(OEt)_3$ (21.86 g, 4 equiv, 131.6 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated at about 160° C. for about 24 hours. After cooling in the air to room temperature, the reaction solution was evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-15 (8.21 g, yield 75%).

[0181] Intermediate IM-15 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=332.

(Synthesis of Intermediate IM-16)

[0182] In an Ar atmosphere, IM-15 (7.00 g, 21.0 mmol), $Pd(dba)_2$ (0.36 g, 0.03 equiv, 0.6 mmol), NaOtBu (4.04 g, 2.0 equiv, 42.1 mmol), toluene (105 mL), iodobenzene (4.72 g, 1.1 equiv, 23.1 mmol) and tBu_3P (0.43 g, 0.1 equiv, 2.1 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-16 (7.40 g, yield 86%).

[0183] Intermediate IM-16 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=408.

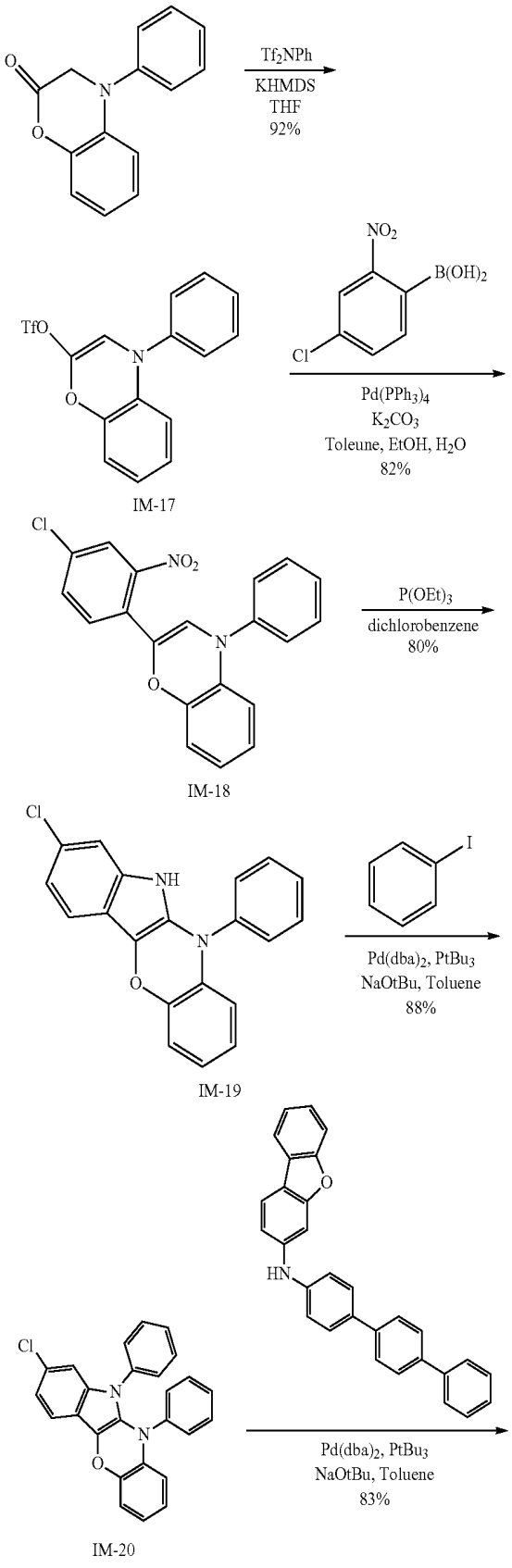
(Synthesis of Compound B13)

[0184] In an Ar atmosphere, IM-16 (5.00 g, 12.2 mmol), $Pd(dba)_2$ (0.21 g, 0.03 equiv, 0.4 mmol), NaOtBu (2.35 g, 2.0 equiv, 24.5 mmol), toluene (61 mL), bis(dibenzofuran-3-yl)amine (5.51 g, 1.1 equiv, 13.5 mmol) and tBu_3P (0.25 g, 0.1 equiv, 1.2 mmol) were added sequentially into a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Compound B13 (7.76 g, yield 89%) as a solid.

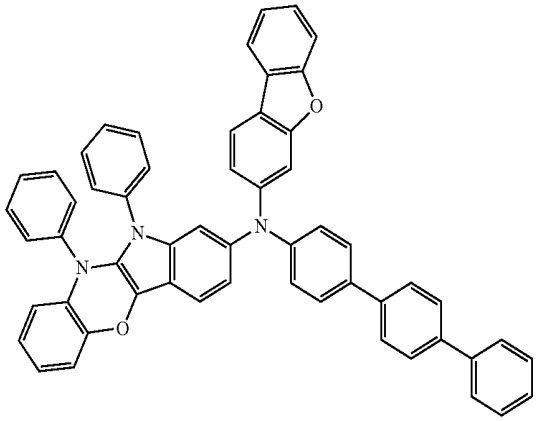
[0185] Compound B13 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=712.

8. Synthesis of Compound B23

[0186]



-continued



B23

(Synthesis of Intermediate IM-17)

[0187] In an Ar atmosphere, 4-phenyl-3,4-dihydro-2H-benzoxazin-2-one (15.00 g, 66.6 mmol) and THF (222 mL, 0.3 M) were added to a 500 mL three neck flask. While stirring the resulting mixture at about −78° C., KHMDS/THF solution (73.3 mL, 1.1 equiv, 1.0 mol) was added dropwise thereto, followed by stirring at the same temperature for about 1 hour. N,N'-bis(trifluoromethanesulfonyl) aniline (28.55 g, 1.2 equiv, 79.9 mmol) and THF solution (20.0 mL, 1 mol/L) were added dropwise thereto, followed by stirring at the same temperature for about 30 minutes. The temperature was elevated to room temperature and the stirring was conducted for about 2 hours. 10% NaOH aqueous solution was added thereto, and then the reaction solution was extracted with AcOEt. After removing the aqueous layer, an organic layer was washed with sodium bicarbonate aqueous solution and saturated saline in order, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product IM-17 (21.89 g, yield 92%) thus obtained was used in the next step without purification.

[0188] Intermediate IM-17 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=357.

(Synthesis of Intermediate IM-18)

[0189] In an Ar atmosphere, IM-17 (17.00 g, 47.6 mmol), 4-chloro-2-nitrophenylboronic acid (10.54 g, 1.1 equiv, 52.3 mmol), K_2CO_3 (19.73 g, 3.0 equiv, 142.7 mmol), $Pd(PPh_3)_4$ (2.74 g, 0.05 eq, 2.4 mmol), and a mixture solution of toluene/EtOH/H_2O (4/2/1) (333 mL) were added sequentially to a 500 mL three neck flask, and the mixture was stirred and heated at about 80° C. for about 5 hours. After cooling in the air to room temperature, the reaction solution was extracted with toluene. After removing aqueous layer, an organic layer was washed with saturated saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-18 (14.23 g, yield 82%).

[0190] Intermediate IM-18 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=364.

(Synthesis of Intermediate IM-19)

[0191] In an Ar atmosphere, IM-18 (12.00 g, 32.9 mmol), o-dichlorobenzene (66 mL) and $P(OEt)_3$ (21.86 g, 4 equiv, 131.6 mmol) were added in order to a 300 mL three neck flask, and the mixture was stirred and heated at about 160° C. for about 24 hours. After cooling in the air to room temperature, the reaction solution was evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-19 (8.76 g, yield 80%).

[0192] Intermediate IM-19 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=332.

(Synthesis of Intermediate IM-20)

[0193] In an Ar atmosphere, IM-19 (7.00 g, 21.0 mmol), $Pd(dba)_2$ (0.36 g, 0.03 equiv, 0.6 mmol), NaOtBu (4.04 g, 2.0 equiv, 42.1 mmol), toluene (105 mL), iodobenzene (4.72 g, 1.1 equiv, 23.1 mmol) and tBu_3P (0.43 g, 0.1 equiv, 2.1 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-20 (7.57 g, yield 88%).

[0194] Intermediate IM-20 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=408.

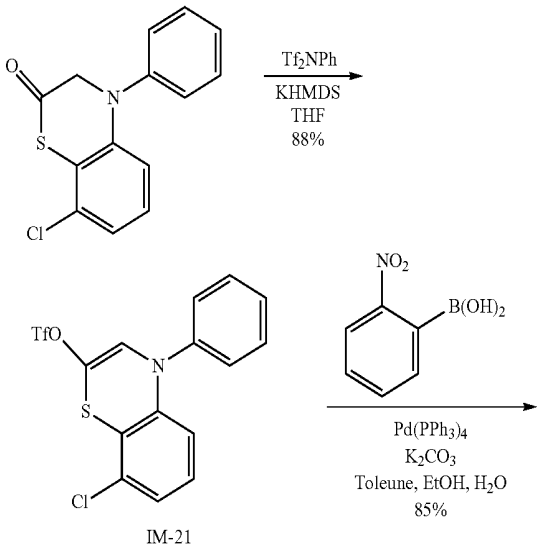
(Synthesis of Compound B23)

[0195] In an Ar atmosphere, IM-20 (5.00 g, 12.2 mmol), $Pd(dba)_2$ (0.21 g, 0.03 equiv, 0.4 mmol), NaOtBu (2.35 g, 2.0 equiv, 24.5 mmol), toluene (61 mL), N-[(1,1':4',1"-terphenyl)-4-yl]dibenzofuran-3-amine (5.54 g, 1.1 equiv, 13.5 mmol) and tBu_3P (0.25 g, 0.1 equiv, 1.2 mmol) were added sequentially to a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Compound B23 (7.96 g, yield 83%) as a solid.

[0196] Compound B23 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=783.

9. Synthesis of Compound C66

[0197]



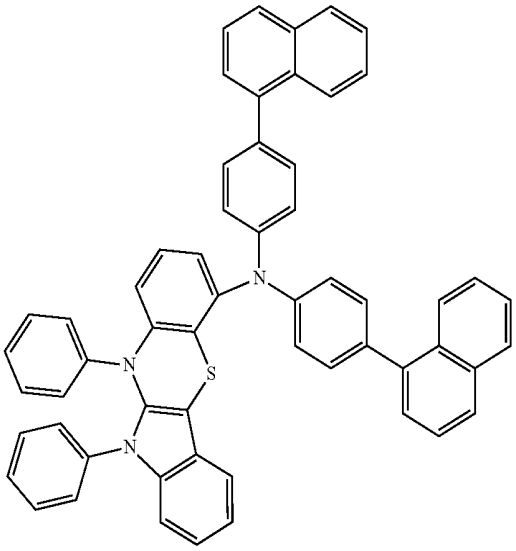
IM-21

IM-22

IM-23

IM-24

-continued



C66

(Synthesis of Intermediate IM-21)

[0198] In an Ar atmosphere, 8-chloro-4-phenyl-3,4-dihydro-2H-benzothiazin-2-one (15.00 g, 54.4 mmol) and THF (181 mL, 0.3 M) were added to a 500 mL three neck flask. While stirring the resulting mixture at about −78° C., KHMDS/THF solution (59.8 mL, 1.1 equiv, 1.0 mol) was added dropwise thereto, followed by stirring at the same temperature for about 1 hour. N,N'-bis(trifluoromethanesulfonyl)aniline (23.32 g, 1.2 equiv, 59.8 mmol) and THF solution (16.3 mL, 1 mol/L) were added dropwise thereto, followed by stirring at the same temperature for about 30 minutes. The temperature was elevated to room temperature and the stirring was conducted for about 2 hours. 10% NaOH aqueous solution was added thereto, and then the reaction solution was extracted with AcOEt. After removing aqueous layer, an organic layer was washed with sodium bicarbonate aqueous solution and saturated saline in that order, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product IM-21 (19.52 g, yield 88%) thus obtained was used in the next step without purification.

[0199] Intermediate IM-21 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=407.

(Synthesis of Intermediate IM-22)

[0200] In an Ar atmosphere, IM-21 (17.00 g, 41.7 mmol), 2-nitrophenylboronic acid (7.65 g, 1.1 equiv, 45.9 mmol), K_2CO_3 (17.28 g, 3.0 equiv, 125.1 mmol), $Pd(PPh_3)_4$ (2.41 g, 0.05 eq, 2.1 mmol) and a mixture solution of toluene/EtOH/H_2O (4/2/1) (292 mL) were added sequentially into a 500 mL three neck flask, and the mixture was stirred and heated at about 80° C. for about 5 hours. After cooling in the air to room temperature, the reaction solution was extracted with toluene. After removing aqueous layer, an organic layer was washed with saturated saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of

hexane and toluene as developing solvent) to obtain Intermediate IM-22 (13.49 g, yield 85%).

[0201] Intermediate IM-22 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=380.

(Synthesis of Intermediate IM-23)

[0202] In an Ar atmosphere, IM-22 (12.00 g, 31.5 mmol), o-dichlorobenzene (63 mL) and $P(OEt)_3$ (20.94 g, 4 equiv, 126.0 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated at about 160° C. for about 24 hours. After cooling in the air to room temperature, the reaction solution was evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-23 (8.57 g, yield 78%).

[0203] Intermediate IM-23 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=348.

(Synthesis of Intermediate IM-24)

[0204] In an Ar atmosphere, IM-23 (7.00 g, 20.1 mmol), $Pd(dba)_2$ (0.35 g, 0.03 equiv, 0.6 mmol), NaOtBu (3.86 g, 2.0 equiv, 40.1 mmol), toluene (100 mL), iodobenzene (4.50 g, 1.1 equiv, 22.1 mmol) and tBu_3P (0.41 g, 0.1 equiv, 2.0 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-24 (7.25 g, yield 85%).

[0205] Intermediate IM-24 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=408.

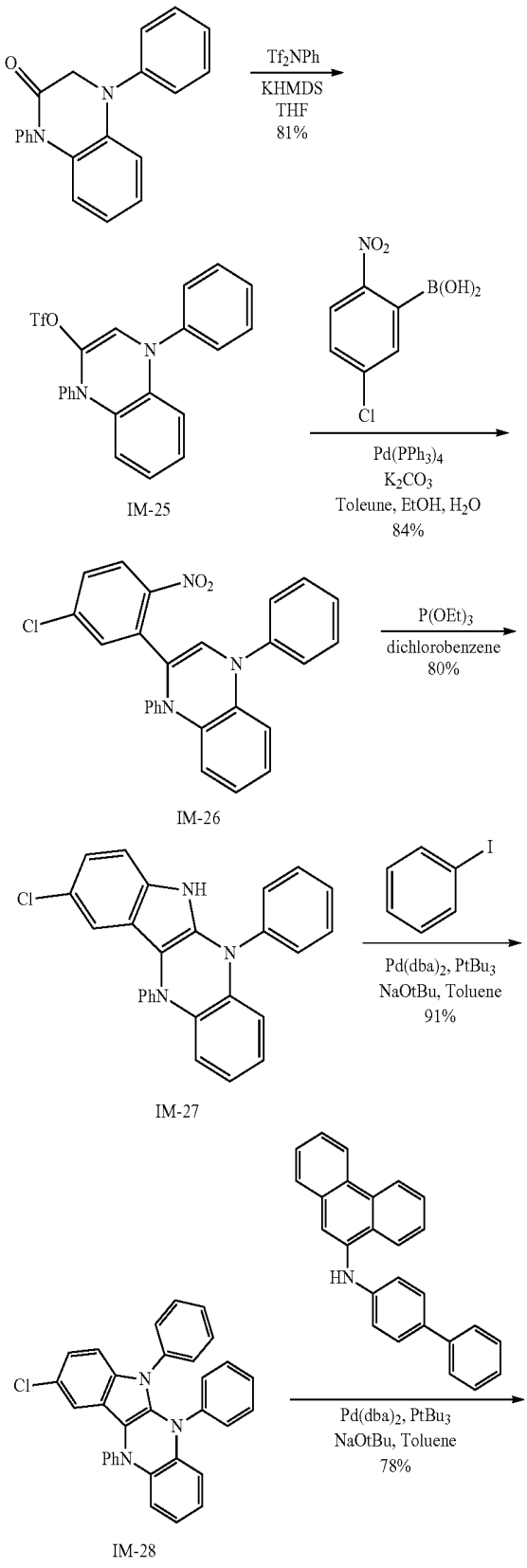
(Synthesis of Compound C66)

[0206] In an Ar atmosphere, IM-24 (5.00 g, 11.8 mmol), $Pd(dba)_2$ (0.20 g, 0.03 equiv, 0.4 mmol), NaOtBu (2.26 g, 2.0 equiv, 23.5 mmol), toluene (58 mL), bis[4-(naphthalen-1-yl)phenyl]amine (5.46 g, 1.1 equiv, 12.9 mmol) and tBu_3P (0.24 g, 0.1 equiv, 1.2 mmol) were added sequentially into a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Compound C66 (8.48 g, yield 89%) as a solid.

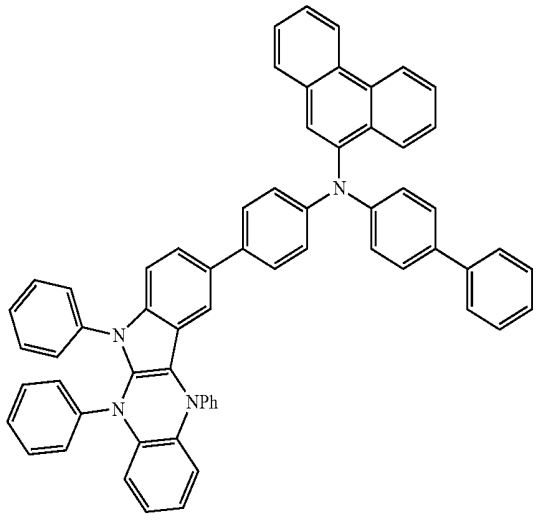
[0207] Compound C66 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=810.

10. Synthesis of Compound D34

[0208]



-continued



D34

(Synthesis of Intermediate IM-25)

[0209] In an Ar atmosphere, 1,4-diphenyl-3,4-dihydroquinoxalin-2(1H)-one (15.00 g, 49.9 mmol) and THF (166 mL, 0.3 M) were added to a 500 mL three neck flask. While stirring the resulting mixture at about −78° C., KHMDS/THF solution (54.9 mL, 1.1 equiv, 1.0 mol) was added dropwise thereto, followed by stirring at the same temperature for about 1 hour. N,N'-bis(trifluoromethanesulfonyl) aniline (21.41 g, 1.2 equiv, 59.9 mmol) and THF solution (15.0 mL, 1 mol/L) were added dropwise thereto, followed by stirring at the same temperature for about 30 minutes. The temperature was elevated to room temperature and the stirring was conducted for about 2 hours. 10% NaOH aqueous solution was added thereto, and then the reaction solution was extracted with AcOEt. After removing the aqueous layer, an organic layer was washed with sodium bicarbonate aqueous solution and saturated saline in order, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product IM-25 (17.49 g, yield 81%) thus obtained was used in the next step without purification.

[0210] Intermediate IM-25 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=432.

(Synthesis of Intermediate IM-26)

[0211] In an Ar atmosphere, (2-bromophenyl)(2-bromo-4-chlorophenyl) ether (10.00 g, 27.6 mmol) and THF (92 mL, 0.3M) were added to a 500 mL three neck flask. While stirring the resulting mixture at about −78° C., nBuLi/n-hexane solution (37.9 mL, 2.2 equiv, 1.6 mol) was added dropwise thereto, followed by stirring at the same temperature for about 1 hour. IM-12 (8.11 g, 1.1 equiv, 30.3 mmol) in THF solution (8 mL, 1 mol/L) was added dropwise thereto, followed by stirring at the same temperature for about 30 minutes. The temperature was elevated to room temperature and the stirring was conducted for about 8 hours. The reaction solution was quenched with a saturated aqueous ammonium chloride solution, and then extracted with toluene. After removing aqueous layer, an organic layer was washed with sodium bicarbonate aqueous solution and saturated saline sequentially, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-26 (5.50 g, yield 50%).

[0212] Intermediate IM-26 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=398.

(Synthesis of Intermediate IM-27)

[0213] In an Ar atmosphere, IM-26 (12.00 g, 27.3 mmol), o-dichlorobenzene (55 mL) and $P(OEt)_3$ (18.13 g, 4 equiv, 109.1 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated at about 160° C. for about 24 hours. After cooling in the air to room temperature, the reaction solution was evaporated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-27 (8.90 g, yield 80%).

[0214] Intermediate IM-27 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=407.

(Synthesis of Intermediate IM-28)

[0215] In an Ar atmosphere, IM-27 (7.00 g, 17.2 mmol), $Pd(dba)_2$ (0.30 g, 0.03 equiv, 0.5 mmol), NaOtBu (3.30 g, 2.0 equiv, 34.3 mmol), toluene (86 mL), iodobenzene (3.85 g, 1.1 equiv, 18.9 mmol) and tBu_3P (0.35 g, 0.1 equiv, 1.7 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-28 (7.56 g, yield 91%).

[0216] Intermediate IM-28 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=484.

(Synthesis of Compound D34)

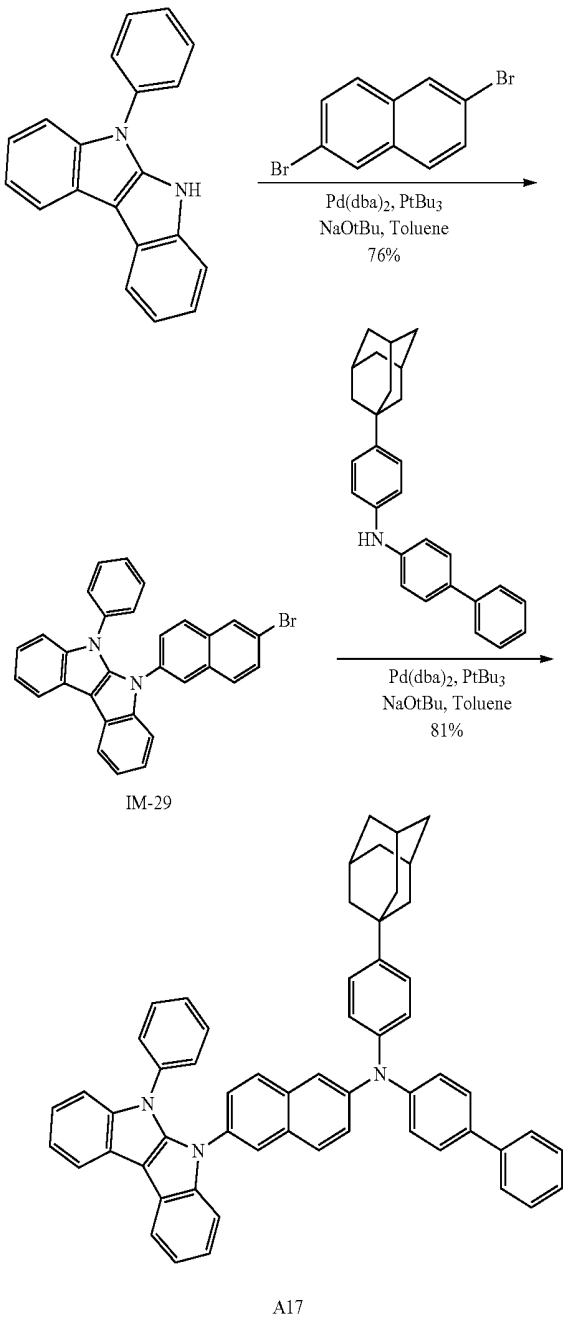
[0217] In an Ar atmosphere, IM-28 (5.00 g, 10.3 mmol), $Pd(dba)_2$ (0.18 g, 0.03 equiv, 0.3 mmol), NaOtBu (1.99 g, 2.0 equiv, 20.3 mmol), toluene (52 mL), N-[(1,1'-biphenyl)-4-yl]phenanthren-9-amine (3.93 g, 1.1 equiv, 11.4 mmol) and tBu_3P (0.21 g, 0.1 equiv, 1.0 mmol) were added sequentially into a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of

hexane and toluene as developing solvent) to obtain Compound D34 (7.00 g, yield 78%) as a solid.

[0218] Compound D34 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=869.

11. Synthesis of Compound A17

[0219]



(Synthesis of Intermediate IM-29)

[0220] In an Ar atmosphere, 5-phenyl-5,6-dihydroindolo [2,3-b]indole (5.00 g, 17.7 mmol), $Pd(dba)_2$ (0.31 g, 0.03 equiv, 0.5 mmol), NaOtBu (11.65 g, 1.0 equiv, 1.70 mmol), toluene (88 mL), 2,6-dibromonaphthalene (5.57 g, 1.1 equiv, 19.5 mmol) and tBu_3P (0.36 g, 0.1 equiv, 1.8 mmol) were added sequentially into a 300 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Intermediate IM-29 (6.56 g, yield 76%).

[0221] Intermediate IM-29 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=487.

(Synthesis of Compound A17)

[0222] In an Ar atmosphere, IM-29 (5.00 g, 11.4 mmol), $Pd(dba)_2$ (0.20 g, 0.03 equiv, 0.3 mmol), NaOtBu (2.20 g, 2.0 equiv, 22.8 mmol), toluene (57 mL), N-{4-[(3r,5r,7r)-adamantan-1-yl]phenyl}-(1,1'-biphenyl)-4-amine (4.28 g, 1.1 equiv, 12.6 mmol) and tBu_3P (0.23 g, 0.1 equiv, 1.1 mmol) were added sequentially into a 200 mL three neck flask, and the mixture was stirred and heated to reflux for about 6 hours. After cooling in the air to room temperature, water was added to the reactant and an organic layer was separated and taken. Toluene was added to the remaining aqueous layer, followed by extraction of the aqueous layer. Organic layers were combined and washed with saline, and then dried over $MgSO_4$. $MgSO_4$ was filtered out and organic layers were concentrated. The crude product thus obtained was purified by silica gel column chromatography (using a mixture of hexane and toluene as developing solvent) to obtain Compound A17 (6.53 g, yield 81%) as a solid.

[0223] Compound A17 was identified by measuring FAB-MS in which a molecular ion peak was observed at mass m/z=786.

[0224] The above-described synthesis examples illustrate exemplary embodiments, and the reaction condition may be changed, if necessary. In addition, the compound according to an embodiment of the inventive concept may be synthesized to have a variety of substituents by using known methods and materials in the art. The compound according to an embodiment of the inventive concept may have a characteristic suitable for an organic electroluminescence device by introducing a variety of substituents to the core structure represented by Formula 1.

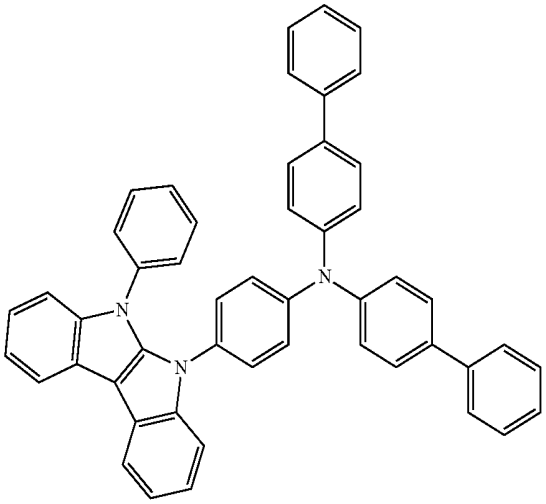
(Device Manufacturing Example)

[0225] Organic electroluminescence devices of Examples 1 to 11 were manufactured by using Example Compounds A2, A13, A22, A35, A42, B6, B13, B23, C66, D34 and A17 as a material for a hole transport layer.

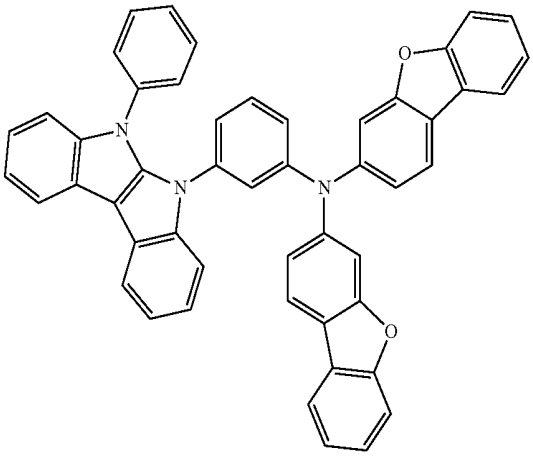
Example Compounds

[0226]

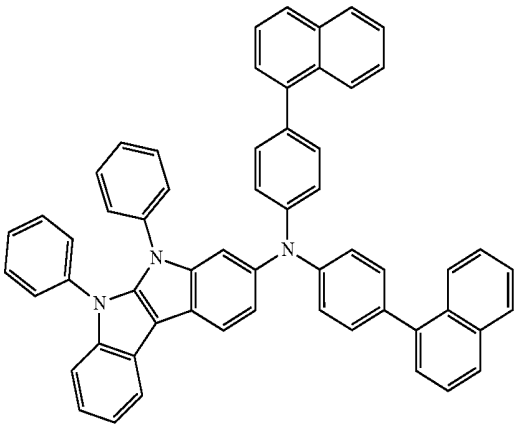
A2



A13

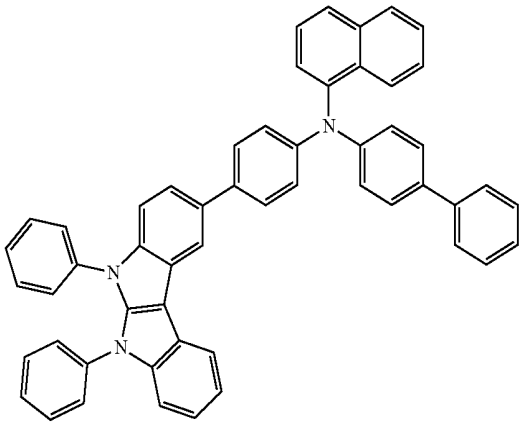


A22

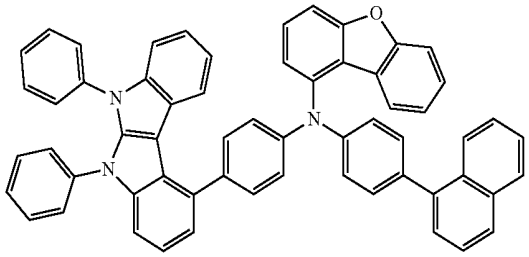


-continued

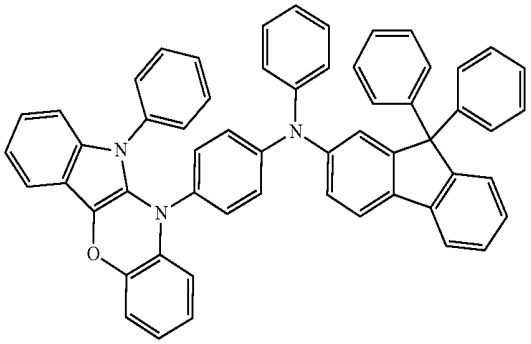
A35



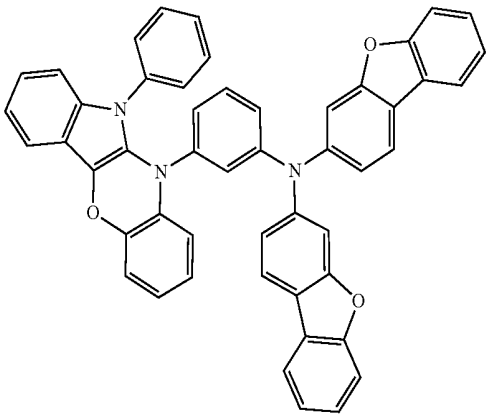
A42



B6

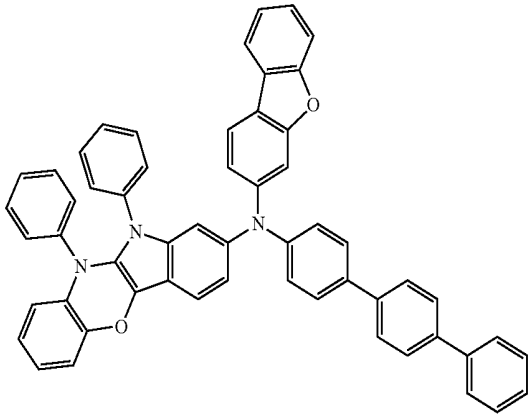


B13

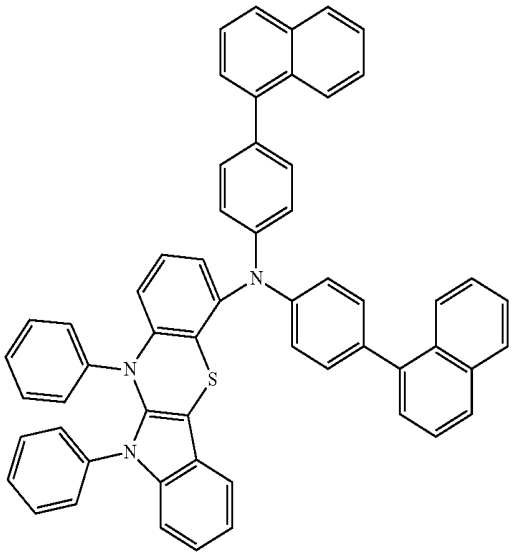


-continued

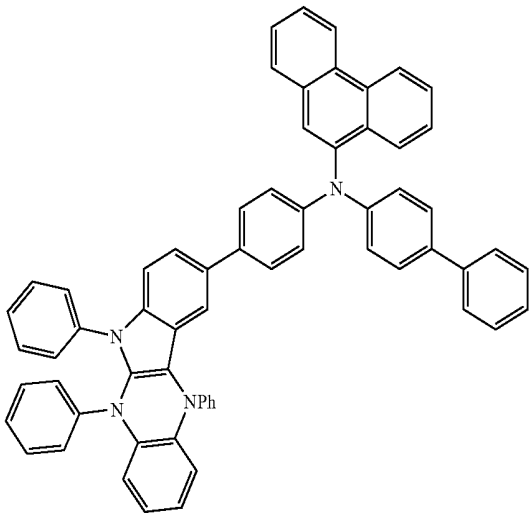
B23



C66

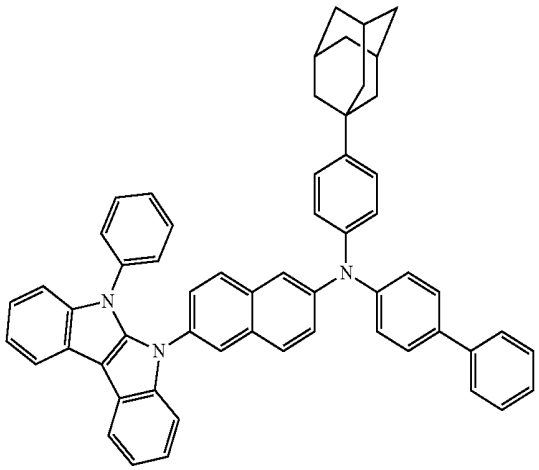


D34



-continued

A17

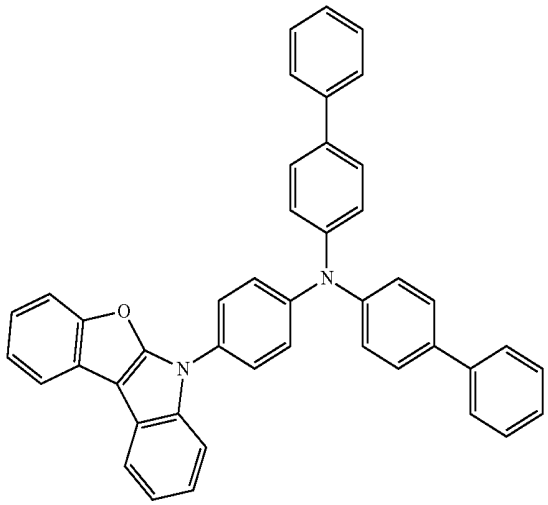


[0227] Organic electroluminescence devices of Comparative Examples 1 to 10 were manufactured by using the following known compounds as a material for a hole transport layer.

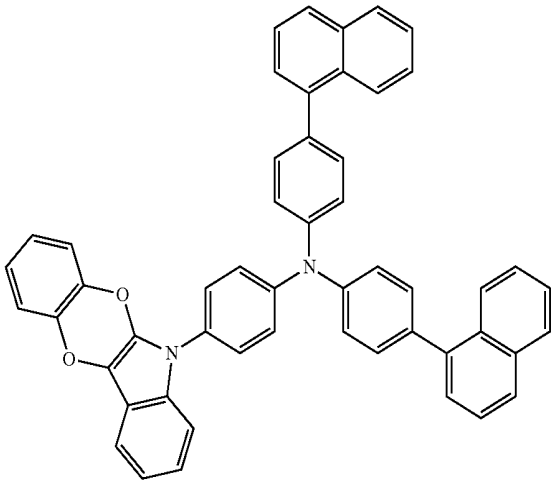
[Comparative Compounds]

[0228]

R1

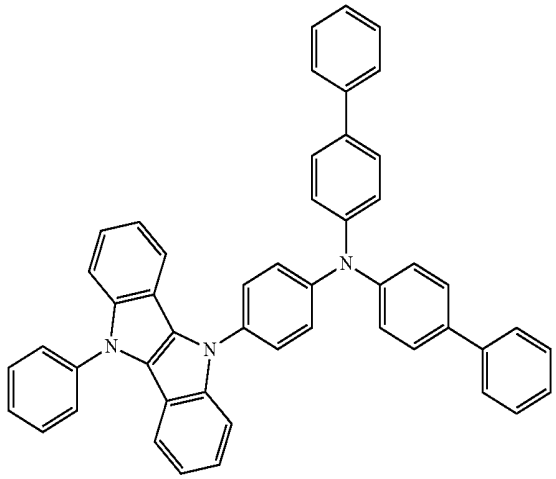


R2

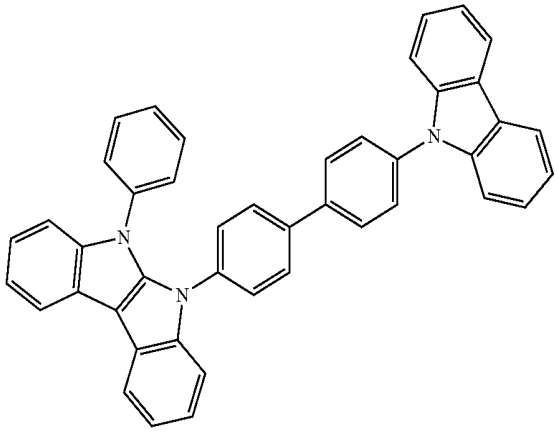


-continued

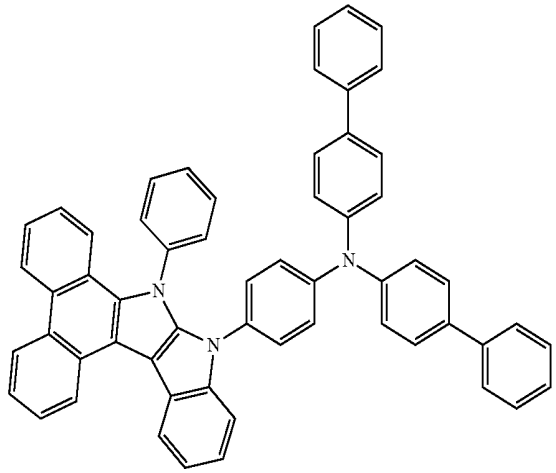
R3



R4

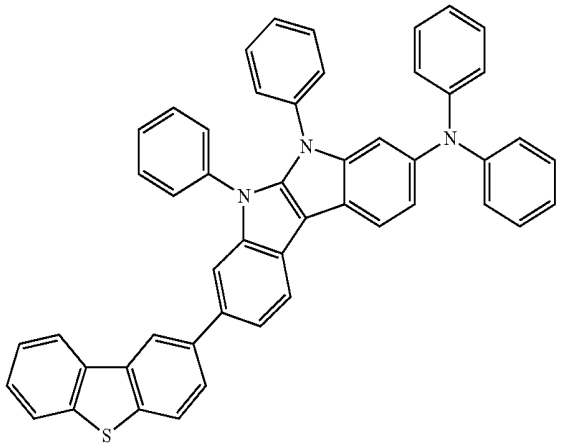


R5

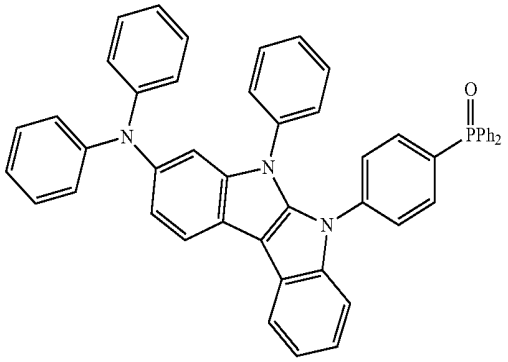


-continued

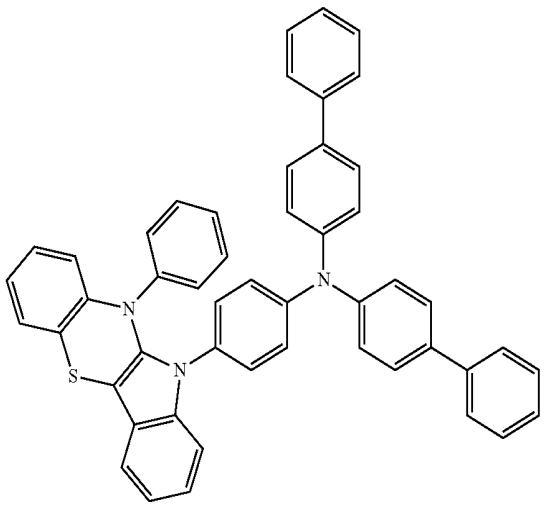
R6



R7

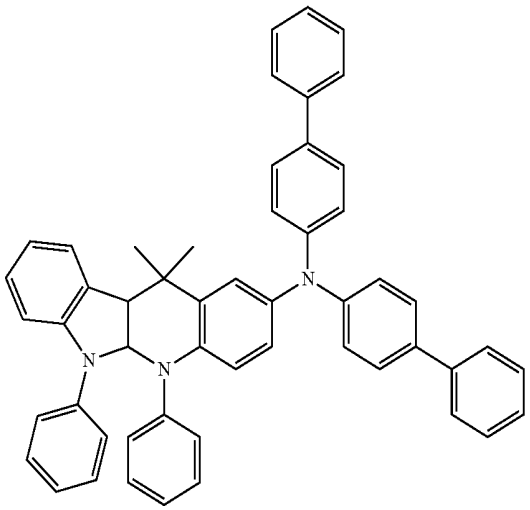


R8

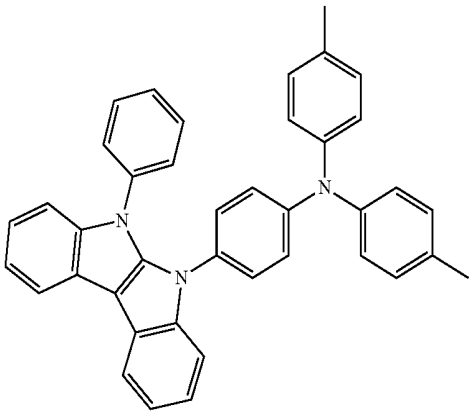


-continued

R9



R10



[0229] Organic electroluminescence devices of Examples 1 to 11 and Comparative Examples 1 to 10 were manufactured by the following method.

[0230] ITO glass substrate (Corning Incorporated) with ITO layer of a thickness of about 1,500 Å was cut into a size of 50 mm×50 mm×0.7 mm, followed by performing ultrasonic cleaning with isopropyl alcohol and pure water for about 5 minutes each. After performing UV irradiation and ozone treatment for about 30 minutes, the ITO glass substrate was set in a vacuum deposition apparatus.

[0231] On the substrate, a hole injection layer was formed by vacuum deposition of a known compound 1-TNATA to a thickness of about 600 Å, and a hole transport layer was formed by vacuum deposition of Example Compounds or Comparative Compounds to a thickness of about 300 Å.

[0232] On the hole transport layer, an emission layer was formed by co-deposition of 9,10-di-naphthalen-2-yl-anthracene (ADN) as a known blue fluorescence host and 2,5,8,11-tetra-t-butylperylene (TBP) as a known blue fluorescence dopant at a weight ratio of 97:3 to a thickness of about 250 Å.

[0233] Next, an electron transport layer was formed by depositing Alq_3 to a thickness of about 250 Å on the emission layer, and then an electron injection layer was formed by depositing LiF to a thickness of about 10 Å on the electron transport layer. LiF/A1 electrode was formed by vacuum deposition of A1 to a thickness of about 1,000 Å (a second electrode) to manufacture an organic electroluminescence device.

[0234] The driving voltage, efficiency and half-life of the organic electroluminescence devices manufactured in Examples 1 to 11 and Comparative Examples 1 to 10 were measured and shown in Table 1 below.

TABLE 1

Device manufacturing example	Hole transport layer	Voltage (V)	Efficiency (cd/A)	Life LT50 (h)
Example 1	Example Compound A2	5.4	7.7	2000
Example 2	Example Compound A13	5.5	7.8	1950
Example 3	Example Compound A22	5.6	7.6	2100
Example 4	Example Compound A35	5.7	7.5	2050
Example 5	Example Compound A42	5.6	7.8	1900
Example 6	Example Compound B6	5.6	7.8	2050
Example 7	Example Compound B13	5.6	7.9	2000
Example 8	Example Compound B23	5.6	7.7	2100
Example 9	Example Compound C66	5.6	7.7	1900
Example 10	Example Compound D34	5.6	7.6	2000
Example 11	Example Compound A17	5.7	7.9	2000
Comparative Example 1	Comparative Compound R1	6.4	6.0	1650
Comparative Example 2	Comparative Compound R2	6.5	6.1	1600
Comparative Example 3	Comparative Compound R3	6.3	6.0	1550
Comparative Example 4	Comparative Compound R4	6.4	5.8	1550
Comparative Example 5	Comparative Compound R5	6.1	5.7	1600
Comparative Example 6	Comparative Compound R6	5.9	5.8	1600
Comparative Example 7	Comparative Compound R7	6.0	5.4	1450
Comparative Example 8	Comparative Compound R8	5.9	6.8	1680
Comparative Example 9	Comparative Compound R9	6.2	5.5	1500
Comparative Example 10	Comparative Compound R10	5.9	7.5	1800

[0235] The above results are a measured value at a current density of about 10 mA/cm^2, and the half-life means time required for a luminance half-time from an initial luminance of 1,000 cd/m^2. Referring to the results in Table 1, it may be found that the organic electroluminescence devices of Examples 1 to 11 attain low driving voltage, long device life and high efficiency when compared with those of Comparative Examples 1 to 10. Amine compounds are known as a hole transport material which has a strong electron resistance and contributes to a long device life. The condensed cyclic compound according to an embodiment of the inventive concept has an indoloindole group with an excellent heat and charge resistance as a core structure, thereby maintaining the property of amine compounds and increasing thermal stability and electron resistance, which results in extended life of the device using the compound.

[0236] In addition, it seems that the condensed cyclic compound according to an embodiment of the inventive concept has an indoloindole core structure in which a nitrogen atom enhances hole transport property of the whole molecule, thereby enhancing the probability of recombining holes and electrons in an emission layer, which results in enhanced emission efficiency of the device using the compound.

[0237] Furthermore, it seems that the condensed cyclic compound according to an embodiment of the inventive concept is a polycyclic compound with four condensed rings, in which each of two adjacent rings includes a nitrogen atom substituted with an aryl group, thereby maintaining distorted conformation due to electronic repulsion, and the bulky condensed ring inhibits crystallizability and enhances film-forming property, which results in enhanced emission efficiency of the device using the compound.

[0238] The organic electroluminescence devices of Examples 1, 2, 6, 7 and 11 have especially enhanced emission efficiency when compared with those of Comparative Examples. The organic electroluminescence devices of Examples 1, 2, 6, 7 and 11 use condensed cyclic compounds, in which the nitrogen atom included in the indoloindole core structure is substituted with an amine group via a linker, and distortion of aryl group of the linker and indoloindole ring decreases planarity of the whole molecule, thereby inhibiting crystallizability and improving hole transport property. Accordingly, it seems that the organic electroluminescence devices of Examples 1, 2, 6, 7 and 11 have increased probability of recombining holes and electrons in an emission layer and enhanced emission efficiency.

[0239] The organic electroluminescence devices of Examples 3, 4, 5, 8, 9 and 10 have especially extended device life when compared with those of Comparative Examples. The organic electroluminescence devices of Examples 3, 4, 5, 8, 9 and 10 use condensed cyclic compounds, in which the benzene ring of indoloindole is substituted with an amine group, and HOMO of the substituent including the amine group expands further to indoloindole. Accordingly, it seems that the improved stability in the radical state extends device life.

[0240] The organic electroluminescence devices of Comparative Examples 1 and 2 have especially decreased efficiency when compared with those of Examples. The organic electroluminescence devices of Comparative Examples 1 and 2 use Comparative Compounds R1 and R2, in which although the nitrogen atom of the condensed ring is substituted with an amine group via a linker, the condensed ring contains only one nitrogen atom. Accordingly, it seems that enhanced planarity of the whole molecule and strengthened intermolecular interaction decrease hole transport property and emission efficiency of the device.

[0241] The organic electroluminescence device of Comparative Example 3 has especially decreased efficiency when compared with those of Examples. The organic electroluminescence device of Comparative Example 3 uses Comparative Compound R3, in which the core structure is different from those of Example Compounds, although an indoloindole ring is included. Accordingly, it seems that electronic repulsion between aryl groups is relieved and planarity is enhanced, thereby decreasing efficiency of the device.

[0242] The organic electroluminescence device of Comparative Example 4 has decreased efficiency and device life when compared with those of Examples. The organic electroluminescence device of Comparative Example 4 uses Comparative Compound R4, which includes a carbazole group unlike Example Compounds having a noncyclic tertiary amine group. Accordingly, it seems that insufficient hole transport property of carbazole group decreases emission efficiency and life of the device.

[0243] The organic electroluminescence device of Comparative Example 5 has especially decreased efficiency when compared with those of Examples. The organic electroluminescence device of Comparative Example 5 uses Comparative Compound R5, in which two benzene rings are further condensed to the indoloindole core structure, unlike Example Compounds, thereby increasing the electron density of indoloindole ring in HOMO and decreasing the relative contribution of amine group to HOMO, which seems to decrease hole transport property and emission efficiency of the device.

[0244] The organic electroluminescence device of Comparative Example 6 has especially decreased efficiency when compared with those of Examples. The organic electroluminescence device of Comparative Example 6 uses Comparative Compound R6, in which the indoloindole core structure is substituted with a heterocyclic ring, thereby increasing the electron density of indoloindole ring in HOMO and decreasing the relative contribution of amine group to HOMO, which seems to decrease hole transport property and emission efficiency of the device.

[0245] The organic electroluminescence device of Comparative Example 7 has especially decreased efficiency when compared with those of Examples. The organic electroluminescence device of Comparative Example 7 uses Comparative Compound R7, which includes a phosphoryl group, thereby changing LUMO level and scattering excitation energy in an emission layer, which seems to decrease emission efficiency of the device.

[0246] The organic electroluminescence device of Comparative Example 8 has especially decreased device life when compared with those of Examples. The organic electroluminescence device of Comparative Example 8 uses Comparative Compound R8, in which although the core structure is similar to those of Example Compounds, the substitution site of amine group is different from those of Example Compounds. That is, the amine group is substituted not to the ring containing S with a relatively high electron density but to the indole ring with a relatively low electron density. Accordingly, the electrons of amine group are withdrawn into the condensed ring for relieving electronic polarization in the condensed ring, thereby decreasing the electron resistance of amine group, which seems to decrease device life.

[0247] The organic electroluminescence device of Comparative Example 9 has decreased efficiency and device life when compared with those of Examples. The organic electroluminescence device of Comparative Example 9 uses Comparative Compound R9, which includes a carbon atom of sp3 hybrid orbital in the condensed ring. Accordingly, it seems that insufficient thermal stability decreases emission efficiency and life of the device.

[0248] The organic electroluminescence device of Comparative Example 10 has especially decreased device life when compared with those of Examples. The organic electroluminescence device of Comparative Example 10 uses Comparative Compound R10, which has an amine group including an aryl group substituted with an alkyl group of straight chain as a substituent. Especially, in Comparative Compound R10, carbon atoms forming sp3 hybrid on benzyl group has a straight chain structure, which is different from Example Compound A-17 used in the organic electroluminescence device of Example 11, in which carbon atoms on benzyl group form a cycloalkyl group. Accordingly, Com-

parative Compound R10 is unstable in the radical state and easily degraded, which seems to decrease device life.

[0249] The organic electroluminescence device according to an embodiment of the inventive concept has high efficiency and a long device life. The organic electroluminescence device according to an embodiment of the inventive concept has a low driving voltage. The organic electroluminescence device according to an embodiment of the inventive concept uses a condensed cyclic compound including an indoloindole core structure and a tertiary amine substituent as a material for a hole transport region, thereby enhancing emission efficiency and a device life.

[0250] The organic electroluminescence device according to an embodiment of the inventive concept has high efficiency.

[0251] The organic electroluminescence device according to an embodiment of the inventive concept has a long device life.

[0252] The condensed cyclic compound according to an embodiment of the inventive concept may be applied to an organic electroluminescence device, thereby contributing to high efficiency and a long device life.

[0253] Although the exemplary embodiments of the present invention have been described referring to the attached drawings, it is understood that the present invention should not be limited to these exemplary embodiments but various changes and modifications can be made by one ordinary skilled in the art within the spirit and scope of the present invention as hereinafter claimed. It is also understood that the exemplary embodiments described above are merely descriptive, rather than limiting.

What is claimed is:

1. An organic electroluminescence device, comprising:

a first electrode;

a hole transport region disposed on the first electrode;

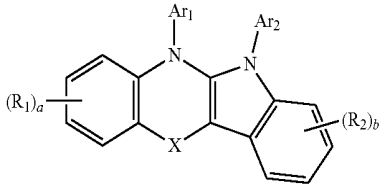
an emission layer disposed on the hole transport region;

an electron transport region disposed on the emission layer; and

a second electrode disposed on the electron transport region,

wherein the hole transport region comprises a condensed cyclic compound represented by following Formula 1:

[Formula 1]



wherein in Formula 1,

X is a direct linkage, O, S, NR_5, or SiR_6R_7,

each of Ar_1 and Ar_2 is independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring,

each of R_1 and R_2 is independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms,

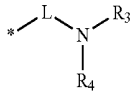
each of a and b is independently an integer of 0 to 4,

each of R_5, R_6, and R_7 is independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring,

the substituted ones are substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and

any one of Ar_1, R_1 or R_2 is represented by following Formula 2:

[Formula 2]



wherein in Formula 2,

L is a substituted or unsubstituted arylene group having 6 to 40 carbon atoms for forming a ring, and

each of R_3 and R_4 is independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and the substituted ones are substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted cycloalkyl group having 3 to 40 carbon atoms for forming a ring, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

2. The organic electroluminescence device of claim **1**, wherein the hole transport region comprises:

a hole injection layer; and

a hole transport layer disposed between the hole injection layer and the emission layer, and

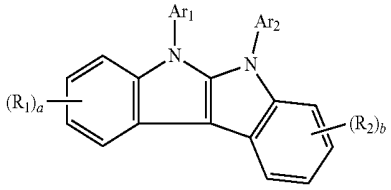
the hole transport layer comprises the condensed cyclic compound.

3. The organic electroluminescence device of claim **2**, wherein the hole transport layer comprises a plurality of organic layers, and

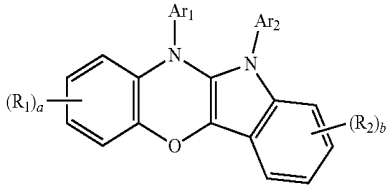
an organic layer adjacent to the emission layer among the plurality of organic layers comprises the condensed cyclic compound.

4. The organic electroluminescence device of claim **1**, wherein Formula 1 is represented by any one of following Formulae 1-1 to 1-5:

[Formula 1-1]

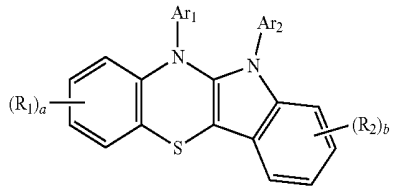


[Formula 1-2]

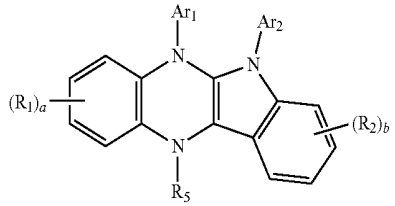


-continued

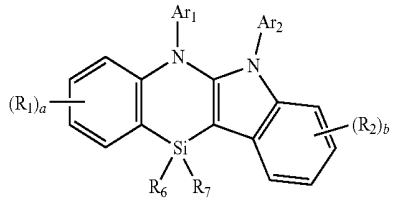
[Formula 1-3]



[Formula 1-4]



[Formula 1-5]

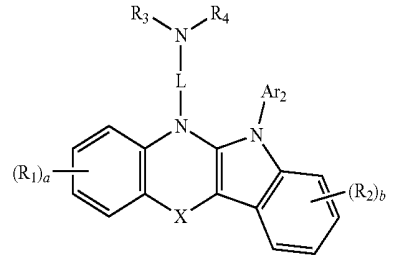


wherein in Formula 1-1 to 1-5,

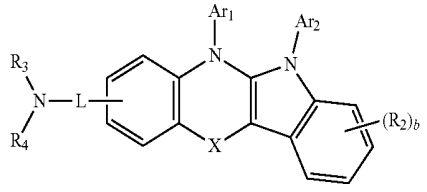
Ar_1, Ar_2, R_1, R_2, R_5 to R_7, a, and b are the same as defined in Formula 1.

5. The organic electroluminescence device of claim **1**, wherein Formula 1 is represented by any one of following Formulae 3-1 to 3-3:

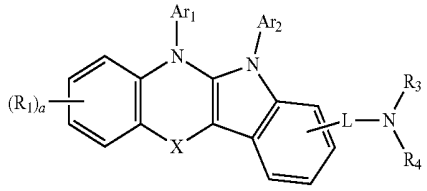
[Formula 3-1]



[Formula 3-2]



[Formula 3-3]



wherein in Formula 3-1 to 3-3,

X, Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formula 1 and 2.

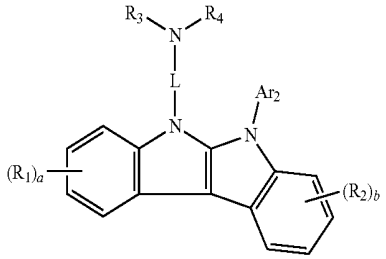
6. The organic electroluminescence device of claim **1**, wherein R_1 and R_2 are each independently a substituted or unsubstituted phenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted phenanthryl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted terphenyl group, a substituted or unsubstituted quaterphenyl group, a substituted or unsubstituted quinqphenyl group, a substituted or unsubstituted sexiphenyl group, a substituted or unsubstituted triphenylenyl group, a substituted or unsubstituted pyrenyl group, a substituted or unsubstituted benzofluoranthenyl group, or a substituted or unsubstituted chrysenyl group.

7. The organic electroluminescence device of claim **1**, wherein L is a substituted or unsubstituted phenylene group, a substituted or unsubstituted biphenylene group, a substituted or unsubstituted naphthylene group, a substituted or unsubstituted anthracenylene group, a substituted or unsubstituted phenanthrene group, or a substituted or unsubstituted fluorenylene group.

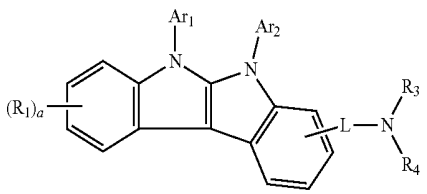
8. The organic electroluminescence device of claim **1**, wherein R_3 and R_4 are each independently a substituted or unsubstituted phenyl group, a substituted or unsubstituted naphthyl group, a substituted or unsubstituted fluorenyl group, a substituted or unsubstituted anthracenyl group, a substituted or unsubstituted phenanthryl group, a substituted or unsubstituted biphenyl group, a substituted or unsubstituted terphenyl group, a substituted or unsubstituted quaterphenyl group, a substituted or unsubstituted thiophene group, a substituted or unsubstituted benzothiophene group, a substituted or unsubstituted dibenzothiophene group, a substituted or unsubstituted furan group, a substituted or unsubstituted benzofuranyl group, a substituted or unsubstituted dibenzofuranyl group, or a substituted or unsubstituted naphthobenzofuranyl group.

9. The organic electroluminescence device of claim **4**, wherein Formula 1-1 is represented by following Formula 4-1 or 4-2:

[Formula 4-1]



[Formula 4-2]

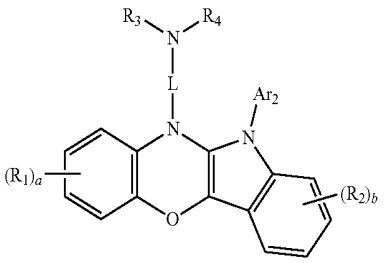


wherein in Formula 4-1 and 4-2,

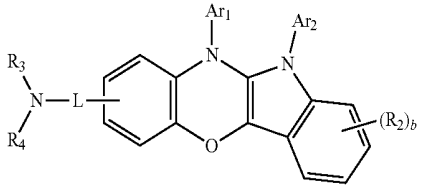
Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formula 1 and 2.

10. The organic electroluminescence device of claim **4**, wherein Formula 1-2 is represented by any one of following Formulae 5-1 to 5-3:

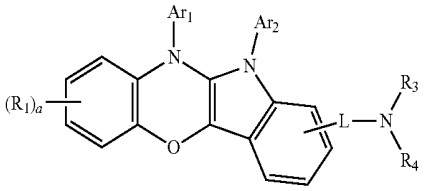
[Formula 5-1]



[Formula 5-2]



[Formula 5-3]

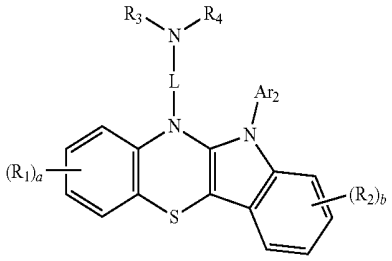


wherein in Formula 5-1 to 5-3,

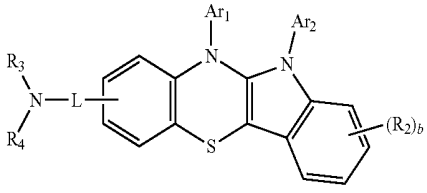
where Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formula 1 and 2.

11. The organic electroluminescence device of claim **4**, wherein Formula 1-3 is represented by any one of following Formulae 6-1 to 6-3:

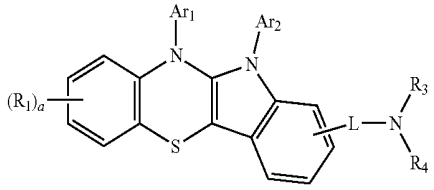
[Formula 6-1]



[Formula 6-2]



[Formula 6-3]

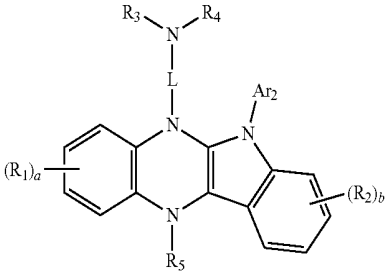


wherein in Formula 6-1 to 6-3,

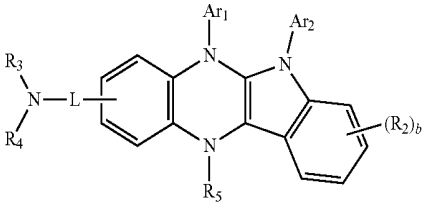
Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formula 1 and 2.

12. The organic electroluminescence device of claim **4**, wherein Formula 1-4 is represented by any one of the following Formula 7-1 to 7-3:

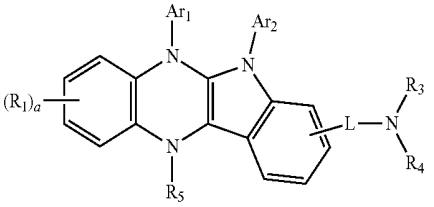
[Formula 7-1]



[Formula 7-2]



[Formula 7-3]

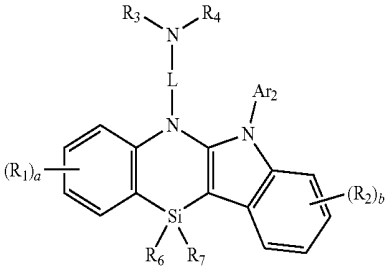


wherein in Formula 7-1 to 7-3,

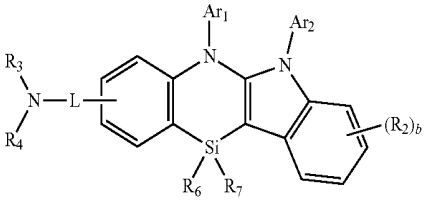
Ar_1, Ar_2, R_1 to R_5, L, a, and b are the same as defined in Formulae 1 and 2.

13. The organic electroluminescence device of claim **4**, wherein Formula 1-5 is represented by any one of following Formula 8-1 to 8-3:

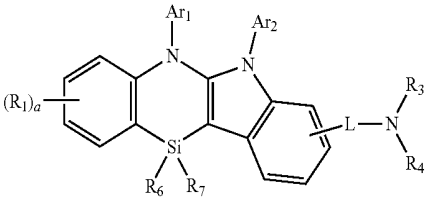
[Formula 8-1]



[Formula 8-2]



[Formula 8-3]



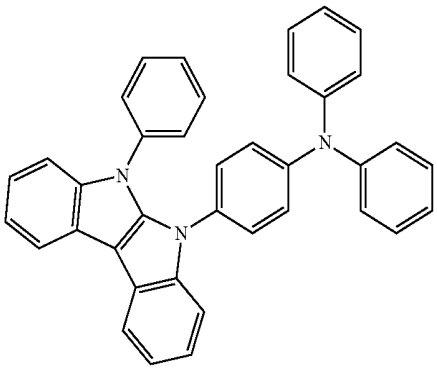
wherein in Formula 8-1 to 8-3,

Ar_1, Ar_2, R_1 to R_4, R_6, R_7, L, a, and b are the same as defined in Formula 1 and 2.

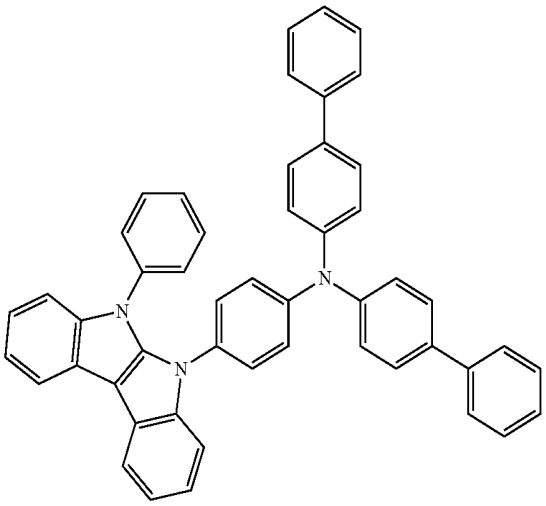
14. The organic electroluminescence device of claim **1**, wherein the compound represented by Formula 1 is any one selected from the group consisting of compounds represented in following Compound Groups 1 to 5:

[Compound Group 1]

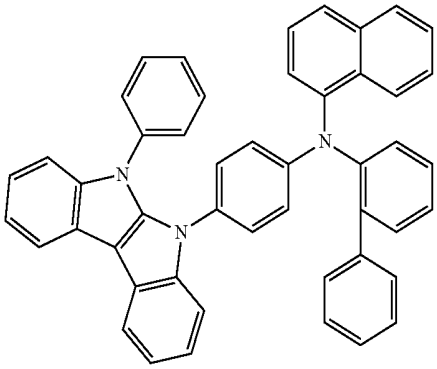
A1



A2

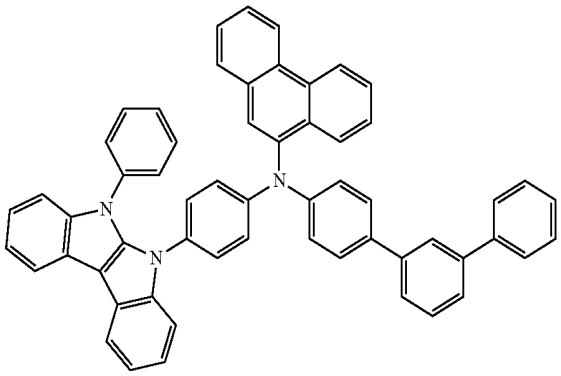


A3

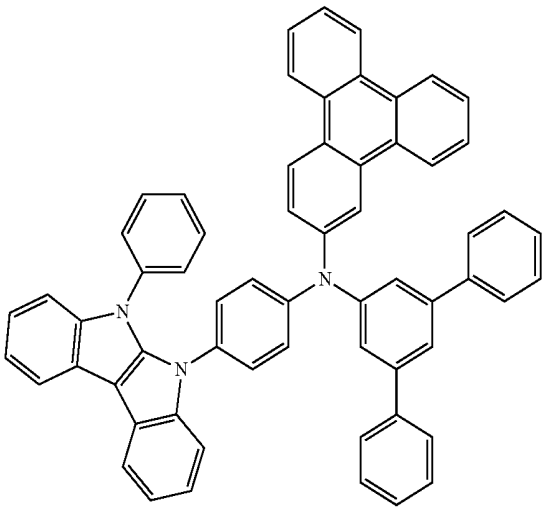


-continued

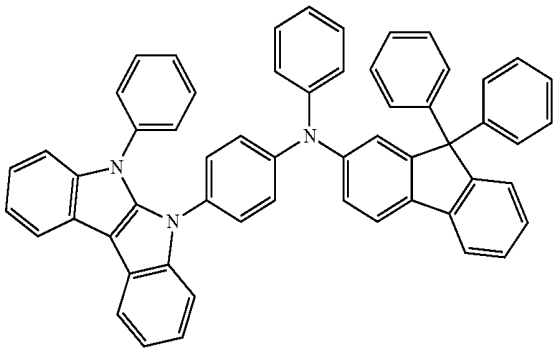
A4



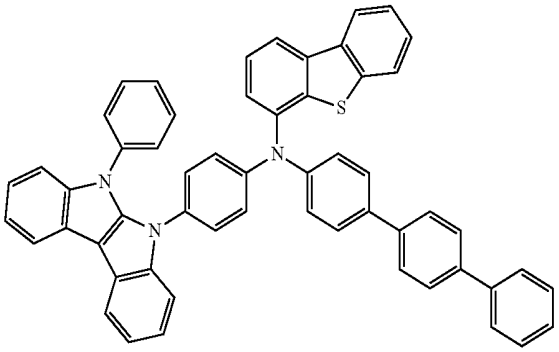
A5



A6

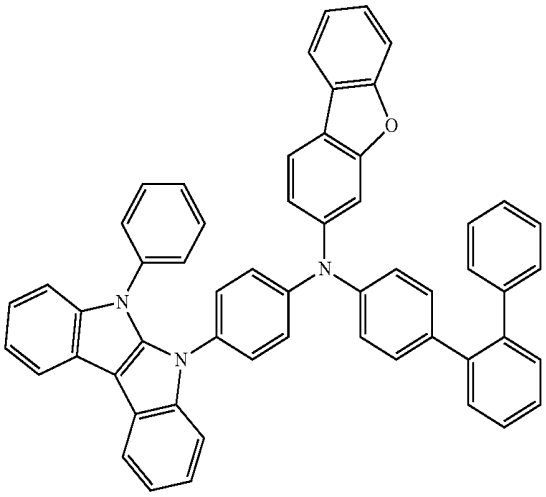


A7

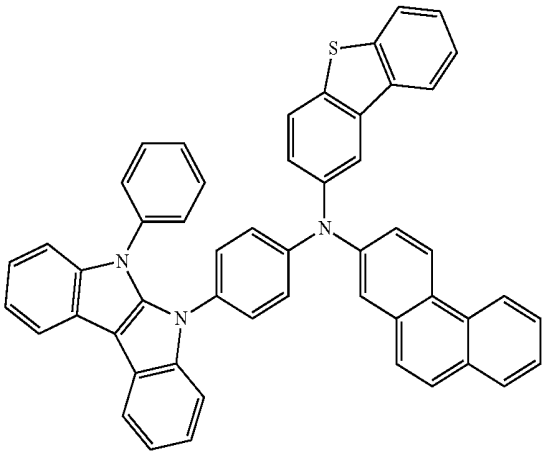


-continued

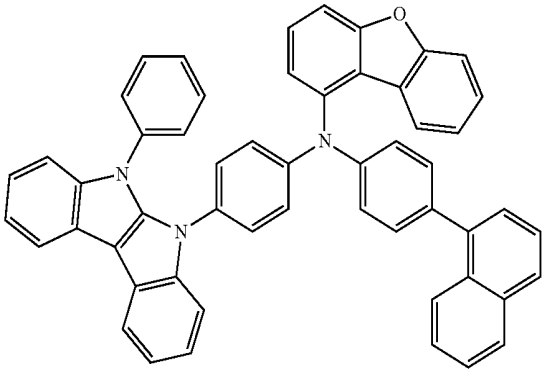
A8



A9

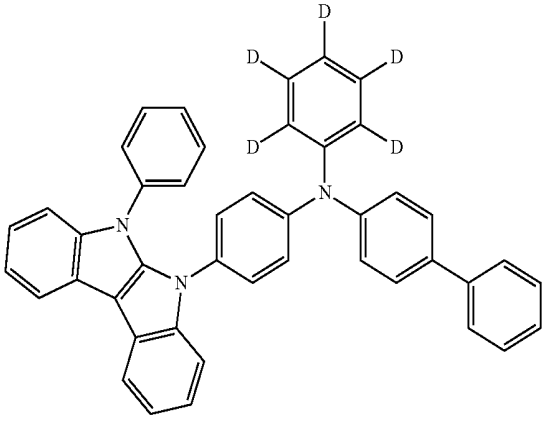


A10

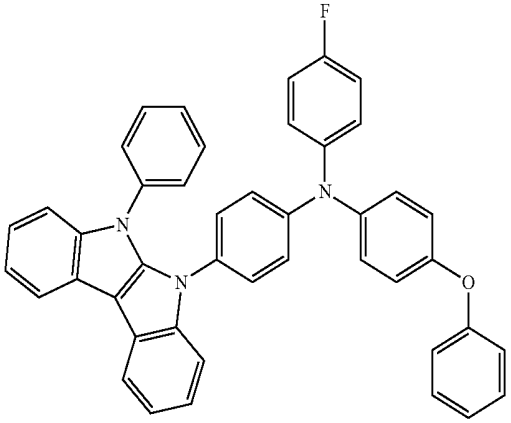


-continued

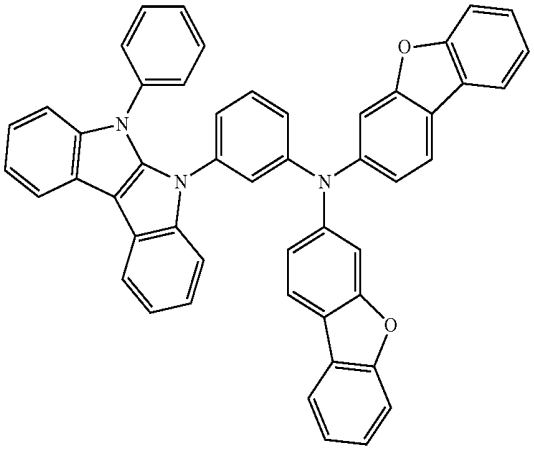
A11



A12

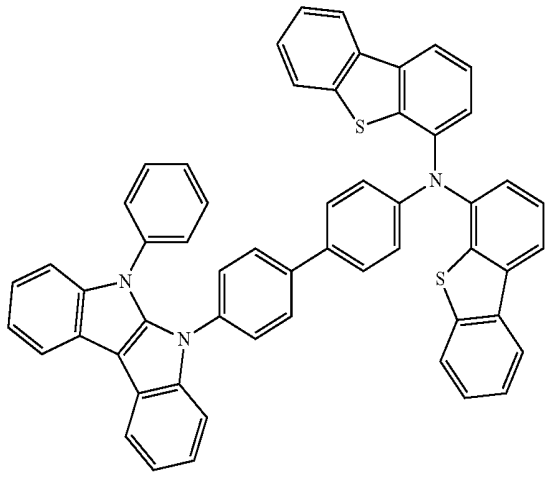


A13

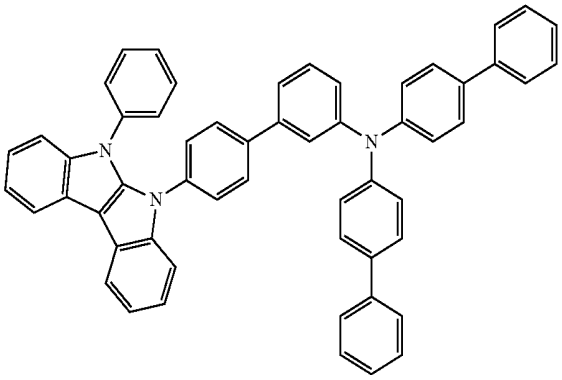


-continued

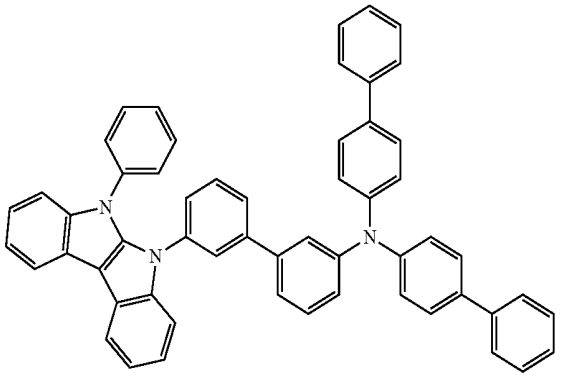
A14



A15

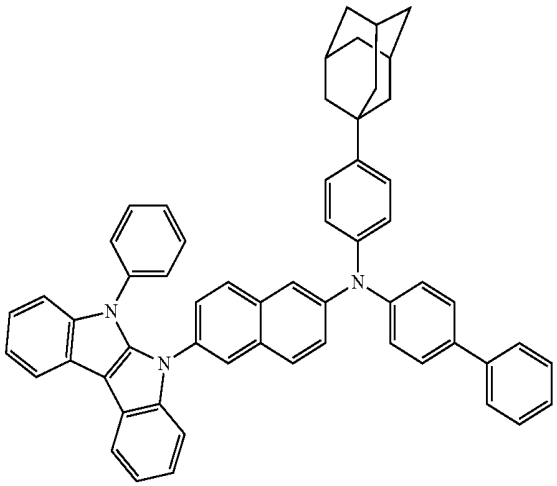


A16

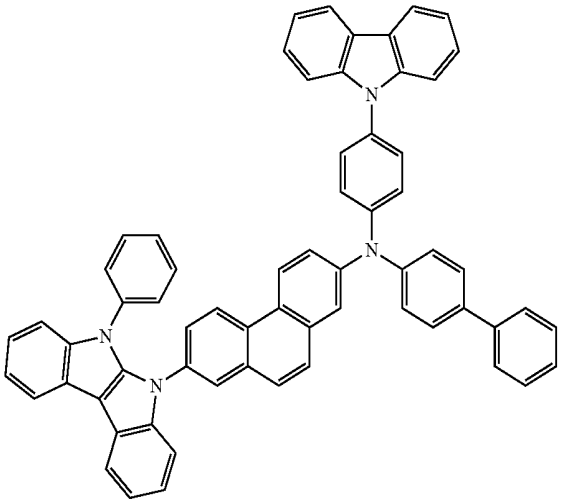


-continued

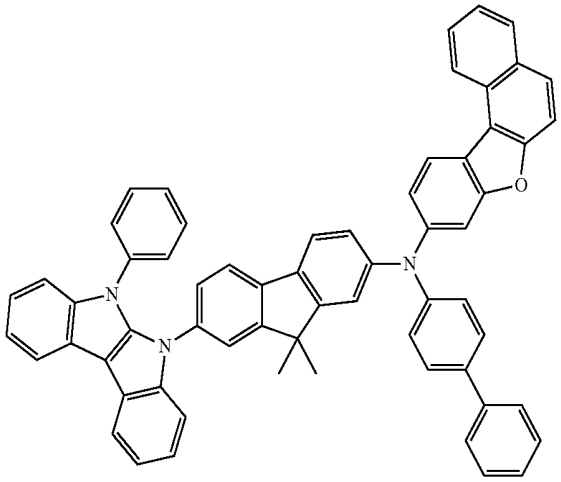
A17



A18

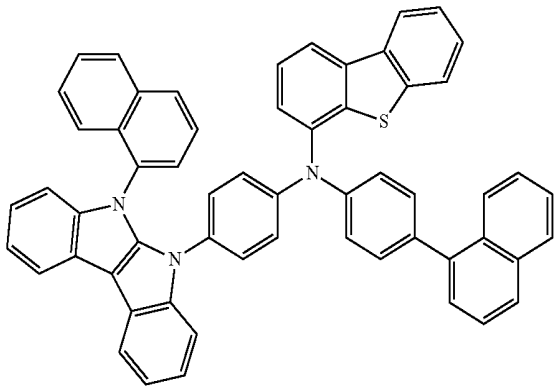


A19

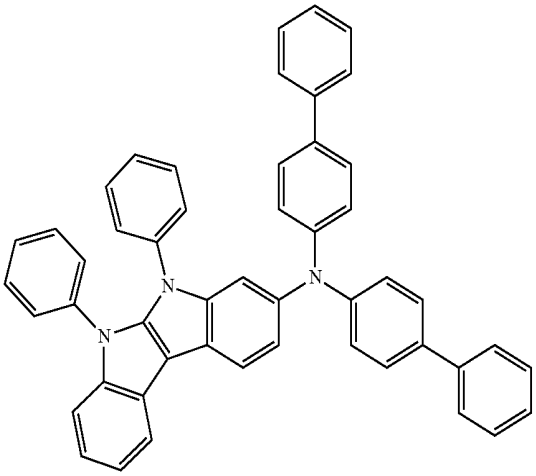


-continued

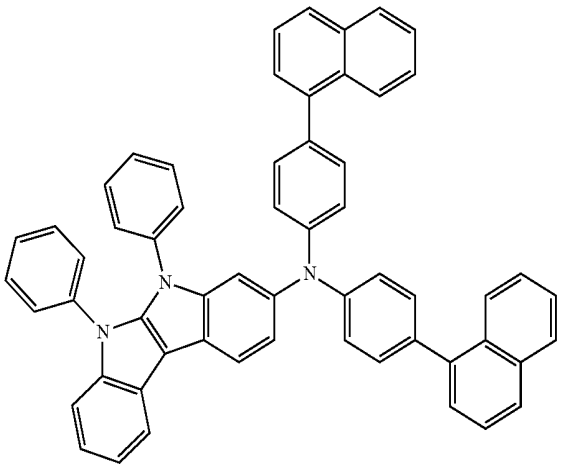
A20



A21

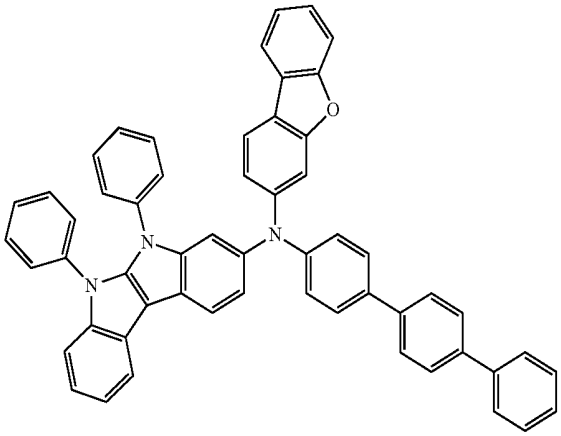


A22

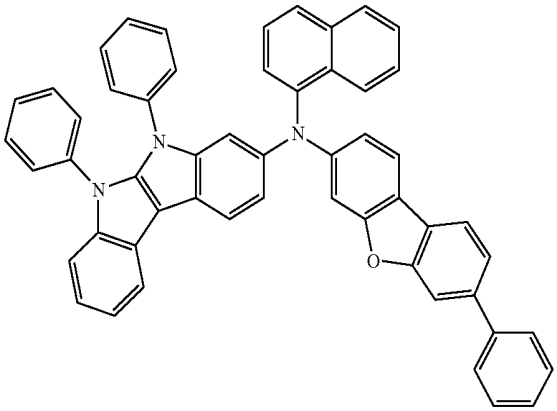


-continued

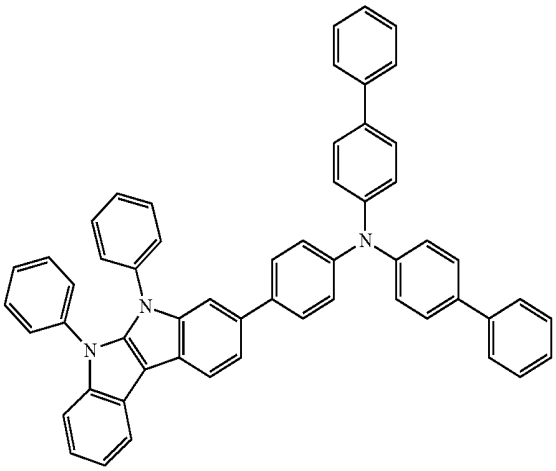
A23



A24

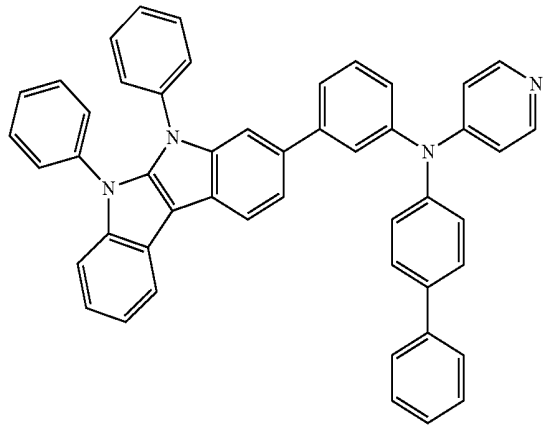


A25

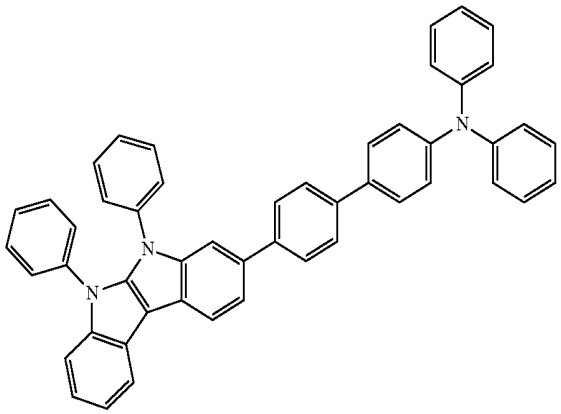


-continued

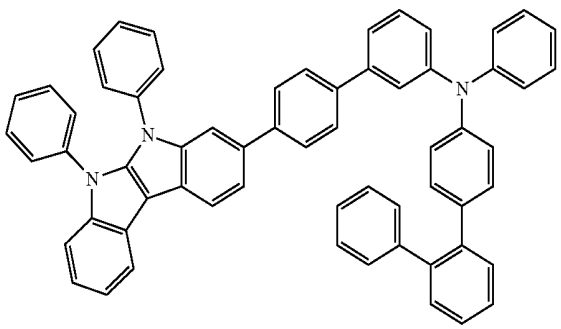
A26



A27

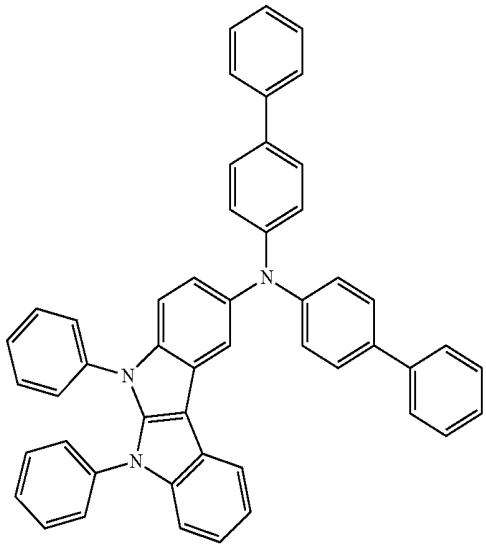


A28

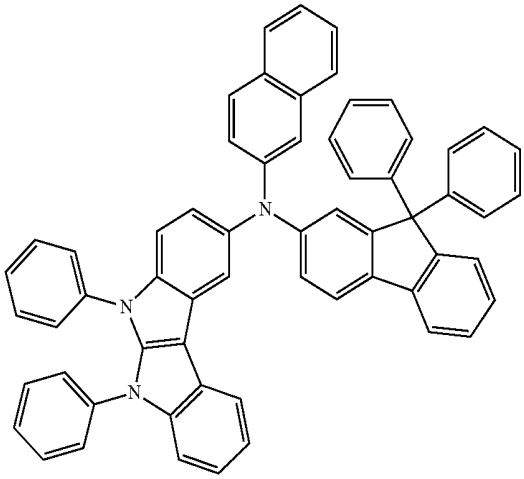


-continued

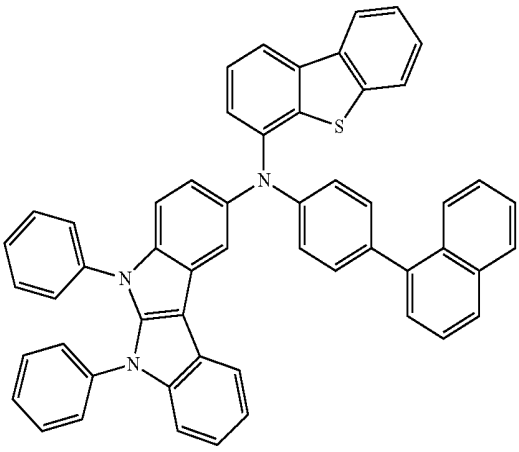
A29



A30

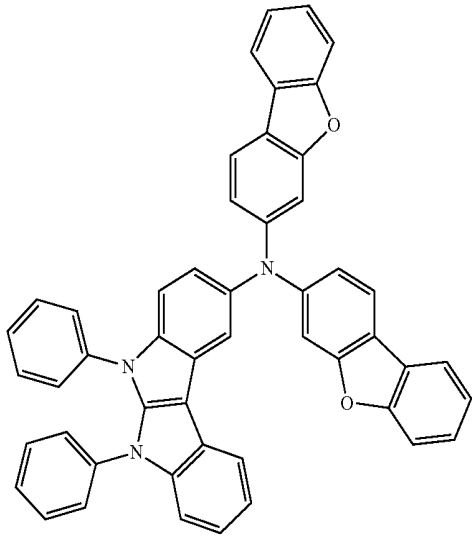


A31

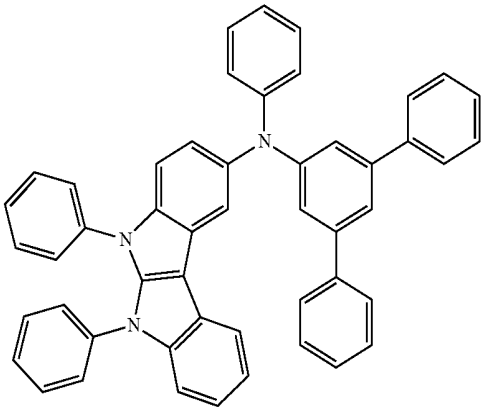


-continued

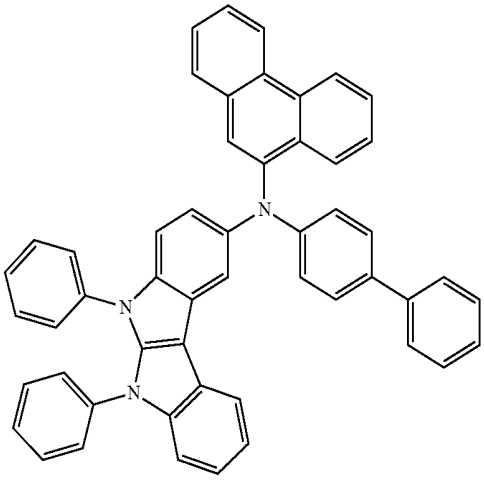
A32



A33

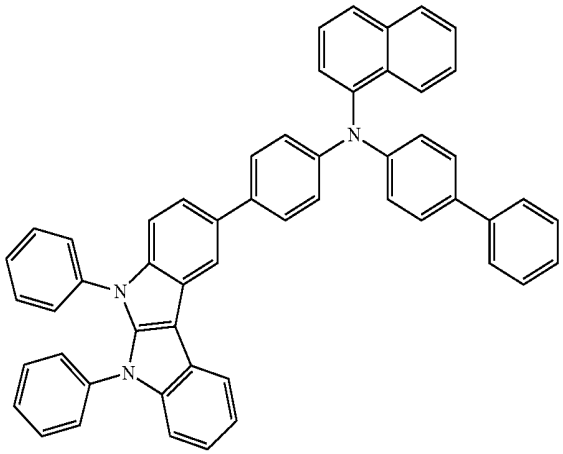


A34

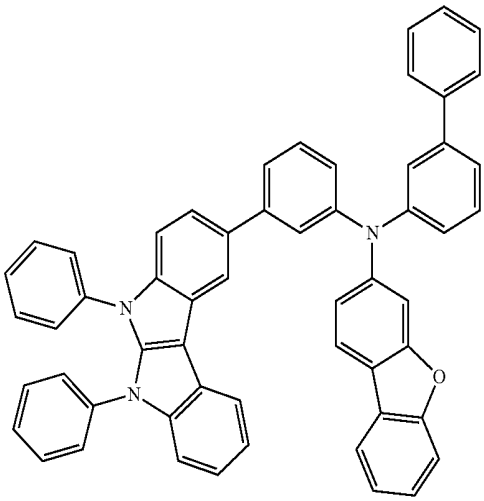


-continued

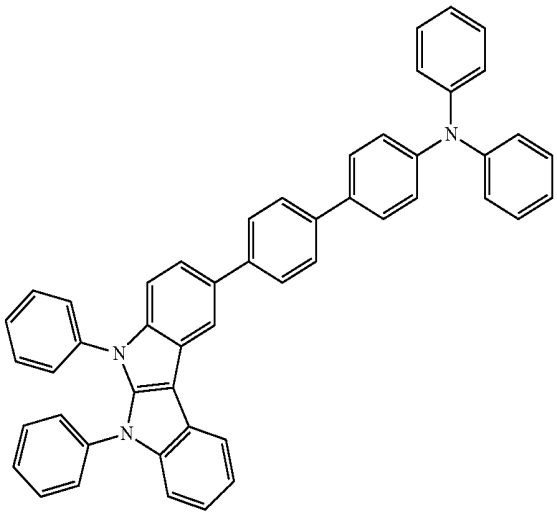
A35



A36

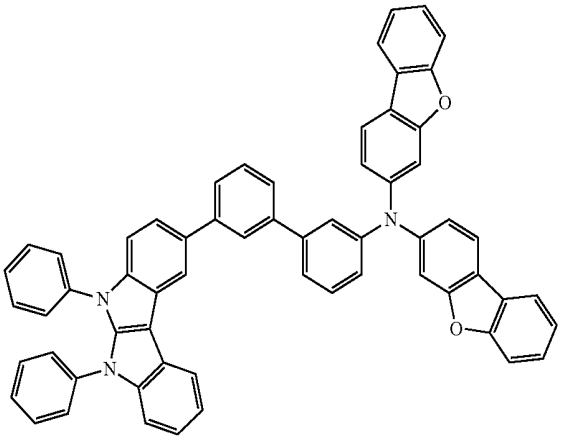


A37

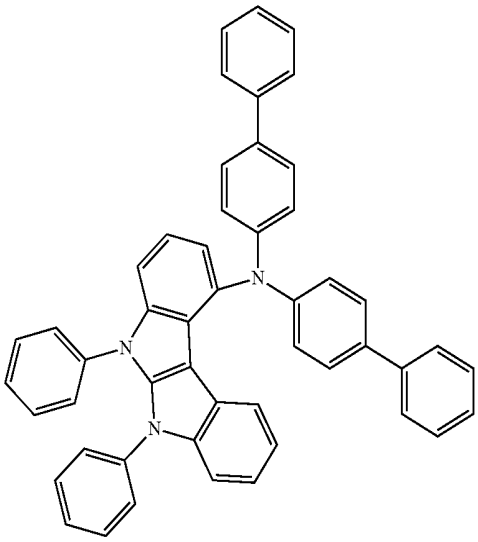


-continued

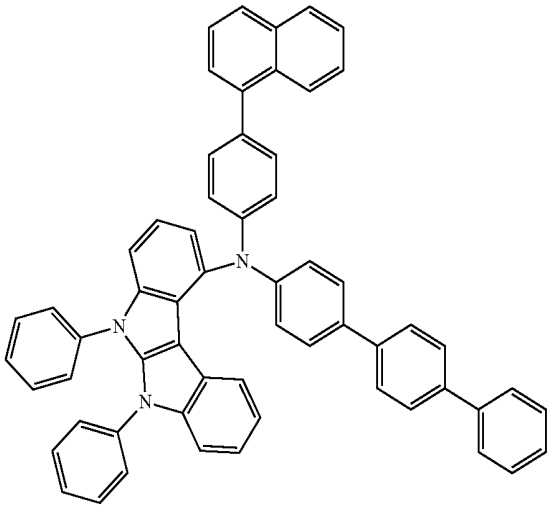
A38



A39

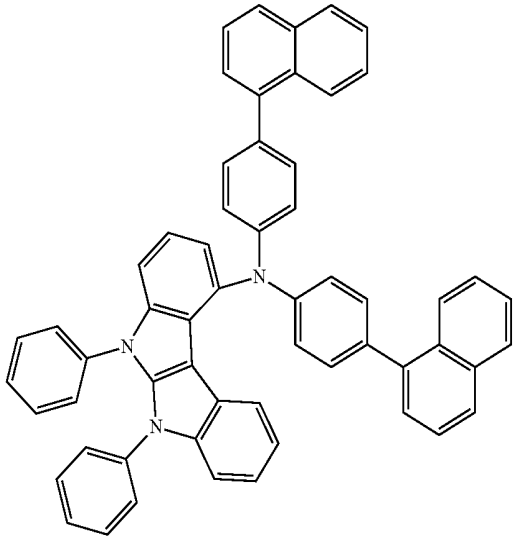


A40

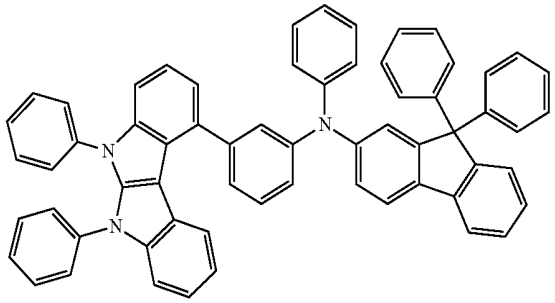


-continued

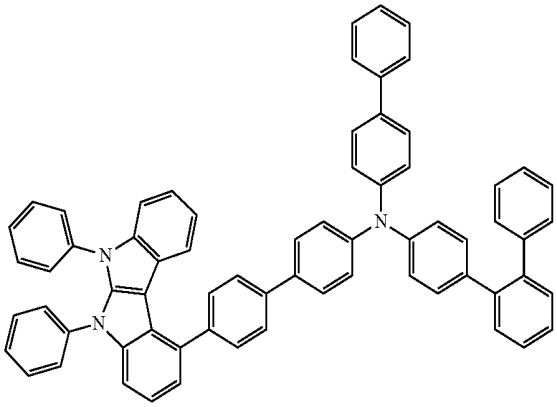
A41



A43

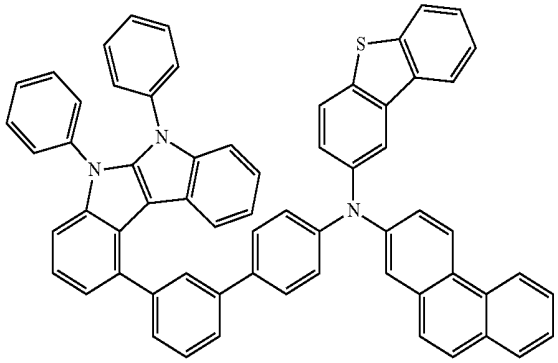


A44

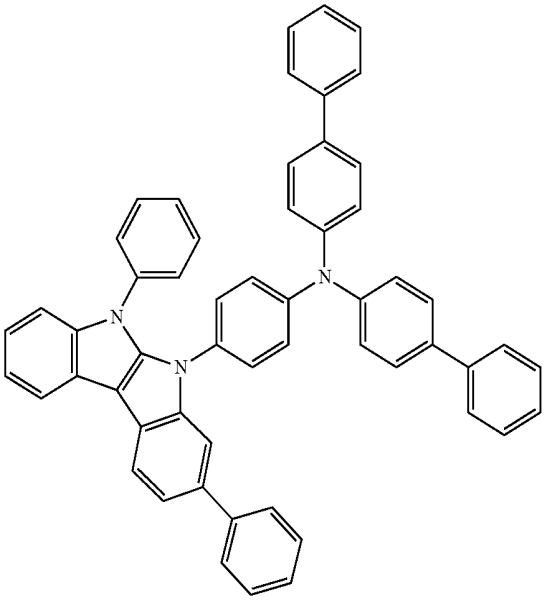


-continued

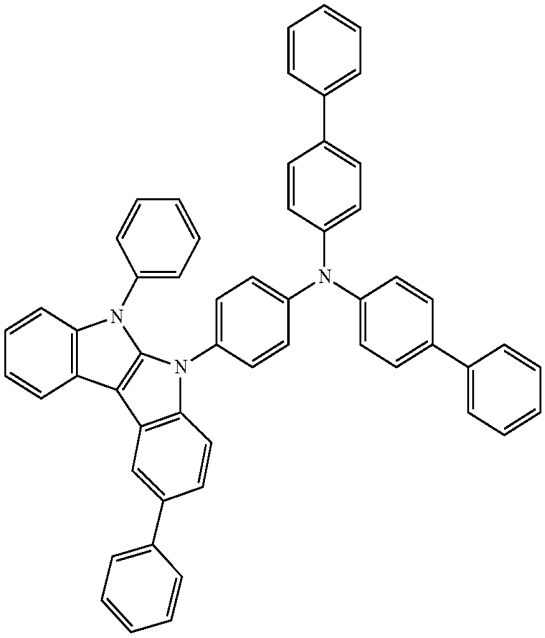
A45



A46

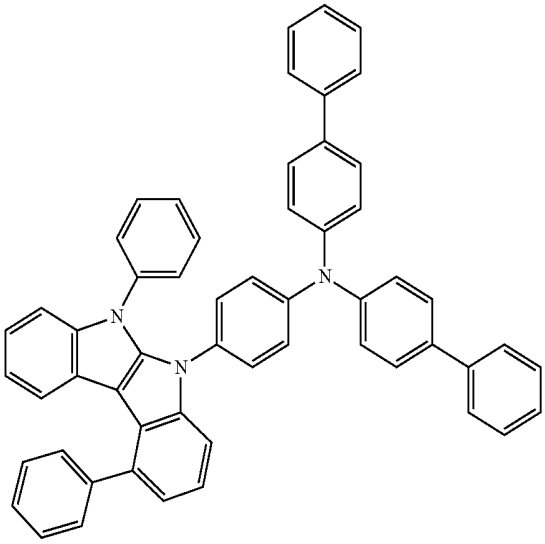


A47

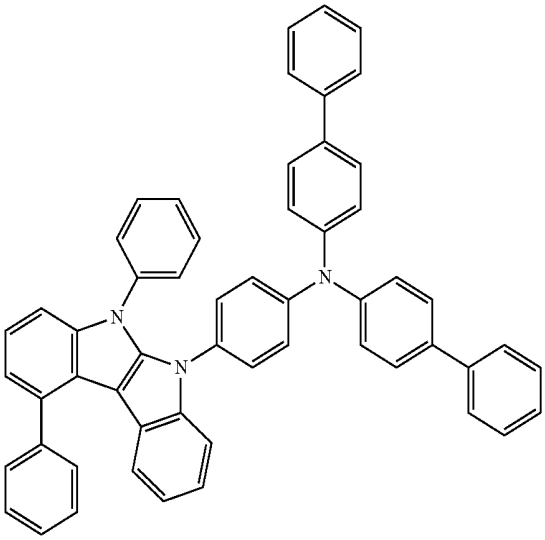


-continued

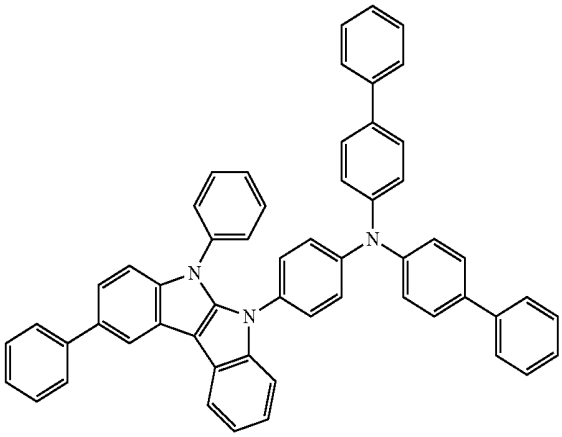
A48



A49

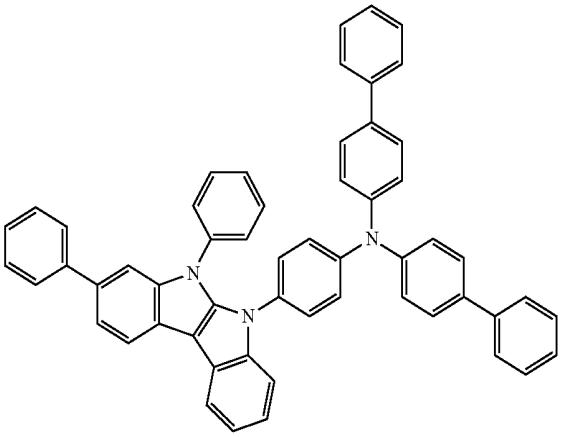


A50

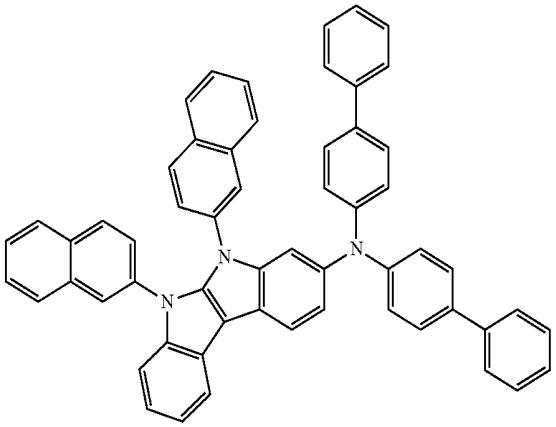


-continued

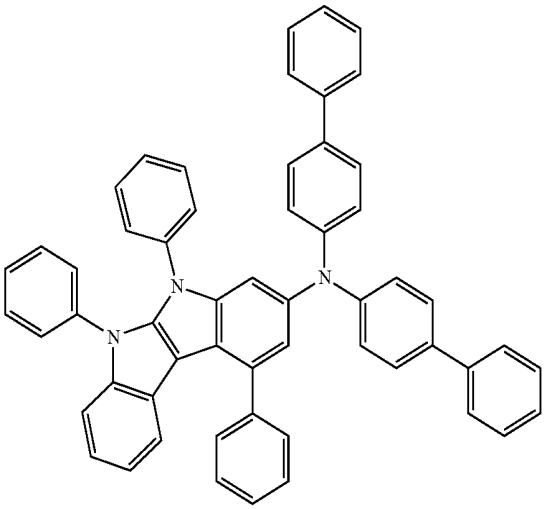
A51



A52

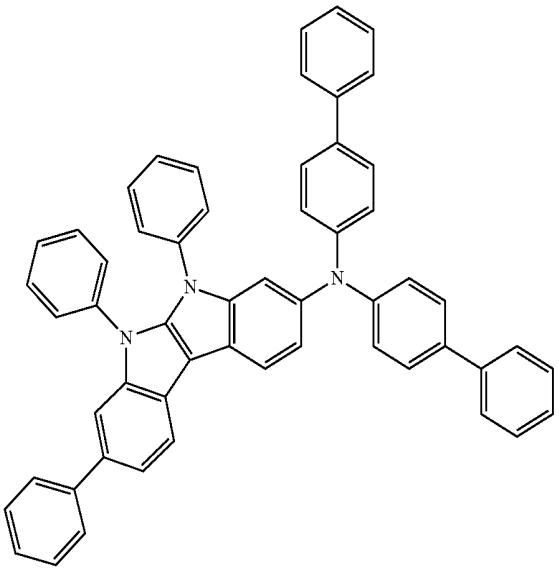


A53

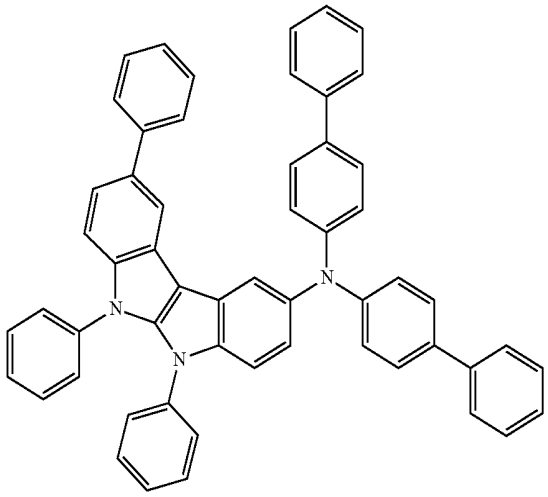


-continued

A54

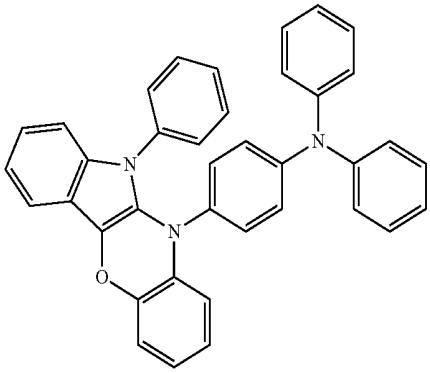


A55



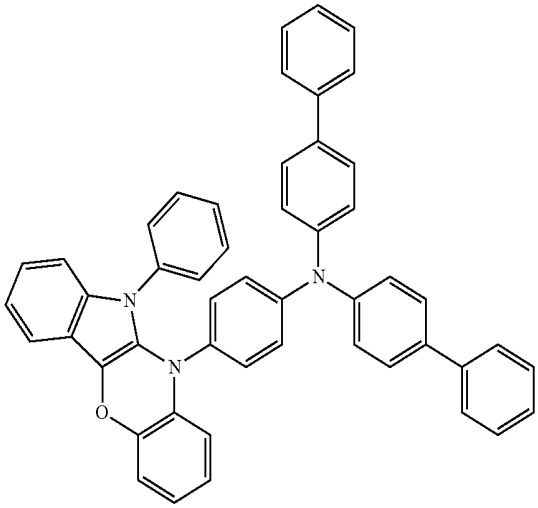
[Compound Group 2]

B1

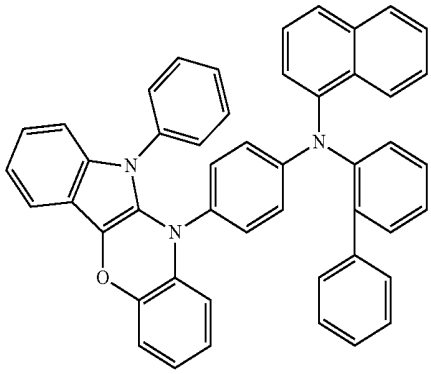


-continued

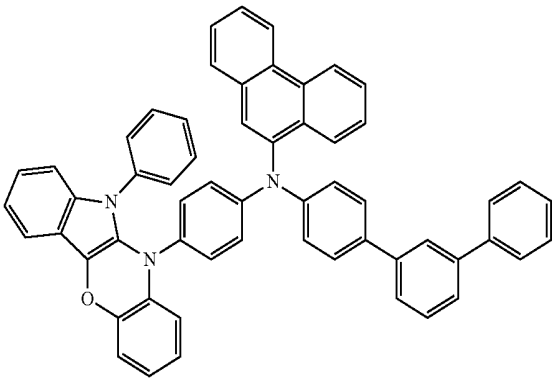
B2



B3

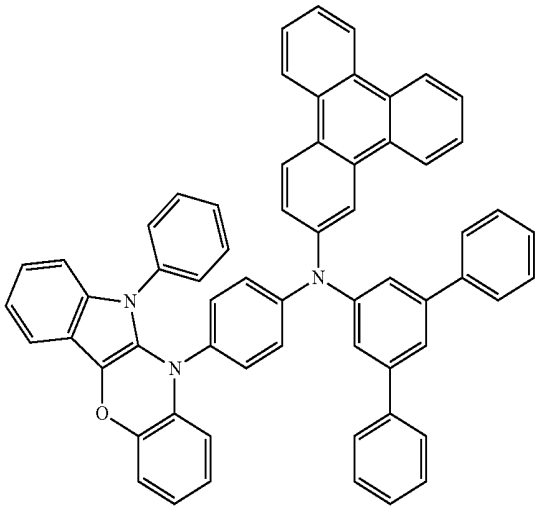


B4

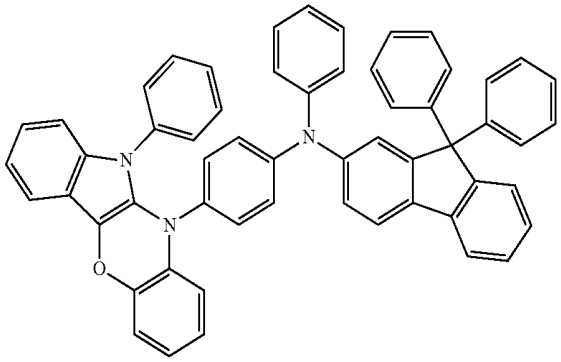


-continued

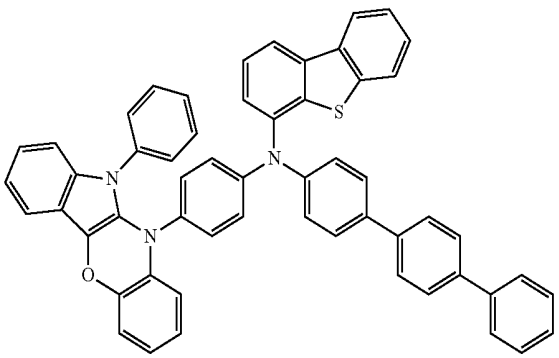
B5



B6

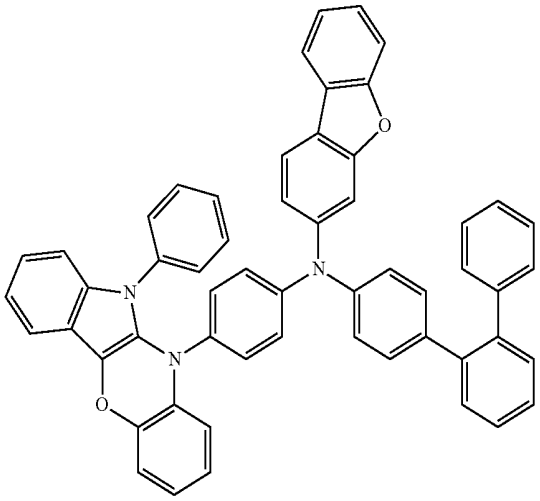


B7

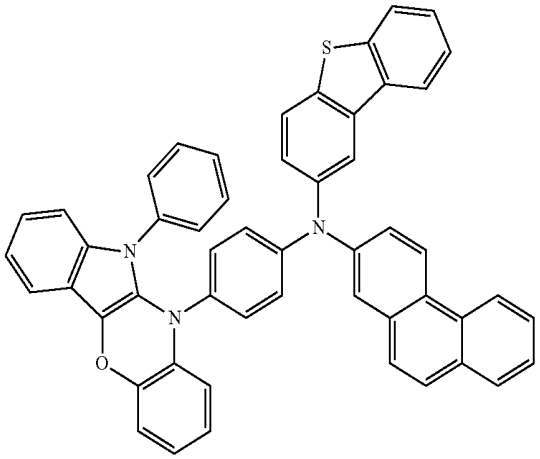


-continued

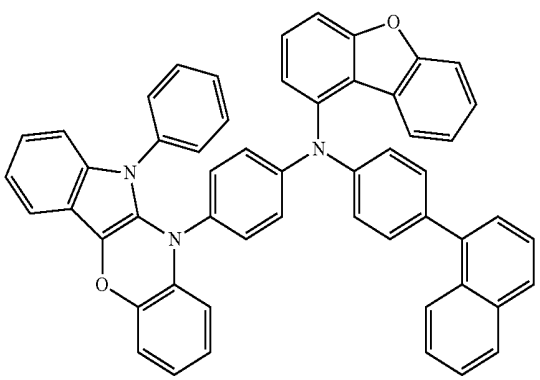
B8



B9

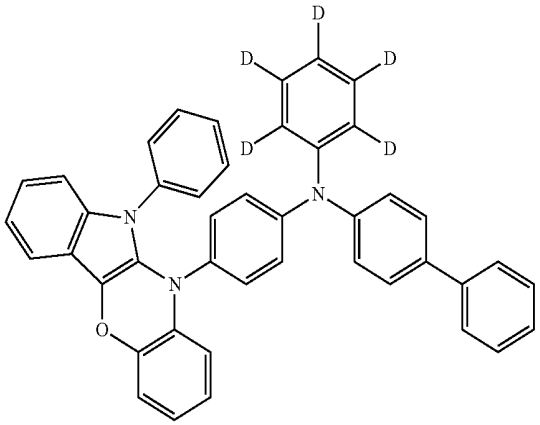


B10

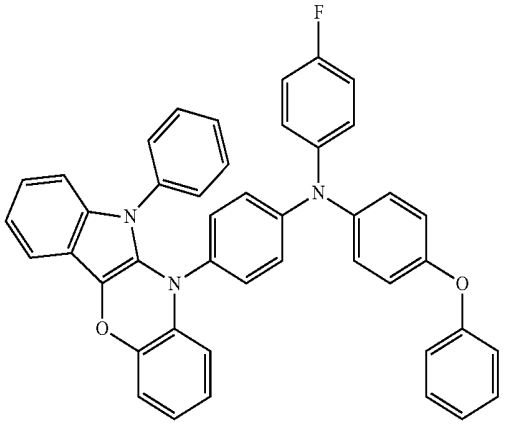


-continued

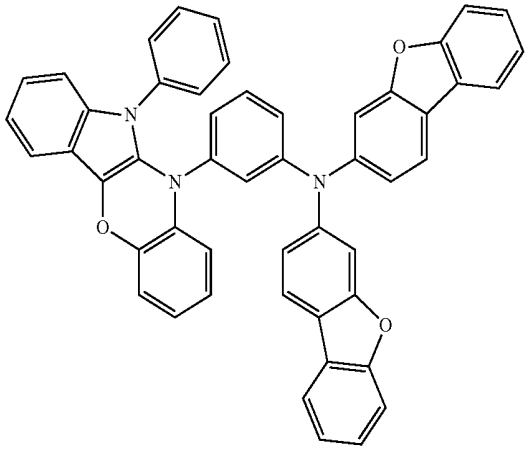
B11



B12

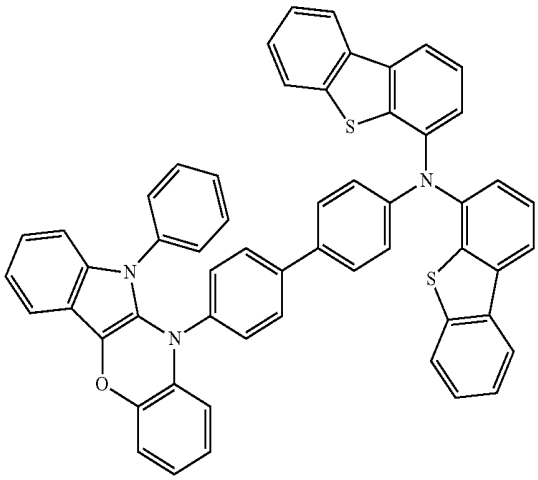


B13

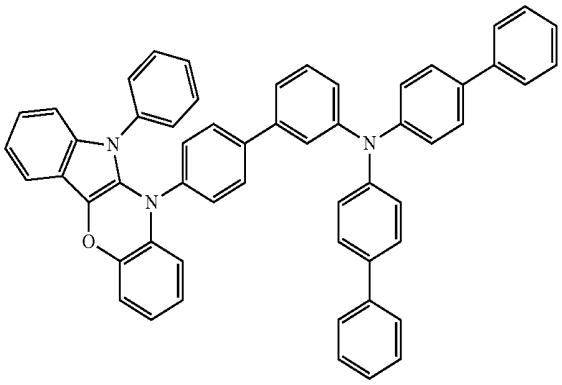


-continued

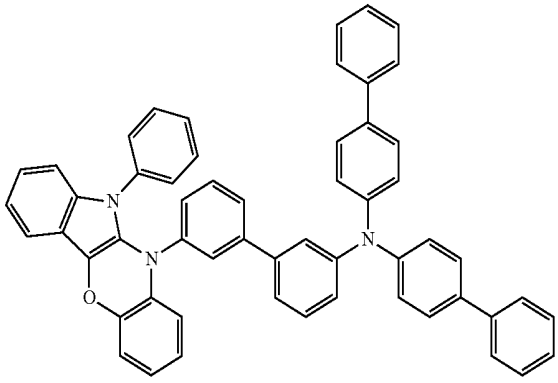
B14



B15

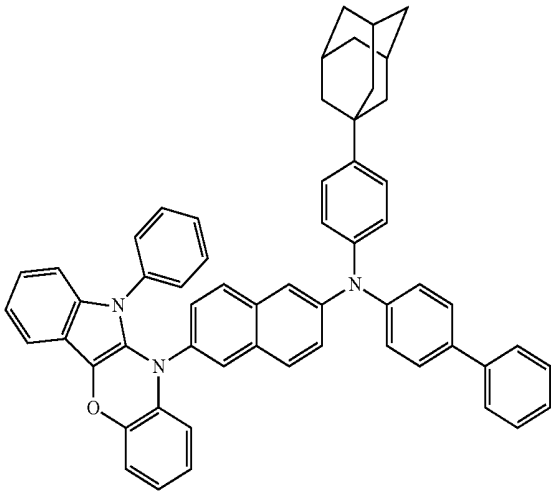


B16

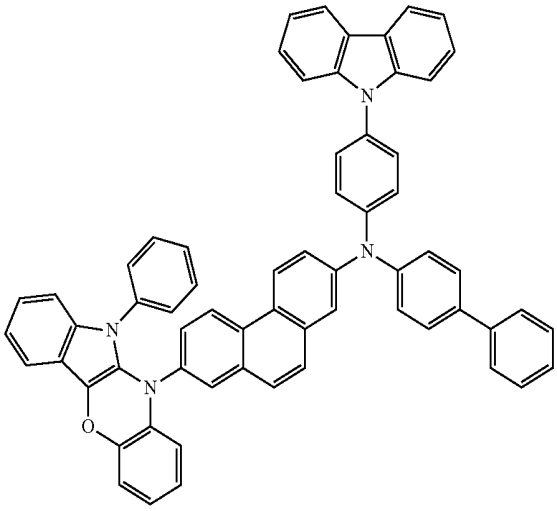


-continued

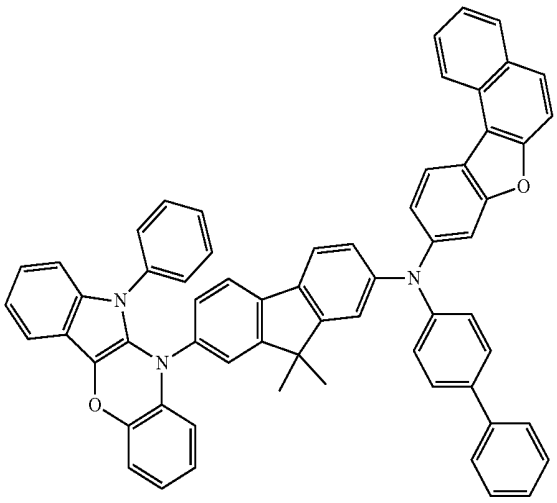
B17



B18

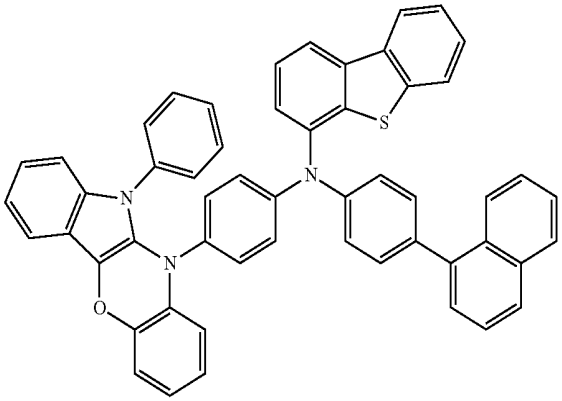


B19

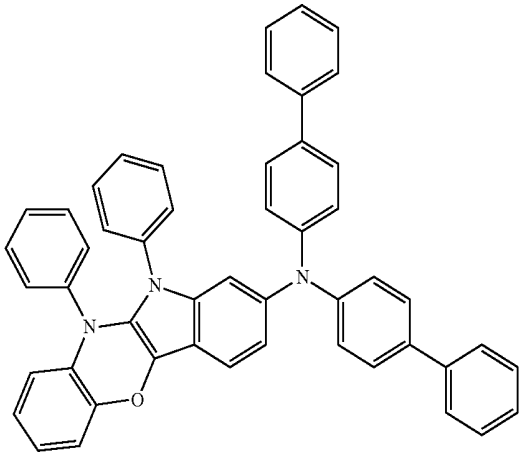


-continued

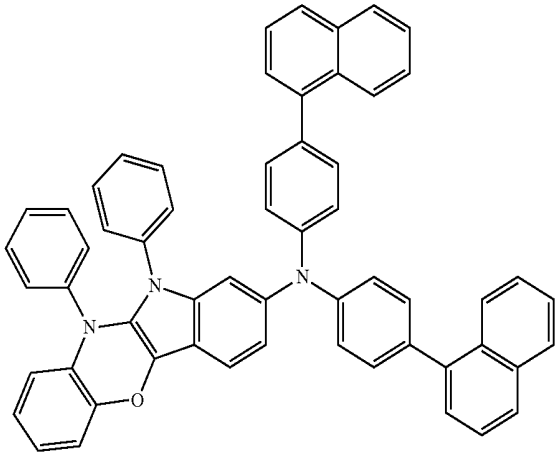
B20



B21

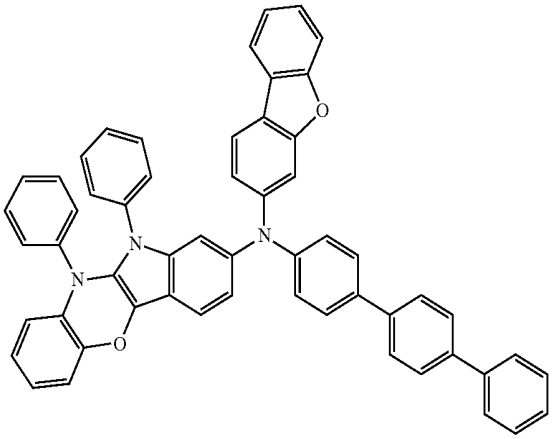


B22

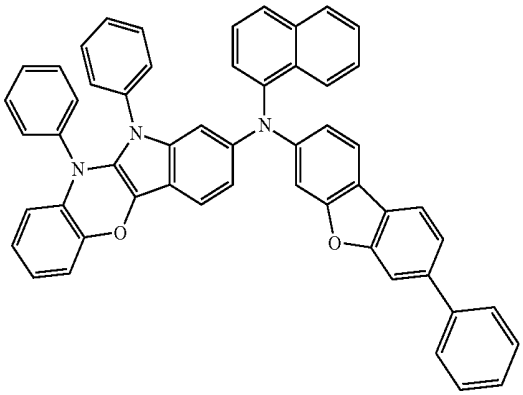


-continued

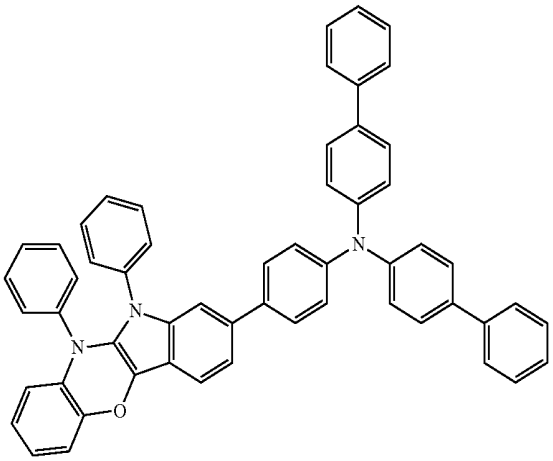
B23



B24

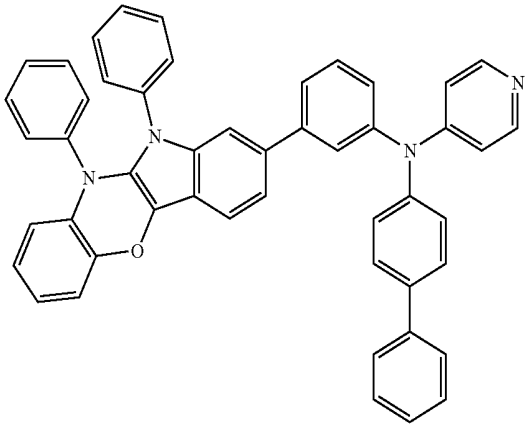


B25

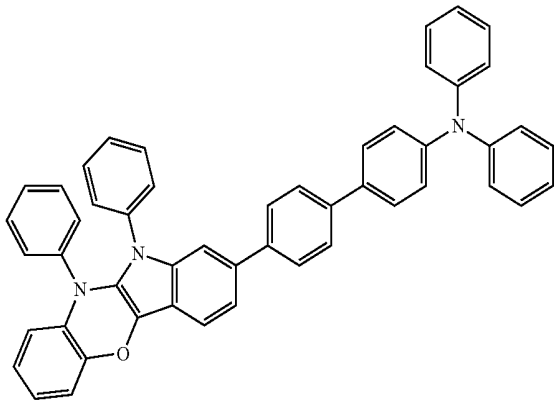


-continued

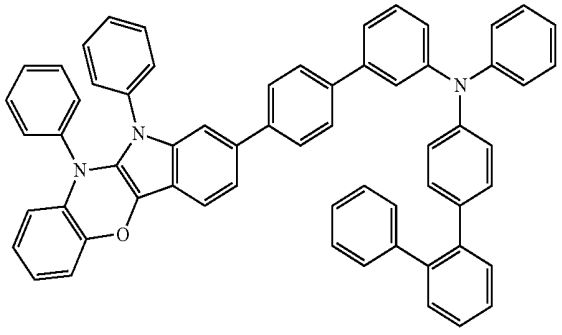
B26



B27

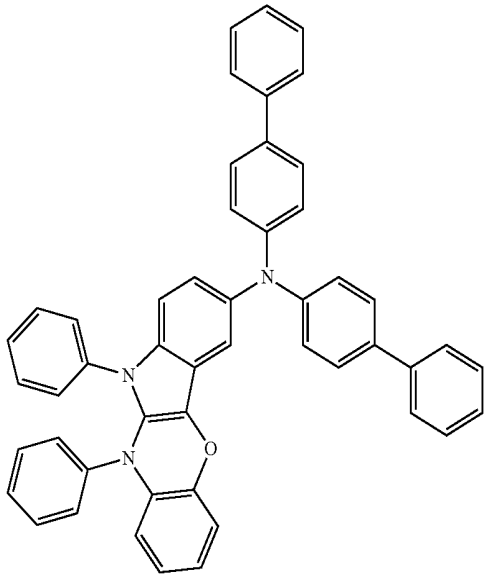


B28

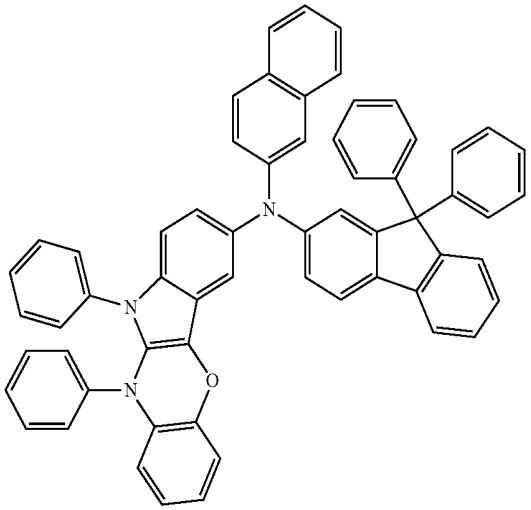


-continued

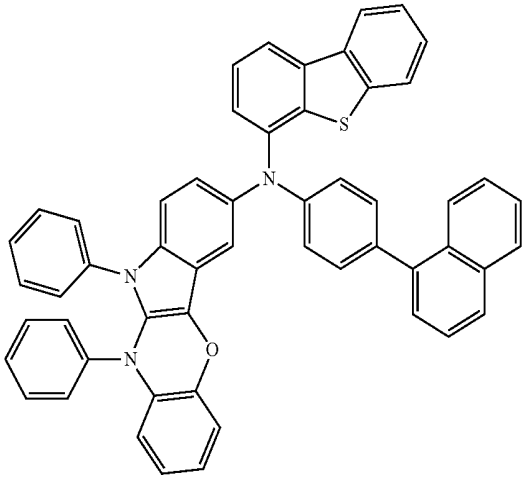
B29



B30

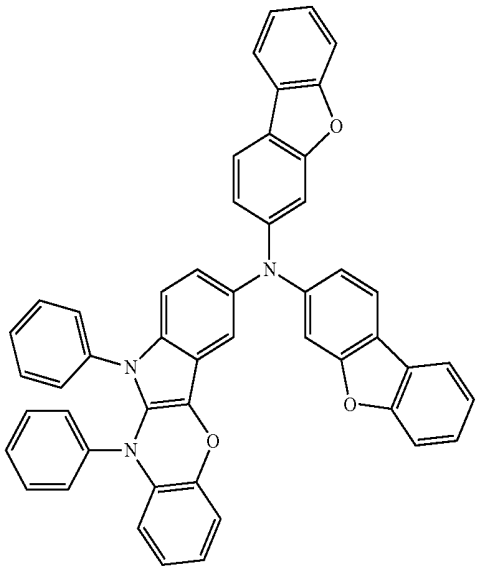


B31

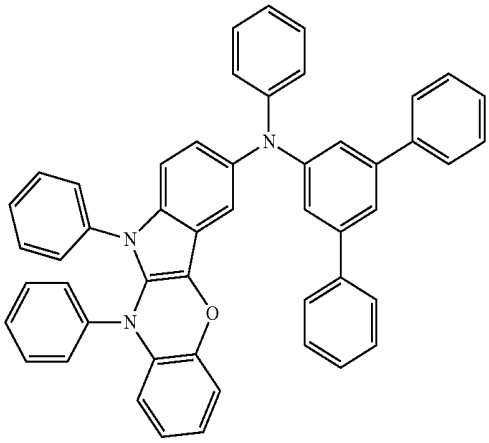


-continued

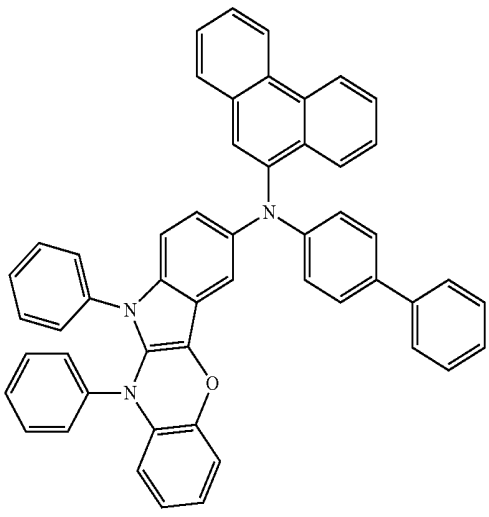
B32



B33

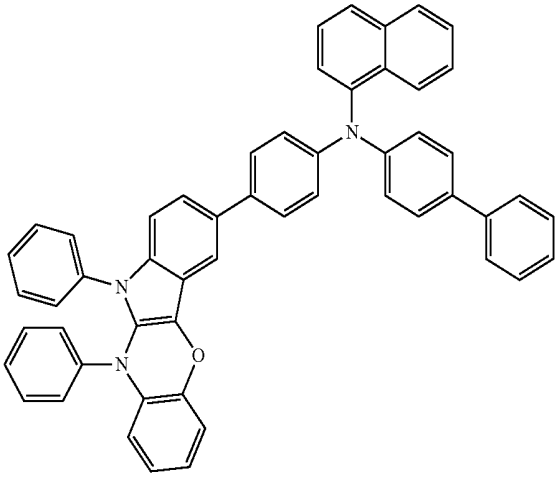


B34

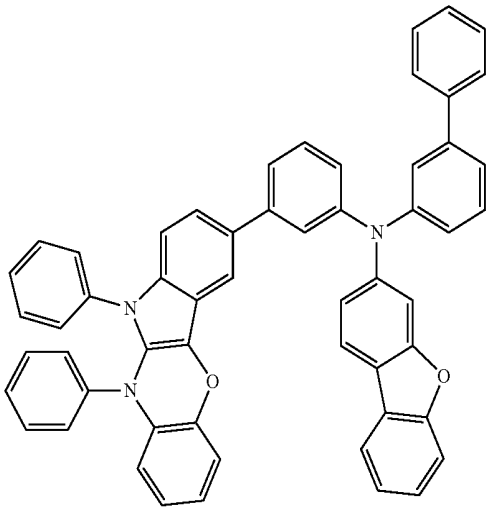


-continued

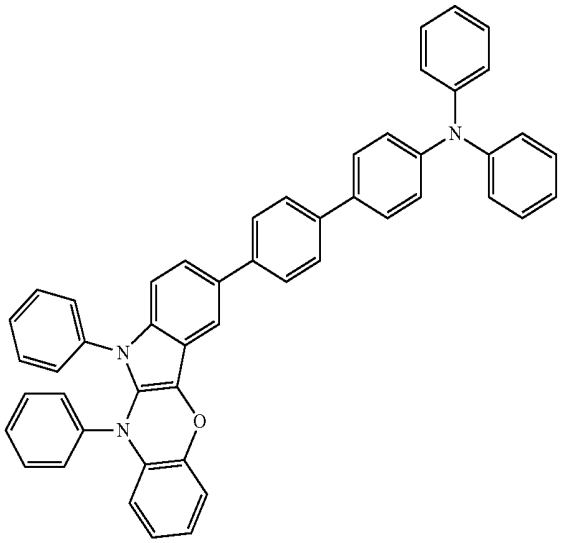
B35



B36

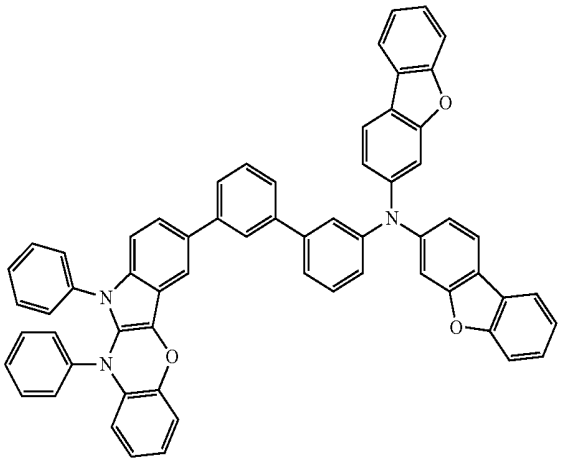


B37

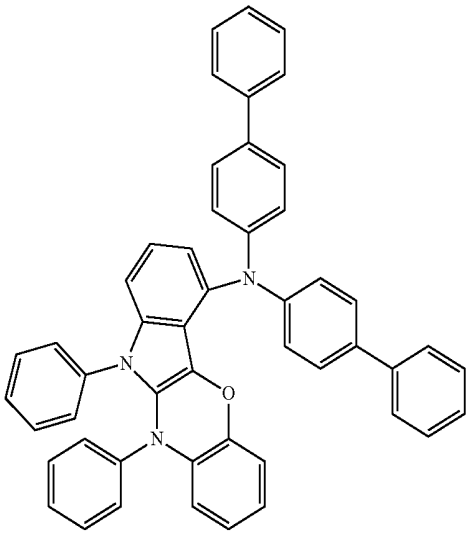


-continued

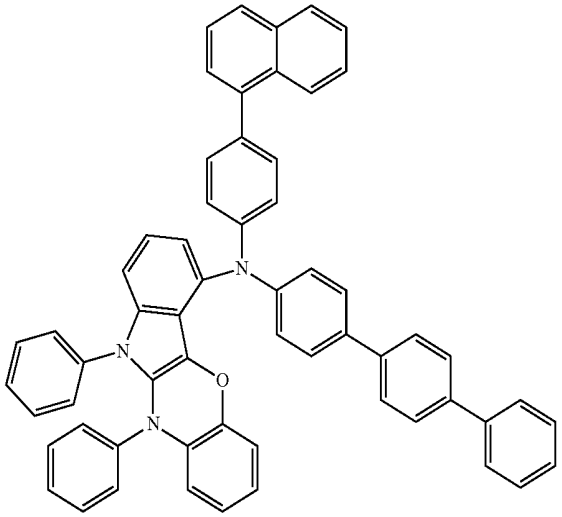
B38



B39

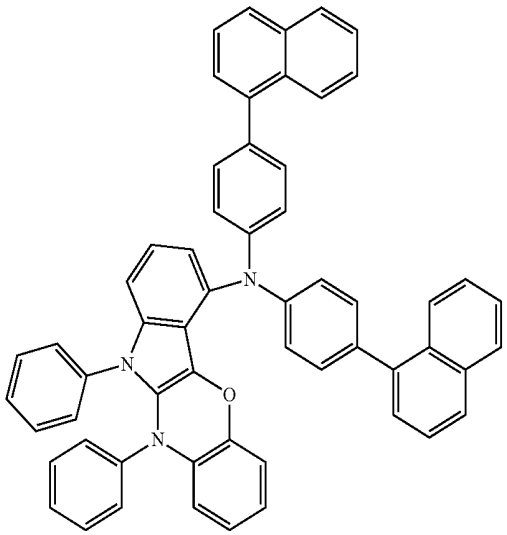


B40

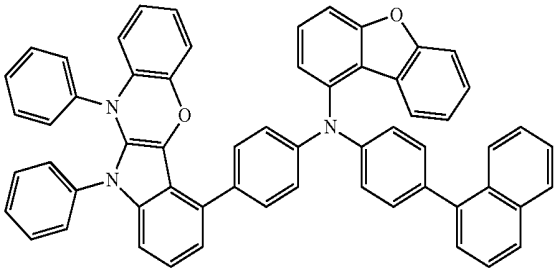


-continued

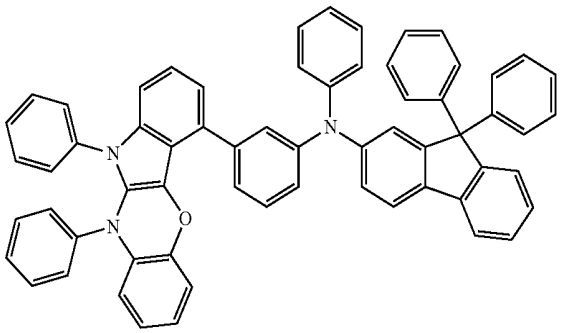
B41



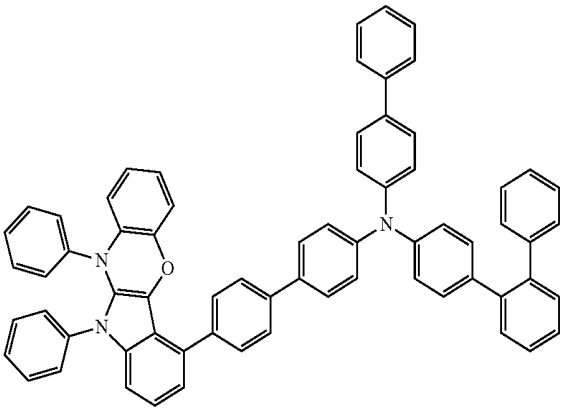
B42



B43

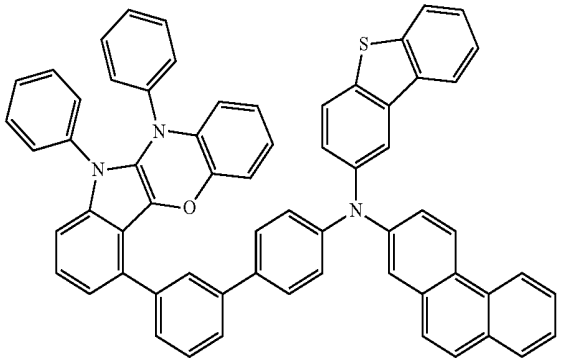


B44

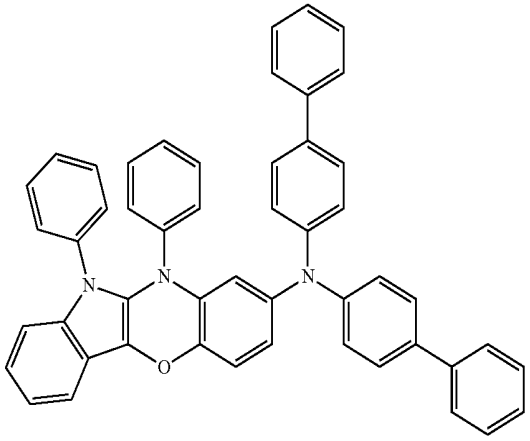


-continued

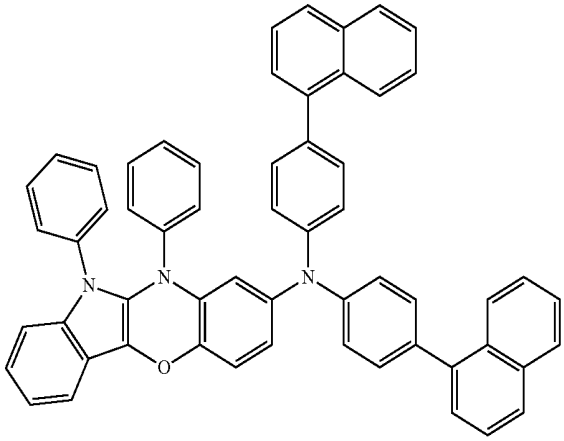
B45



B46

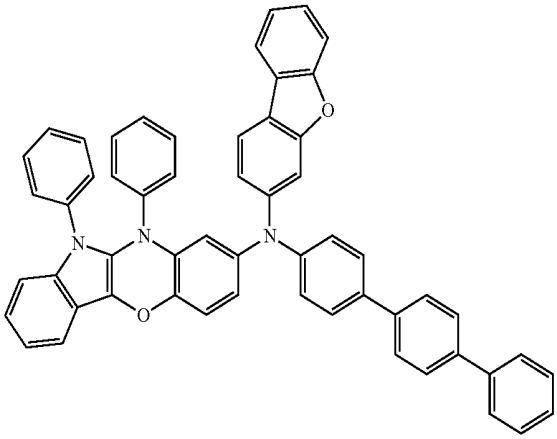


B47

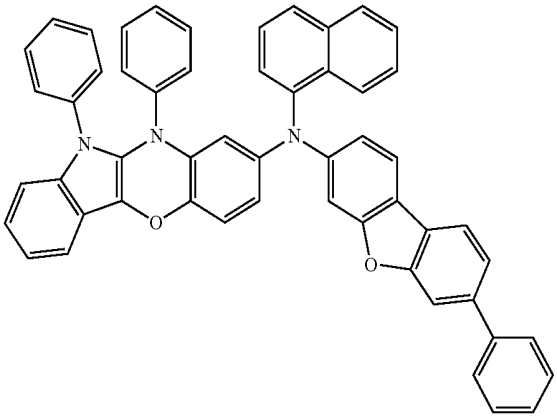


-continued

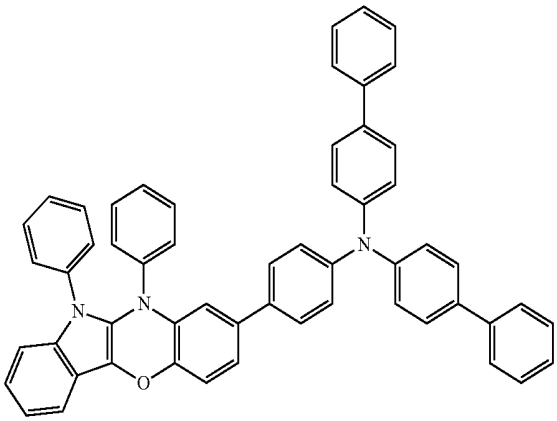
B48



B49

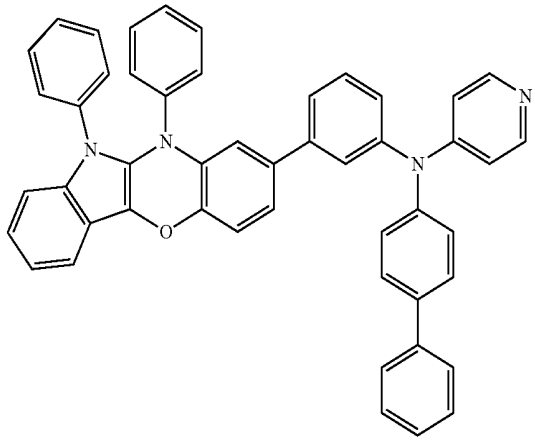


B50

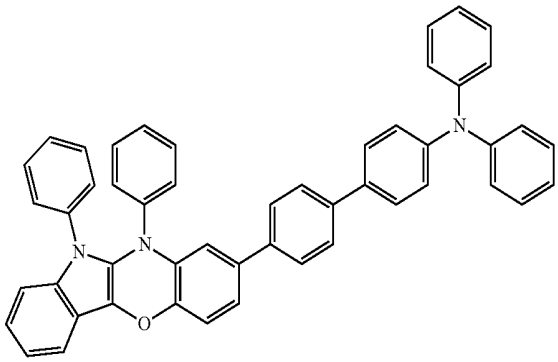


-continued

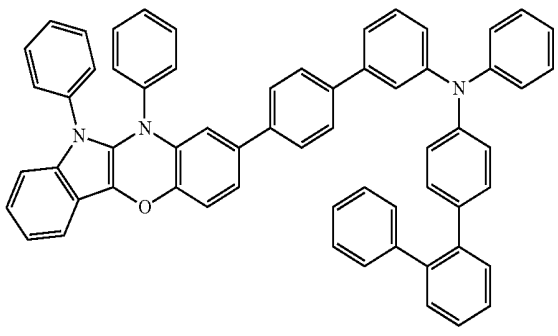
B51



B52

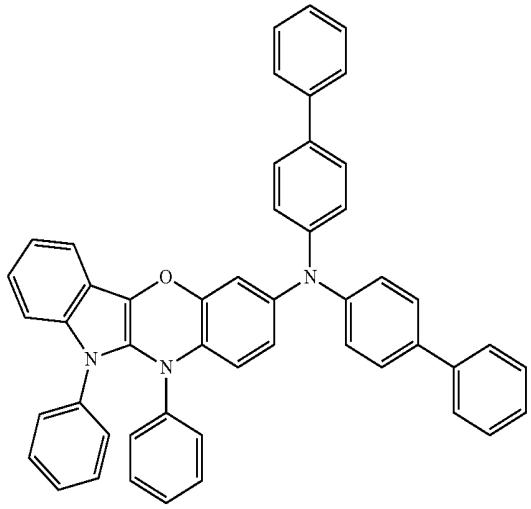


B53

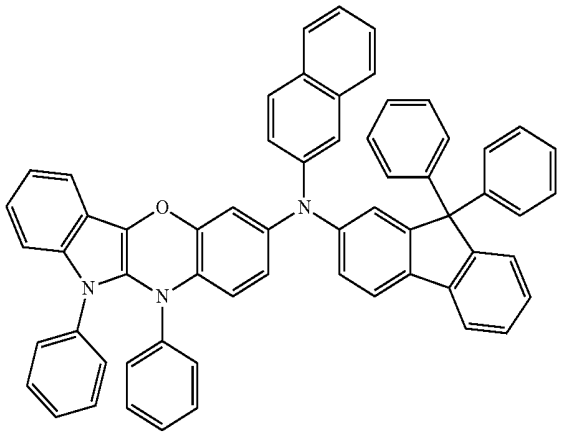


-continued

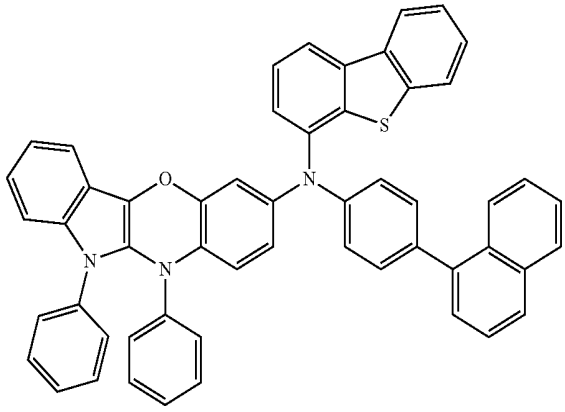
B54



B55

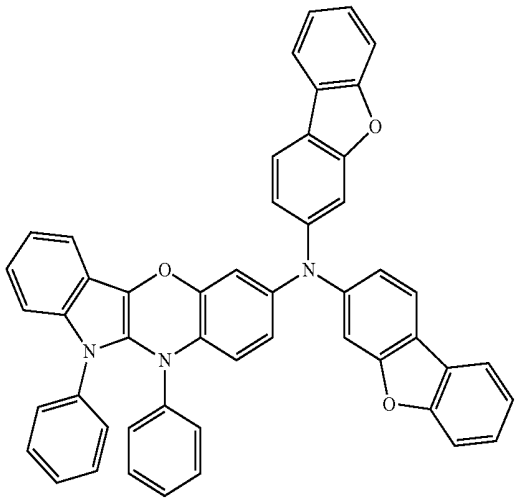


B56

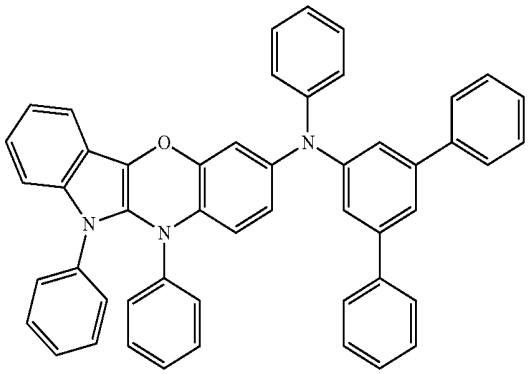


-continued

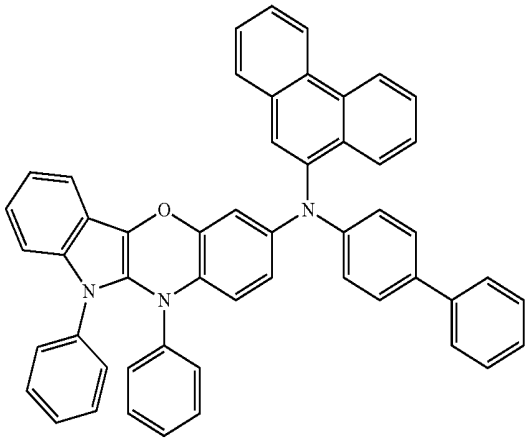
B57



B58

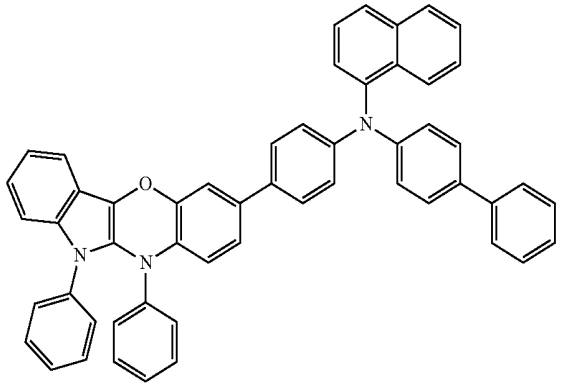


B59

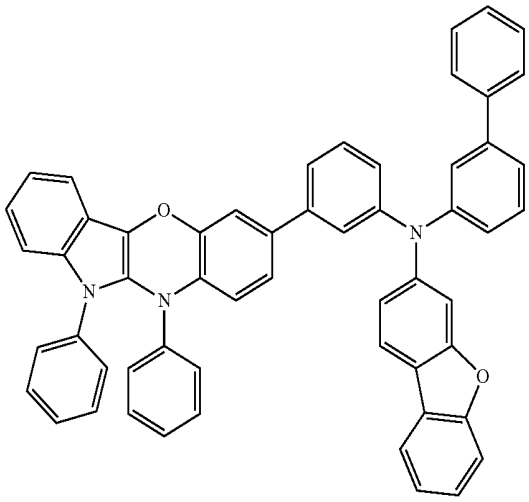


-continued

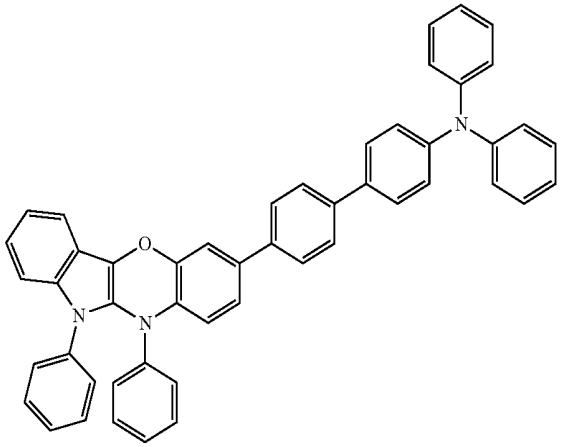
B60



B61

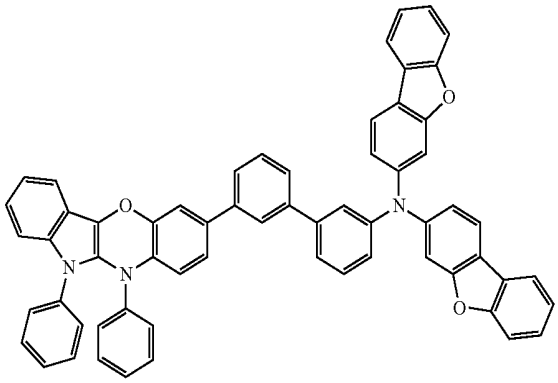


B62

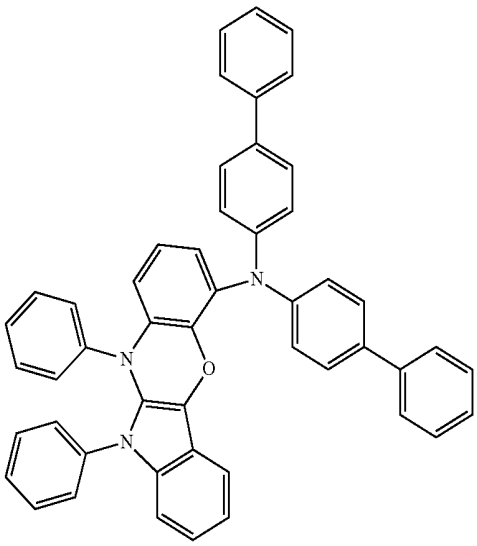


-continued

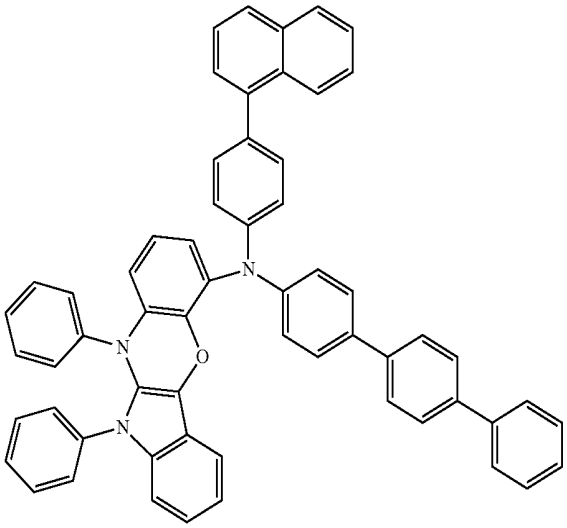
B63



B64

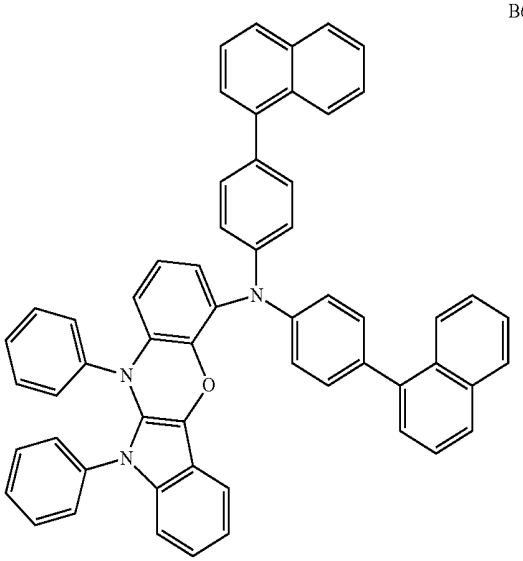


B65

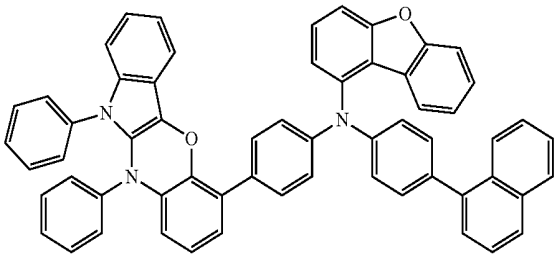


-continued

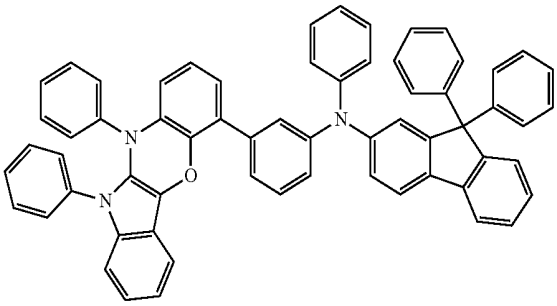
B66



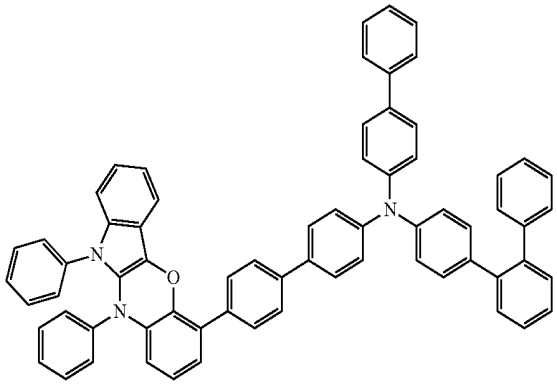
B67



B68

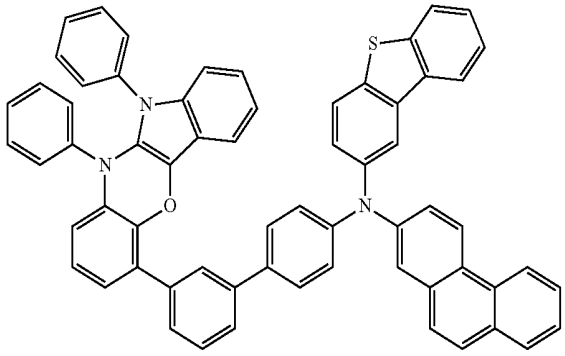


B69



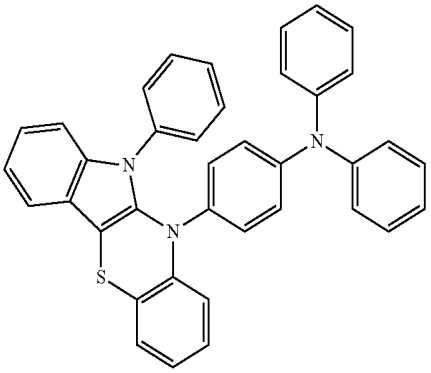
-continued

B70

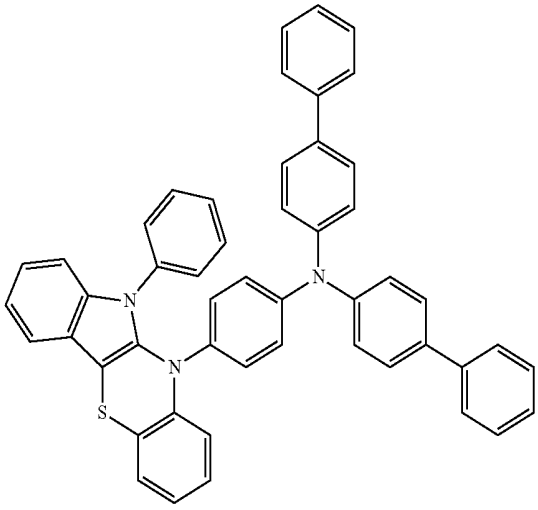


[Compound Group 3]

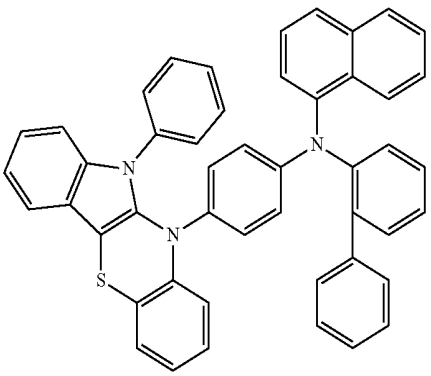
C1



C2

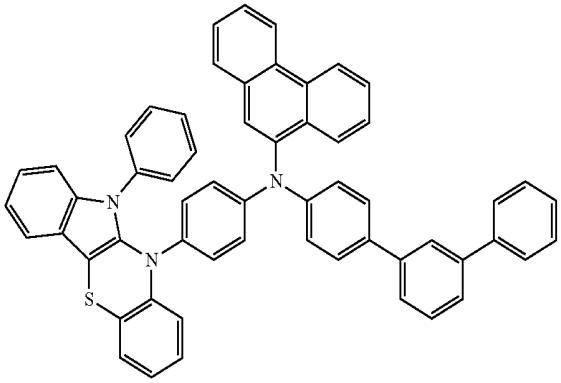


C3

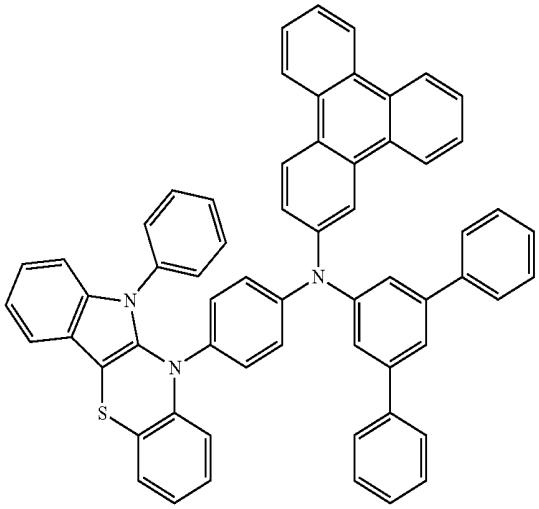


-continued

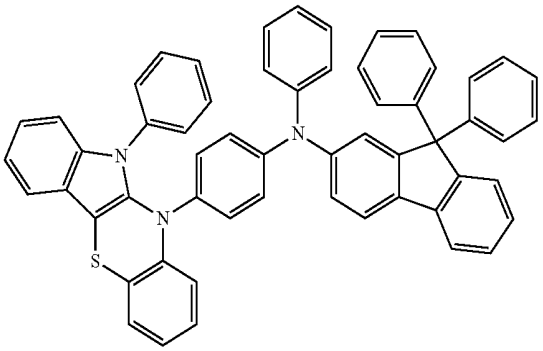
C4



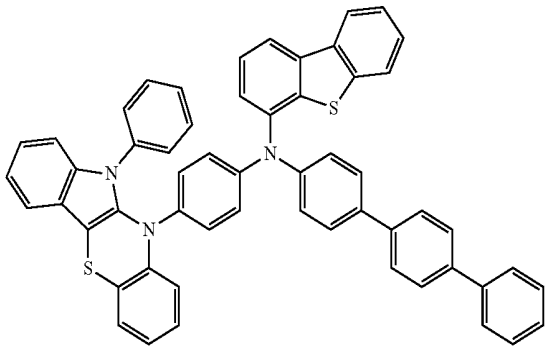
C5



C6

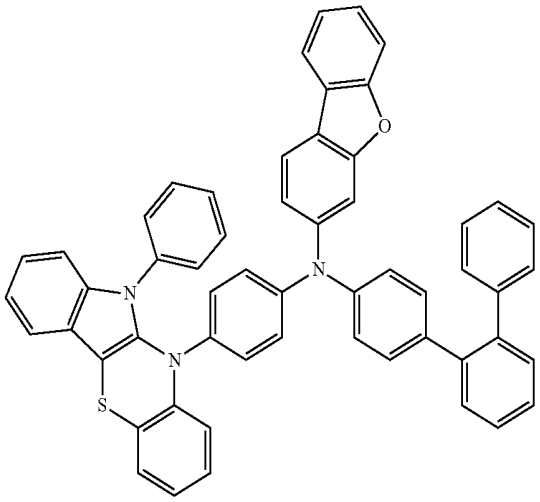


C7

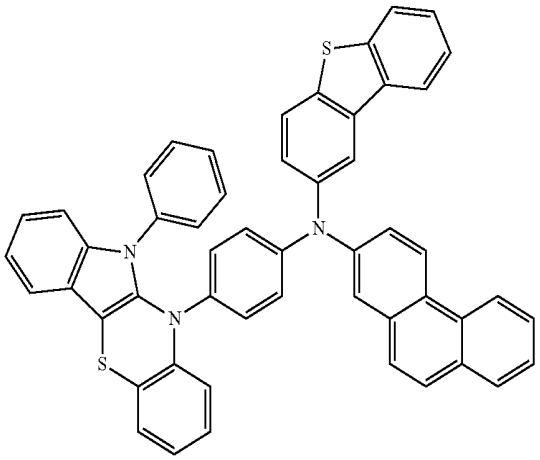


-continued

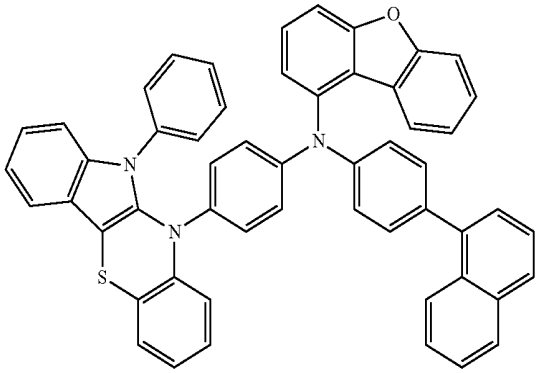
C8



C9

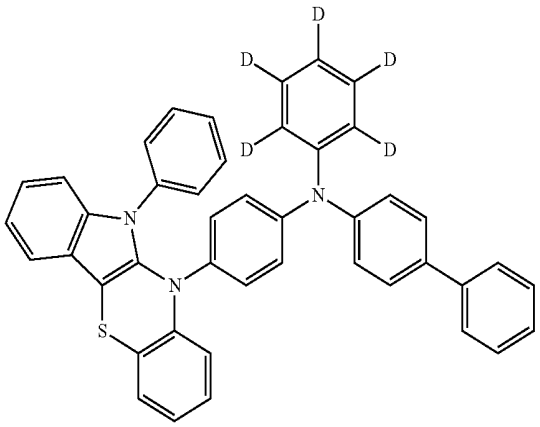


C10

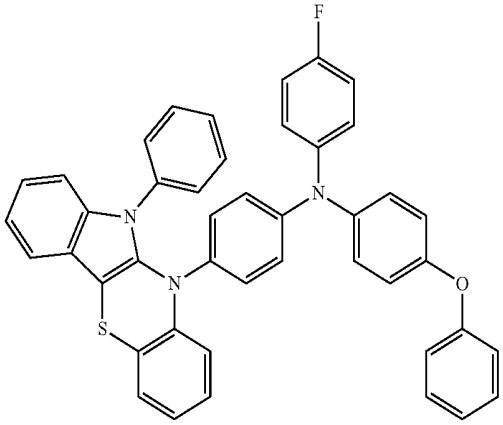


-continued

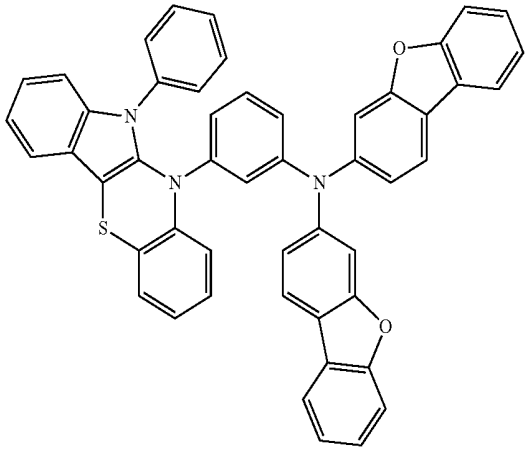
C11



C12

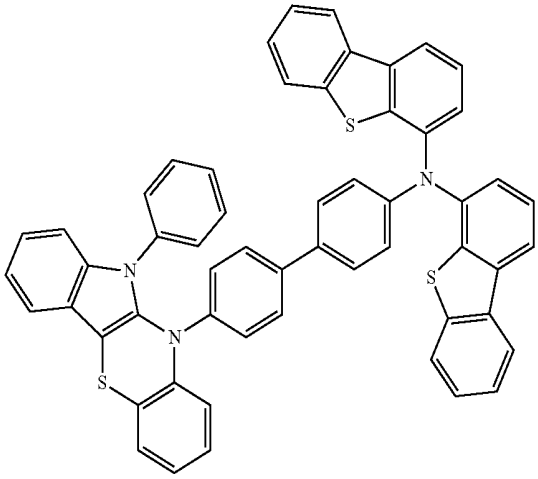


C13

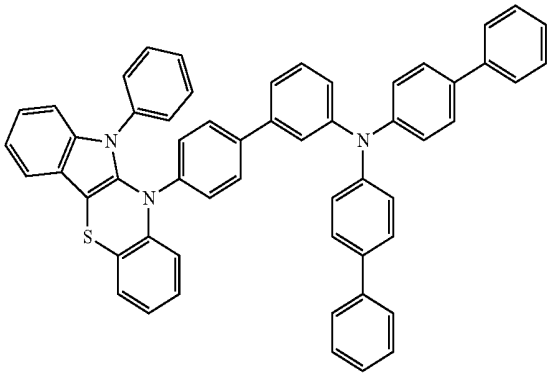


-continued

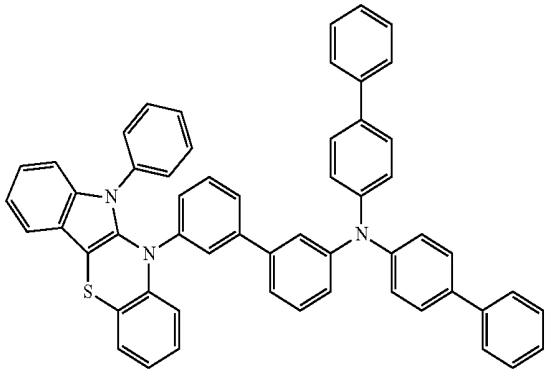
C14



C15

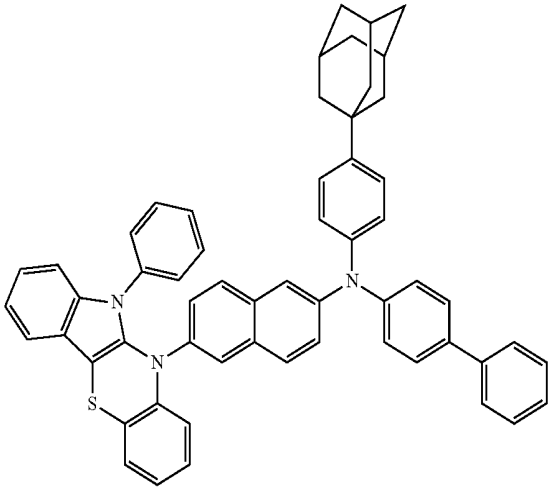


C16

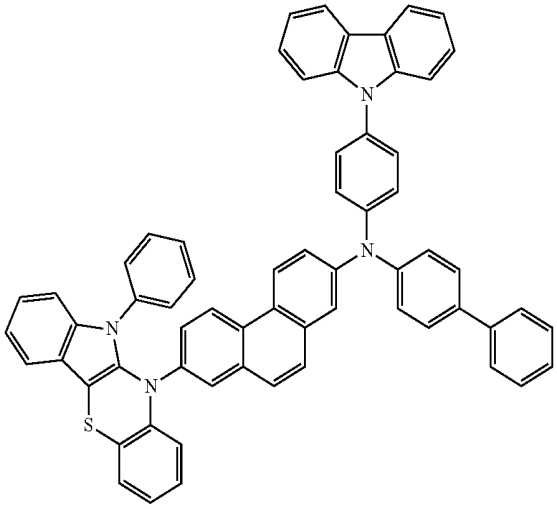


-continued

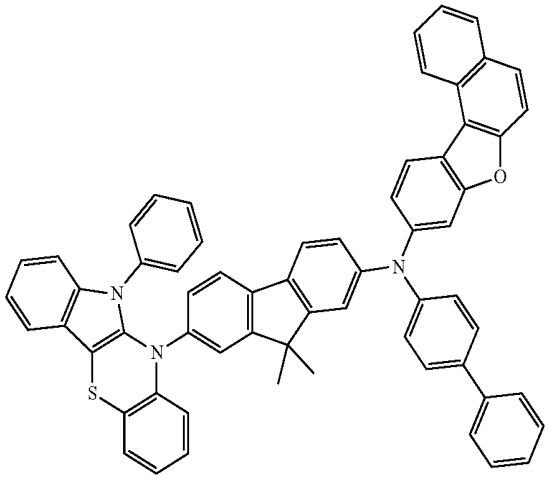
C17



C18

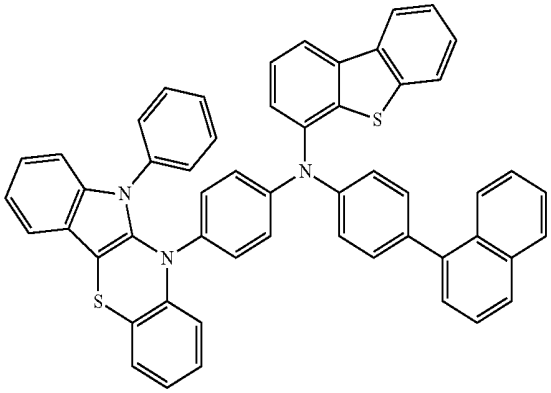


C19

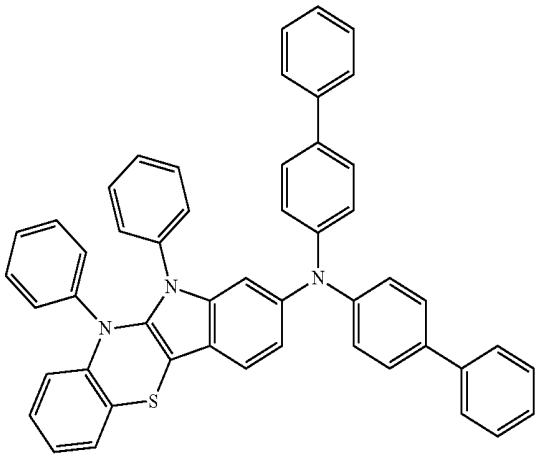


-continued

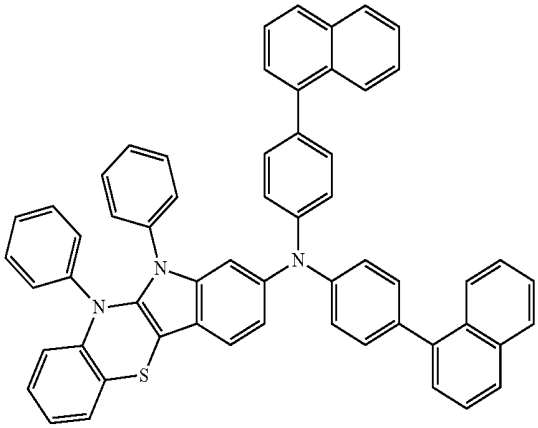
C20



C21

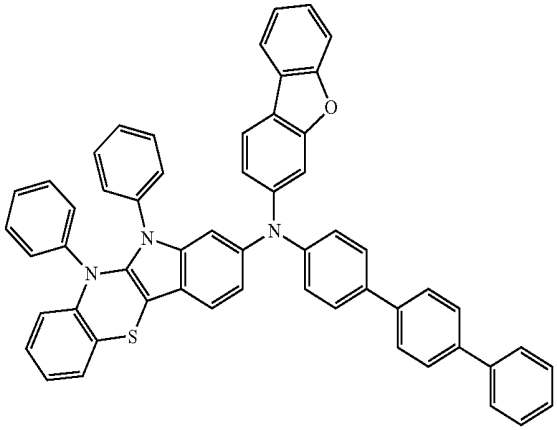


C22

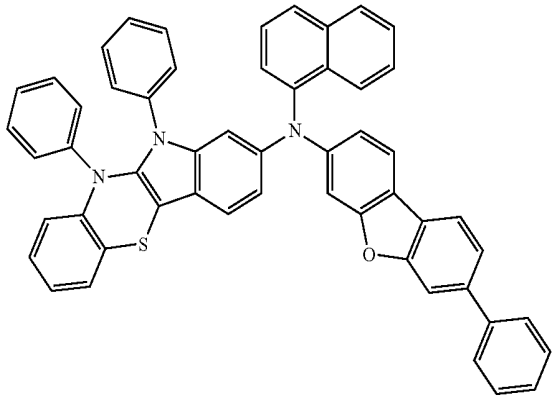


-continued

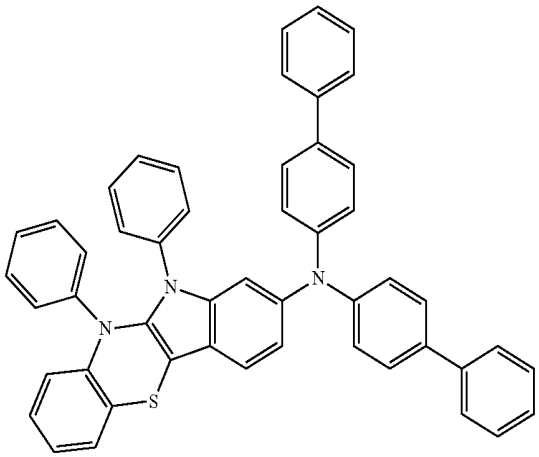
C23



C24

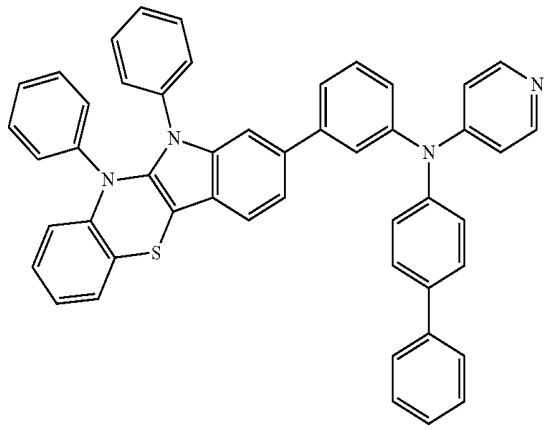


C25

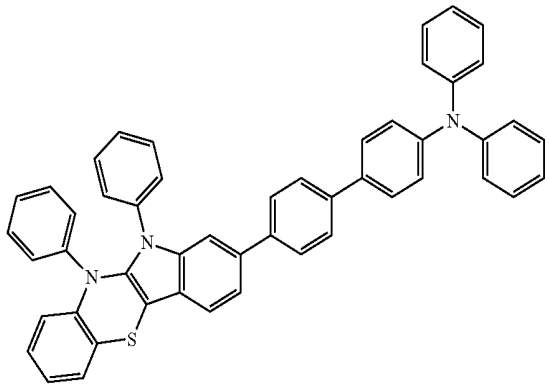


-continued

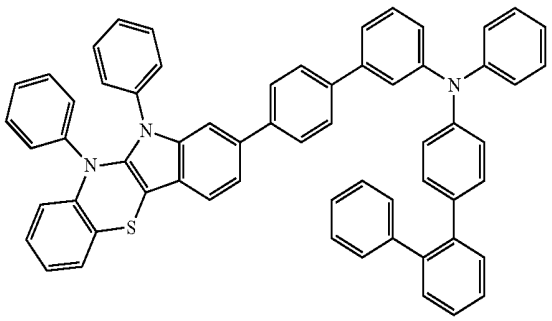
C26



C27

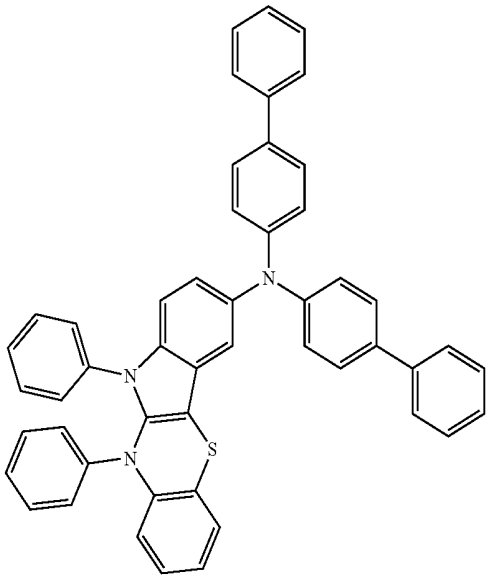


C28

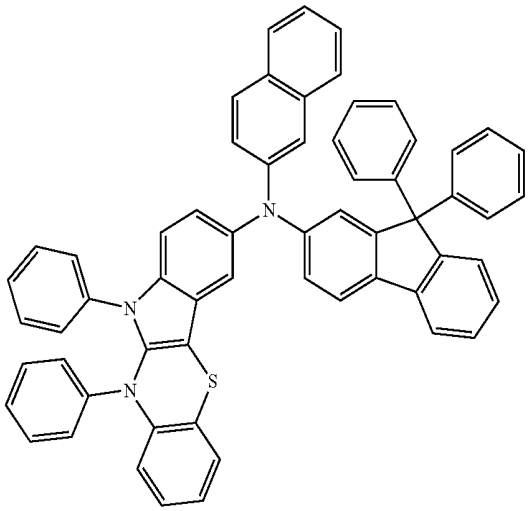


-continued

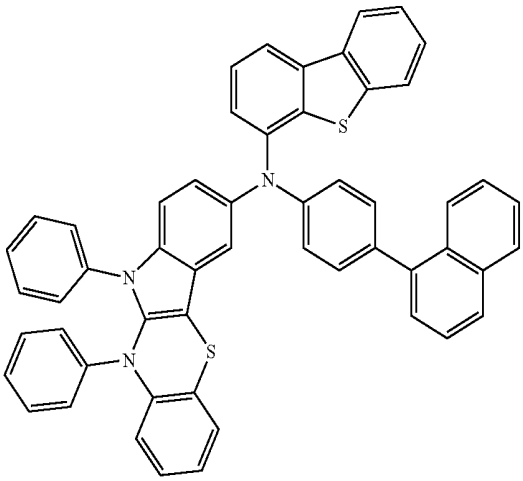
C29



C30

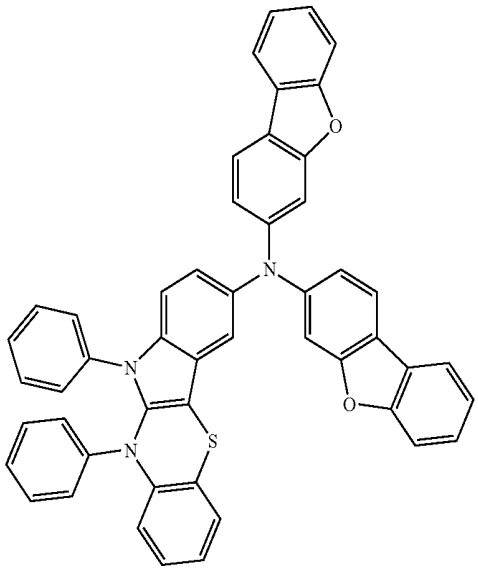


C31

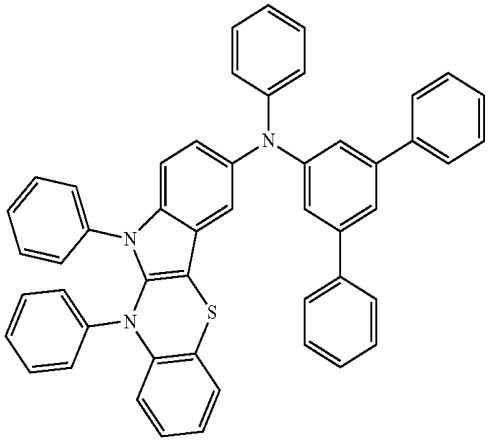


-continued

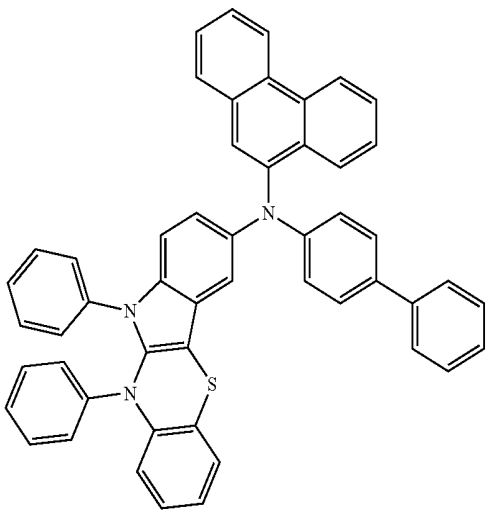
C32



C33

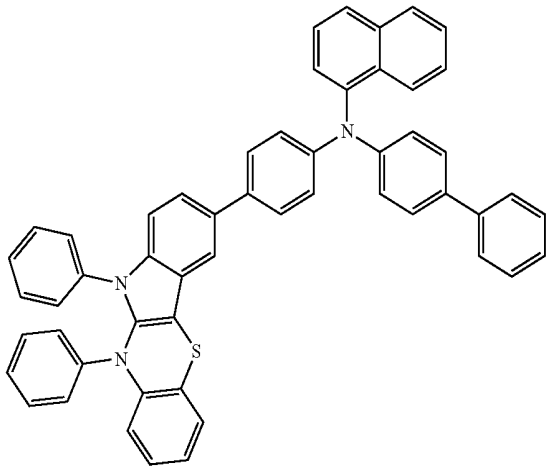


C34

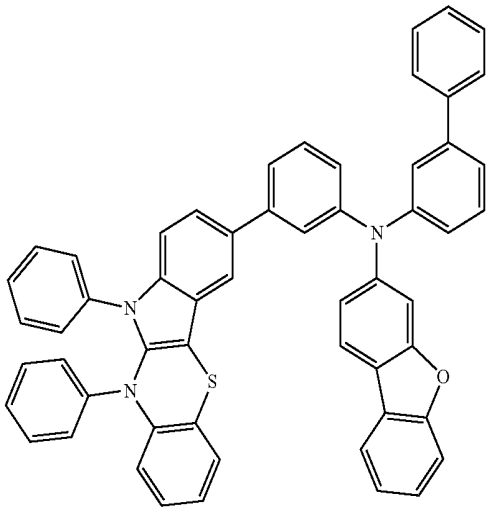


-continued

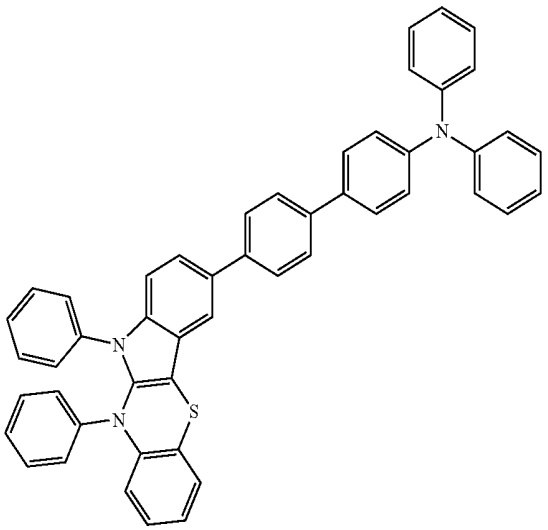
C35



C36

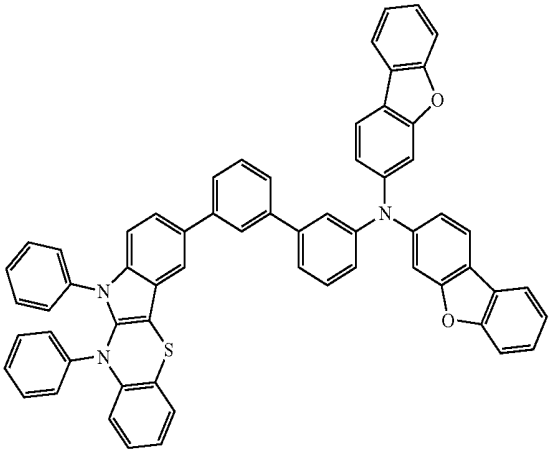


C37

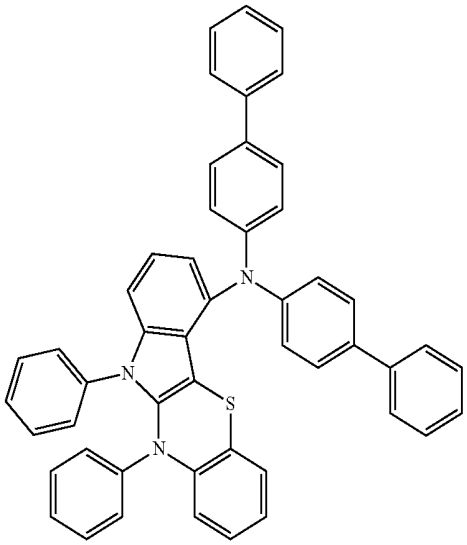


-continued

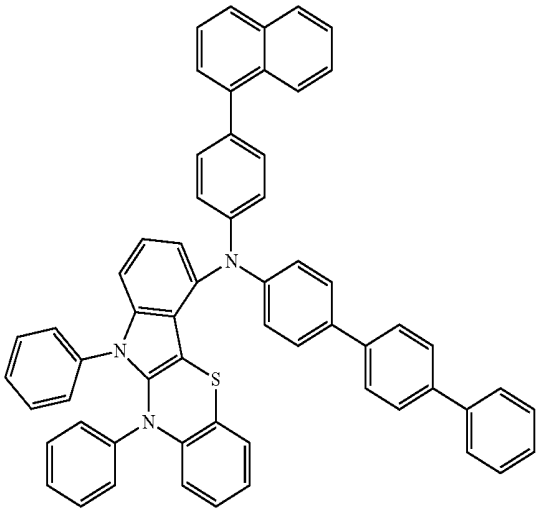
C38



C39

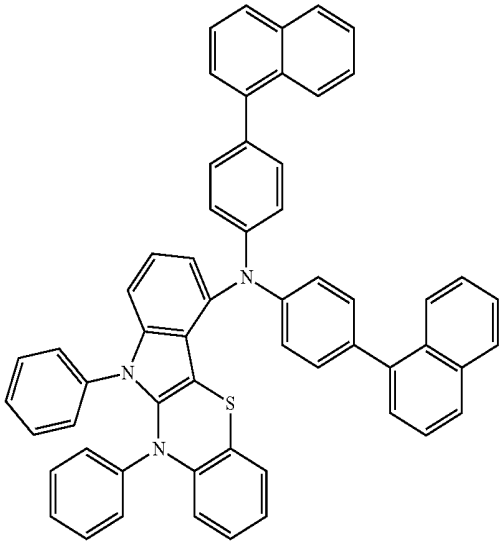


C40

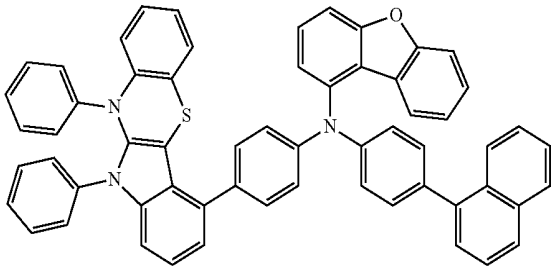


-continued

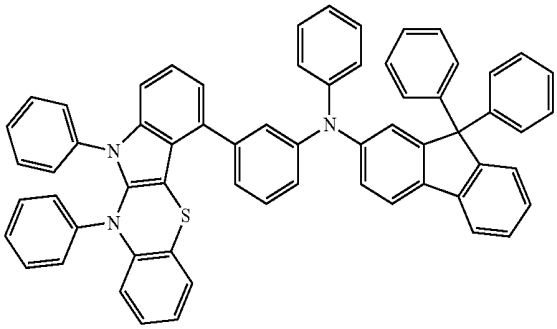
C41



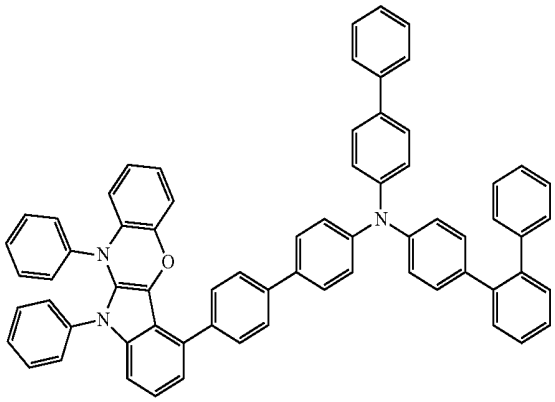
C42



C43

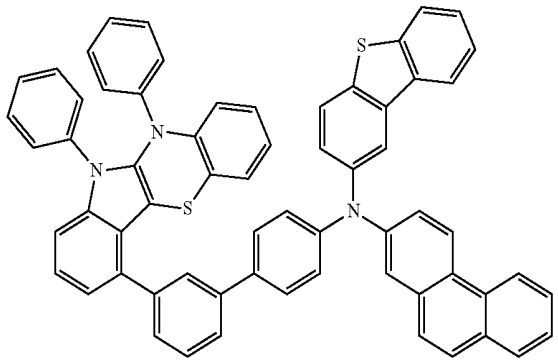


C44

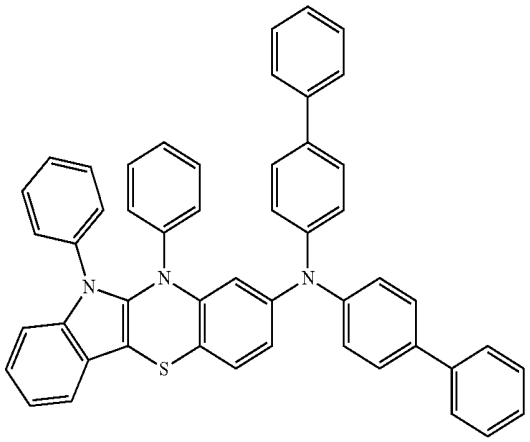


-continued

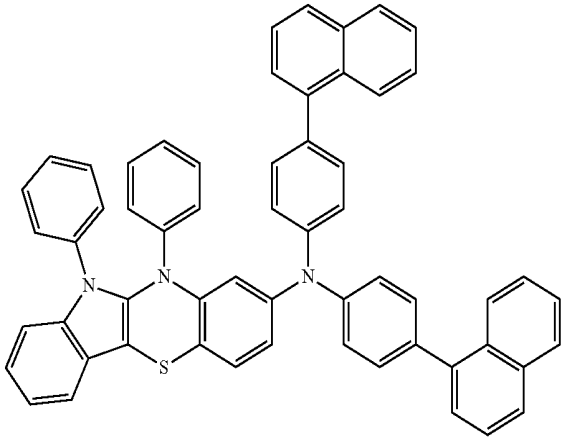
C45



C46

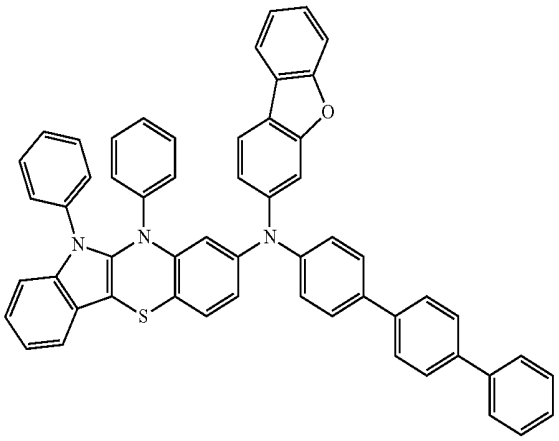


C47

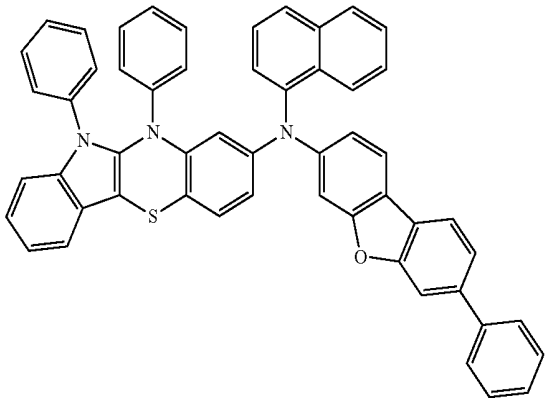


-continued

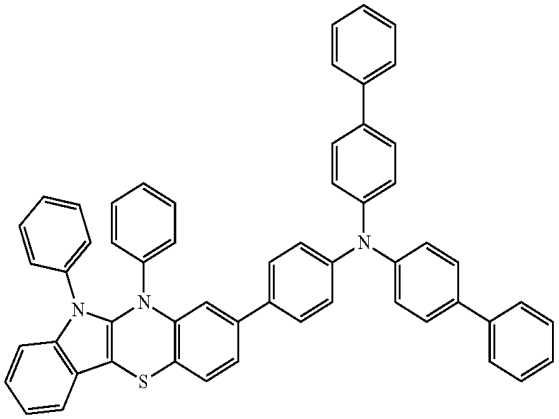
C48



C49

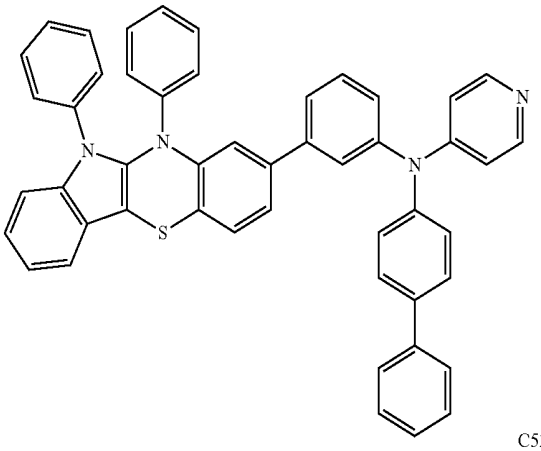


C50

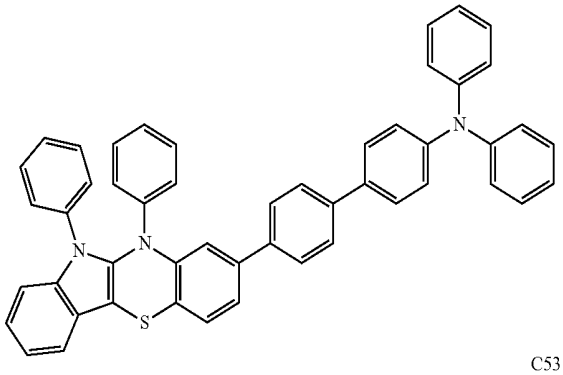


-continued

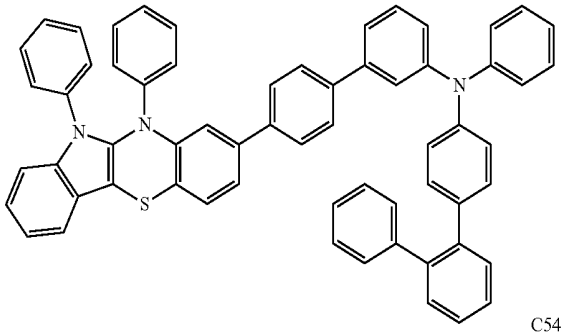
C51



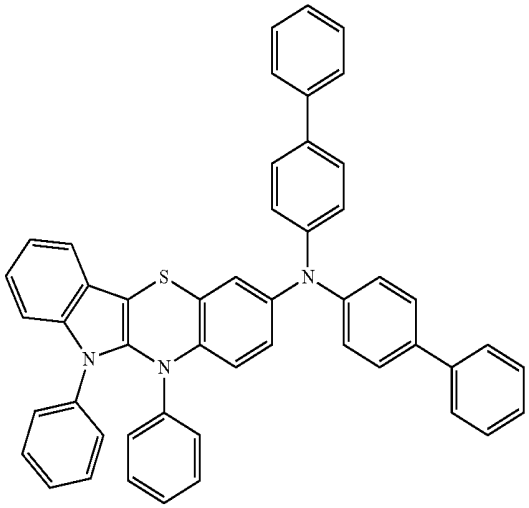
C52



C53

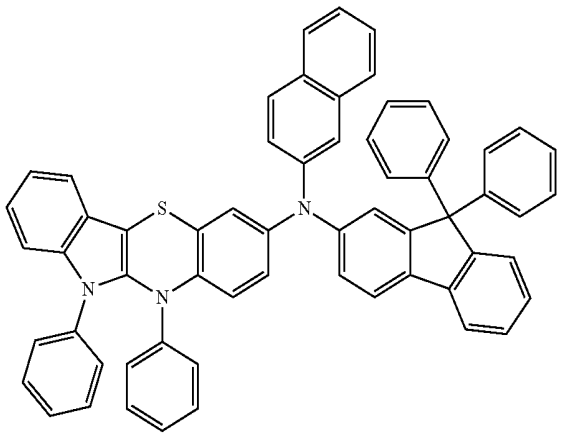


C54

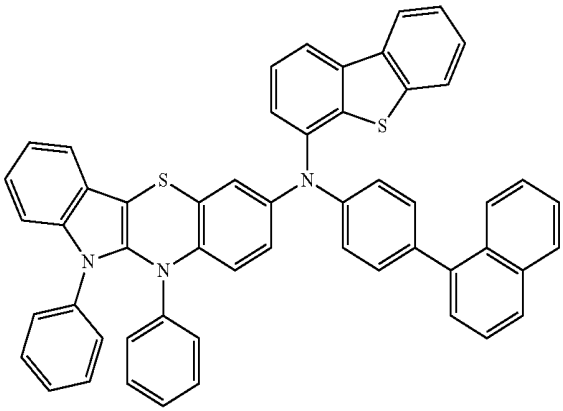


-continued

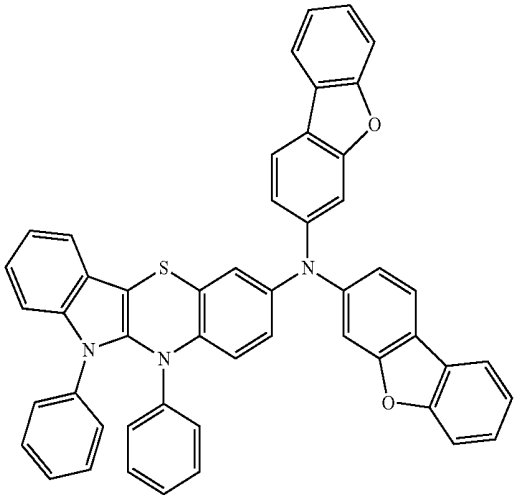
C55



C56

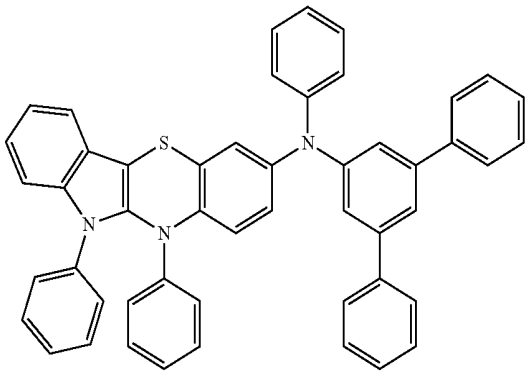


C57

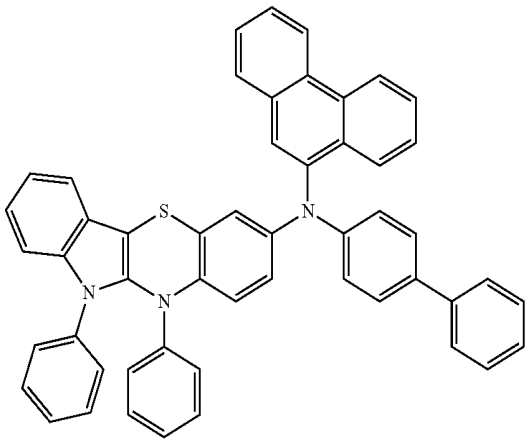


-continued

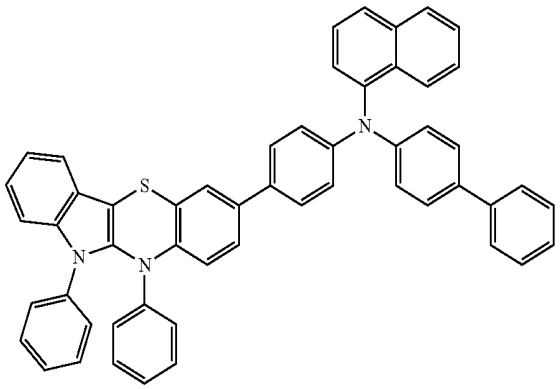
C58



C59

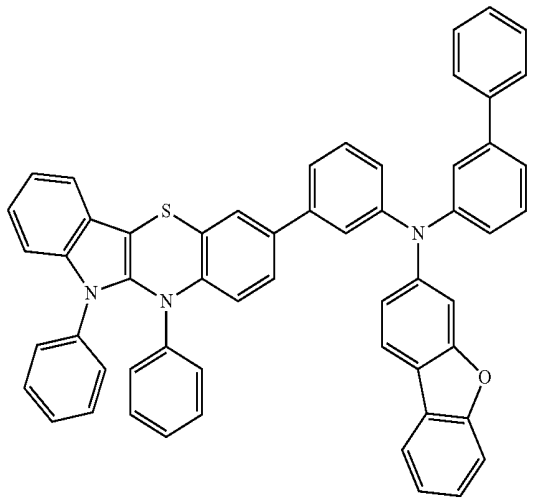


C60

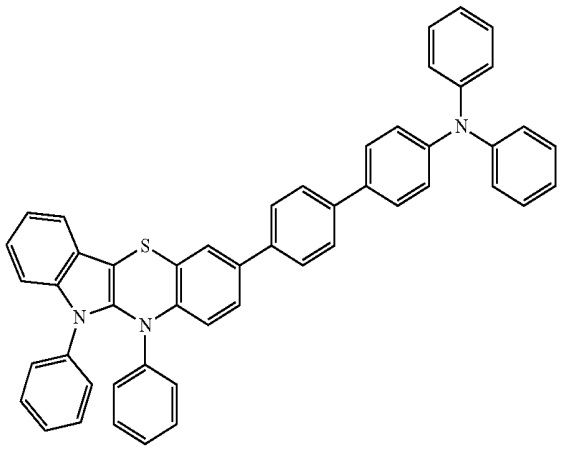


-continued

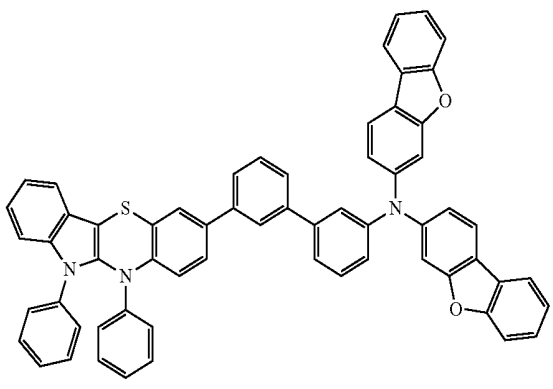
C61



C62

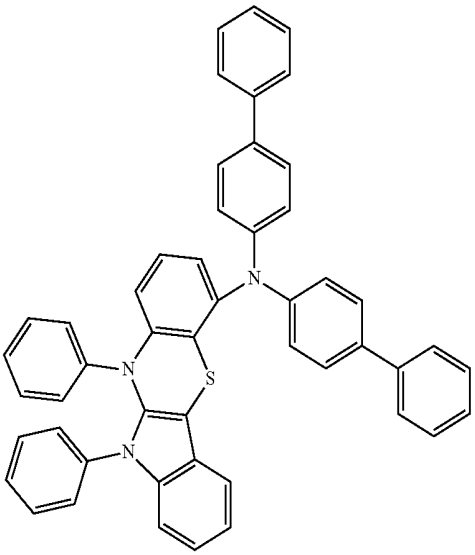


C63

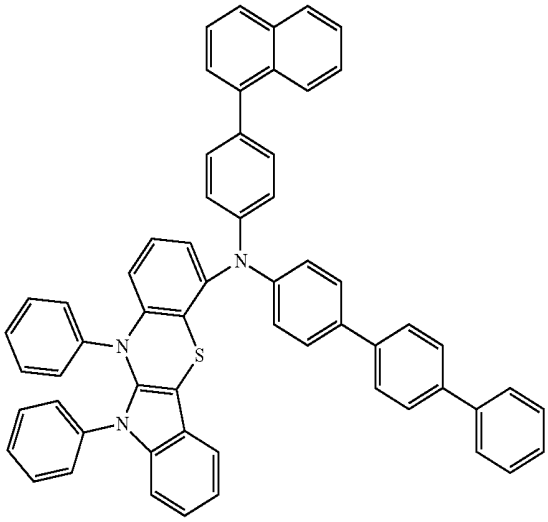


-continued

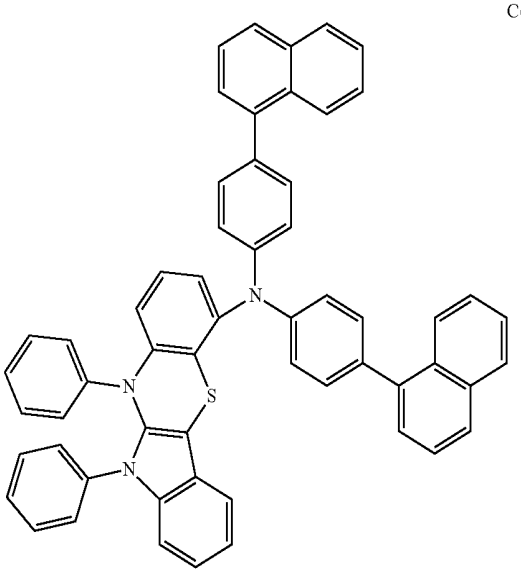
C64



C65

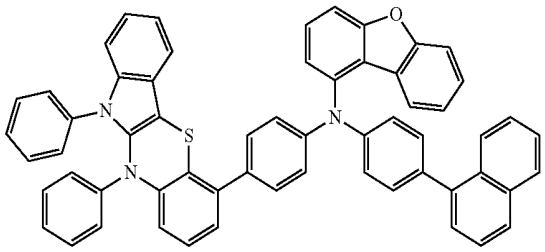


C66

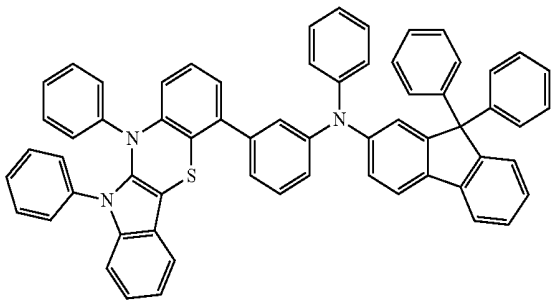


-continued

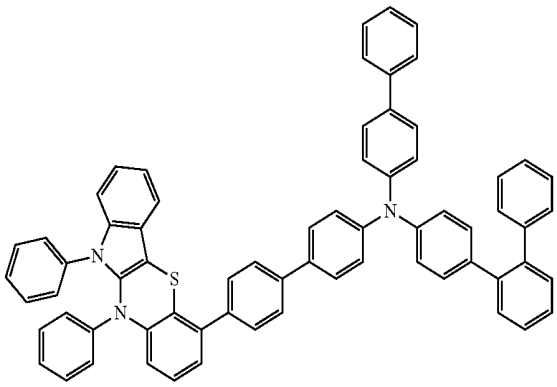
C67



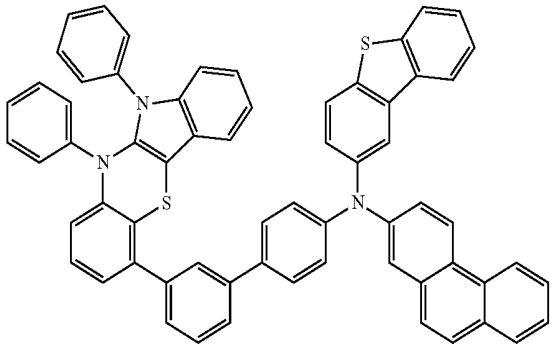
C68



C69

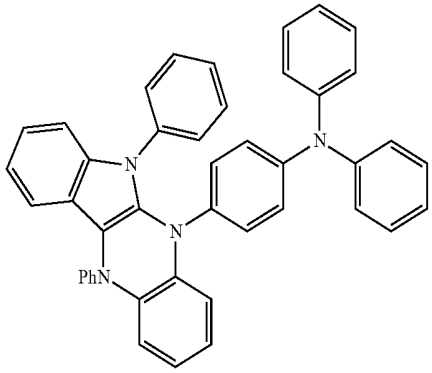


C70

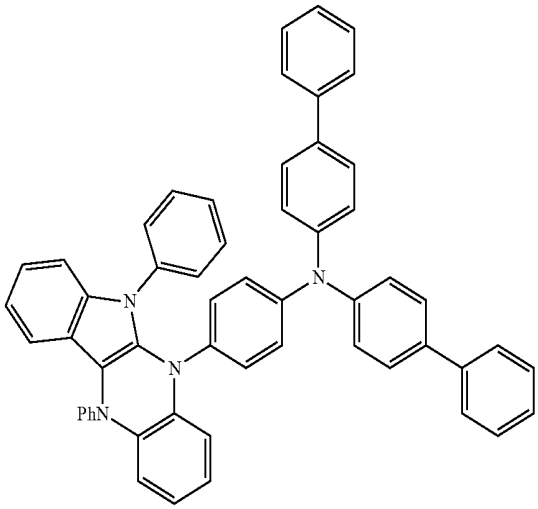


[Compound Group 4]

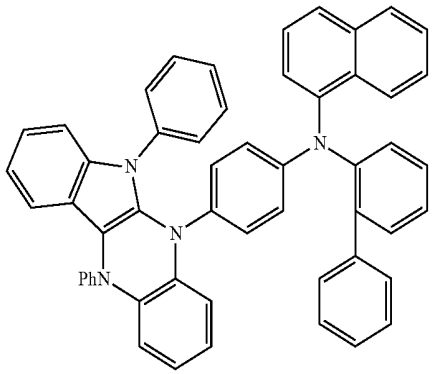
D1



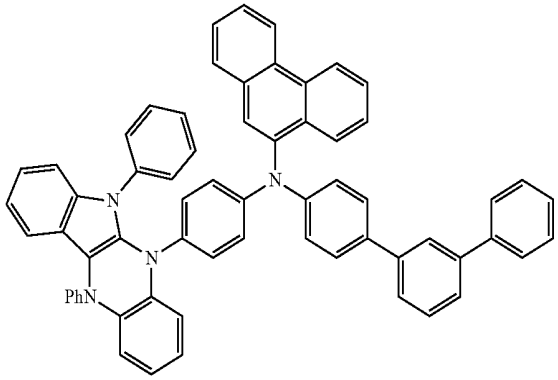
D2



D3

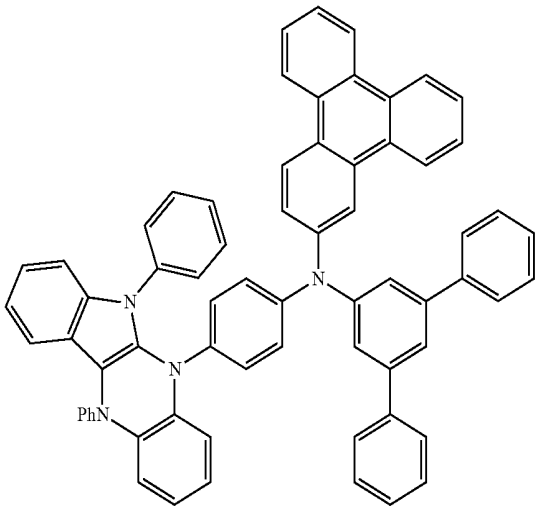


D4

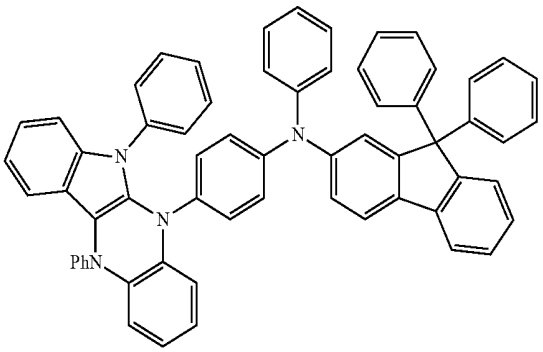


-continued

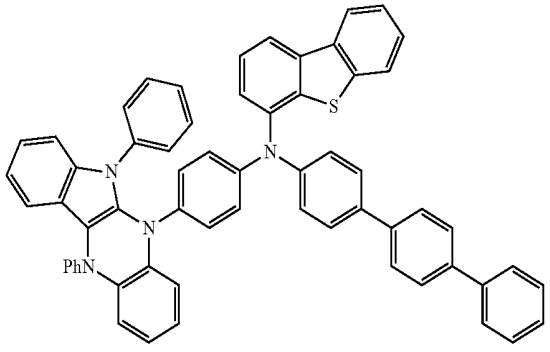
D5



D6

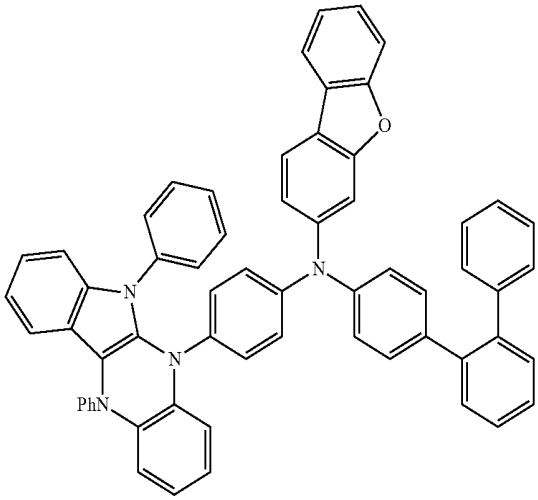


D7



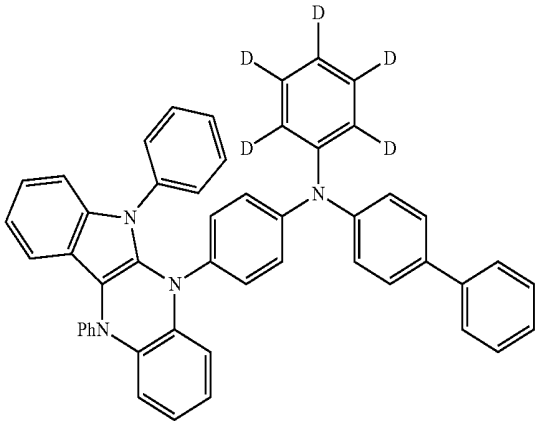
-continued

D8

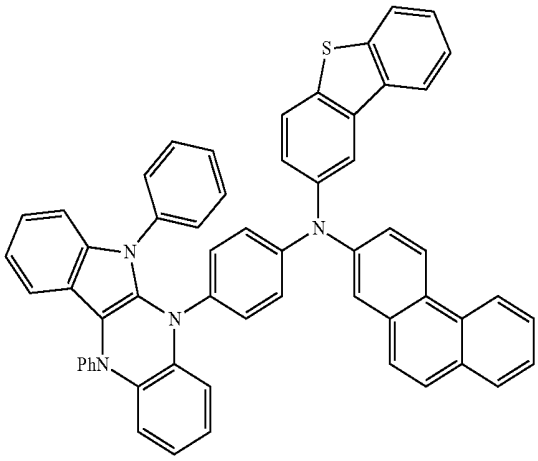


-continued

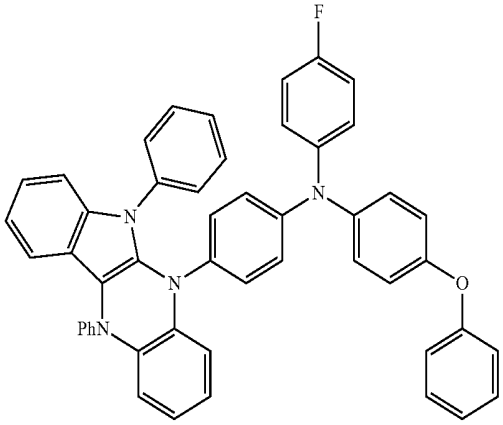
D11



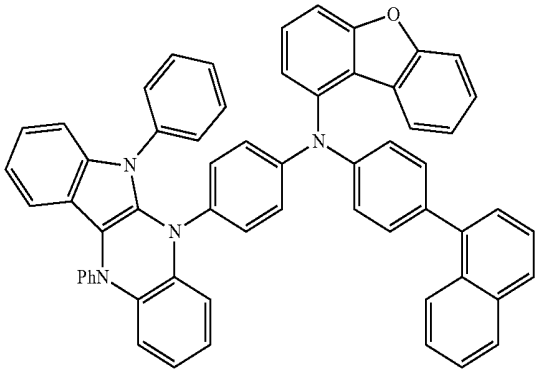
D9



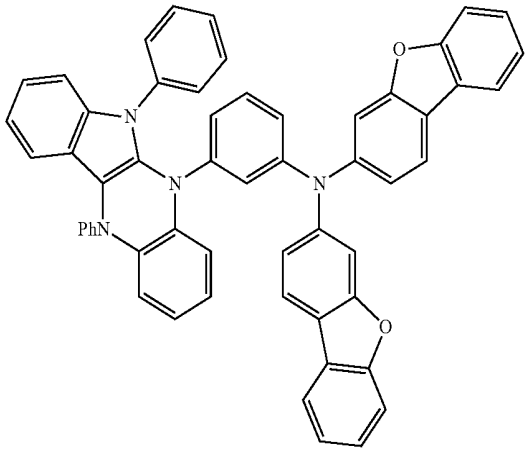
D12



D10

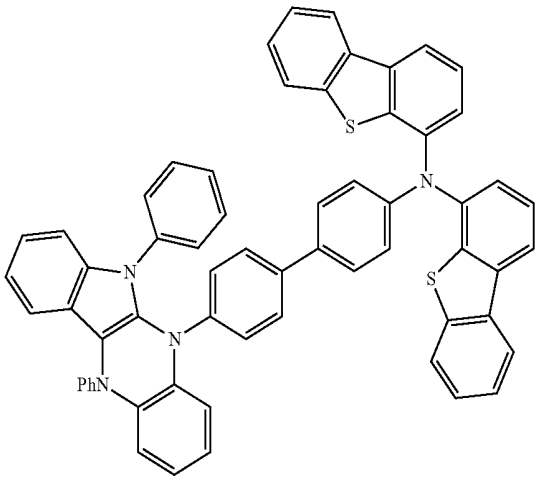


D13

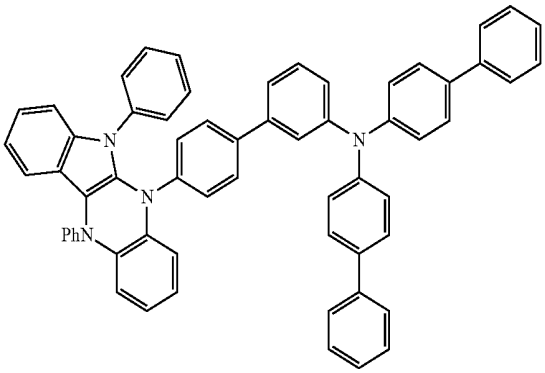


-continued

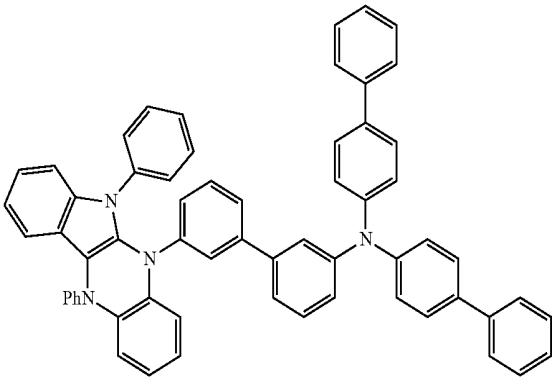
D14



D15

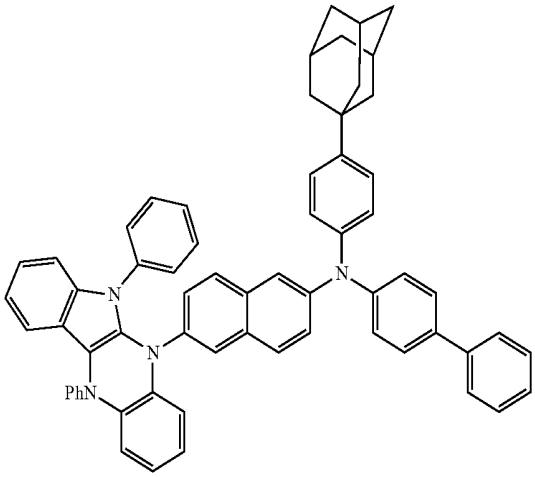


D16

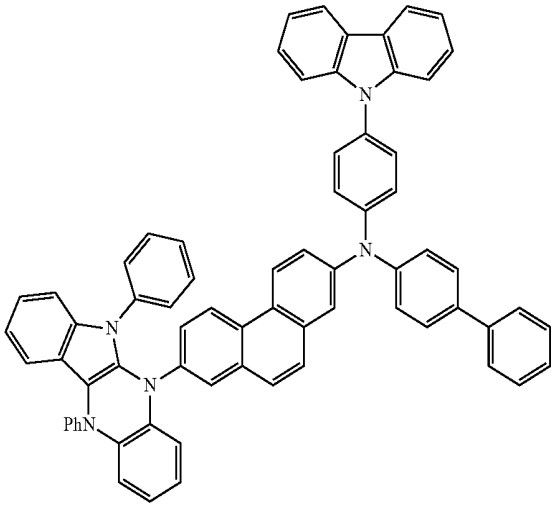


-continued

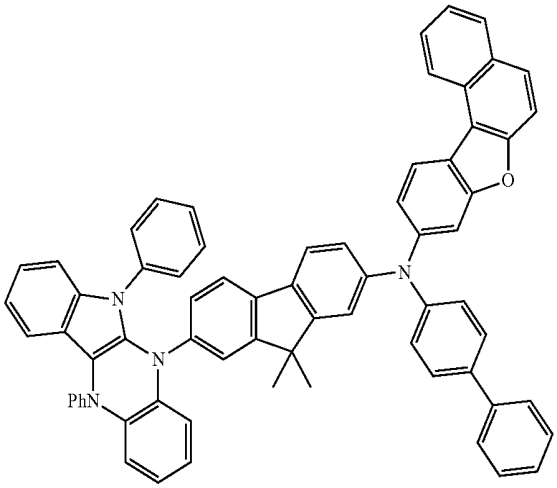
D17



D18

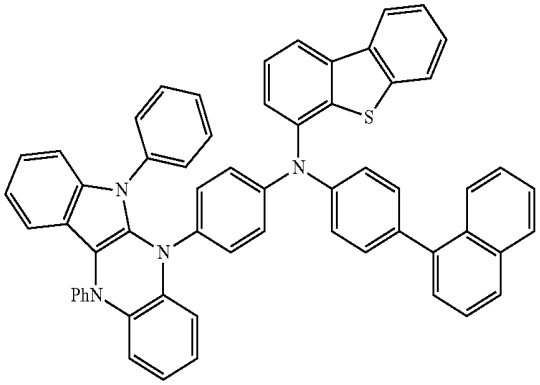


D19

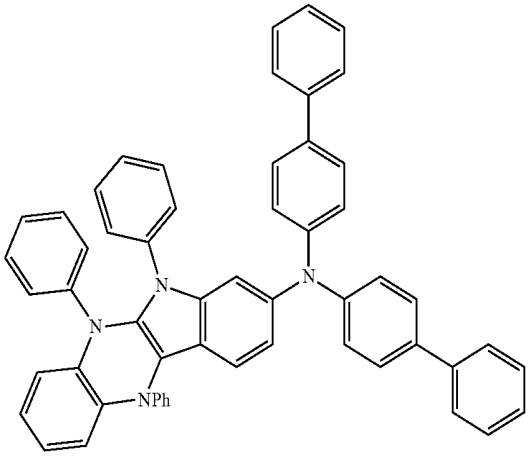


-continued

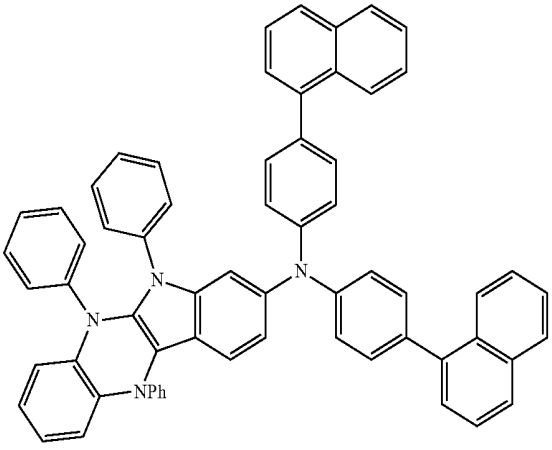
D20



D21

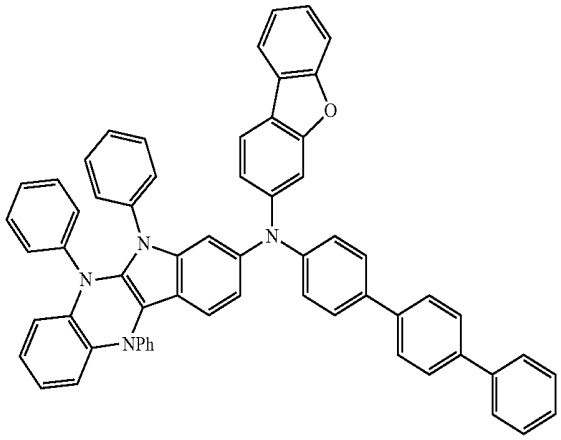


D22

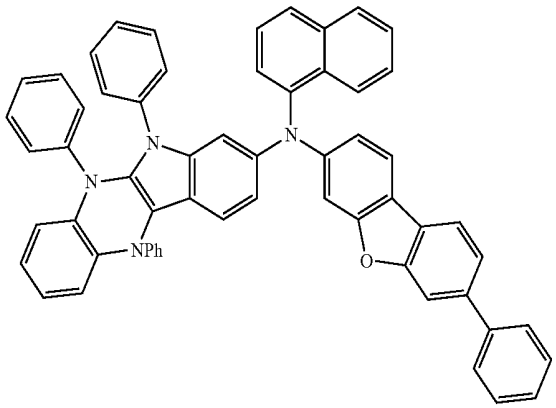


-continued

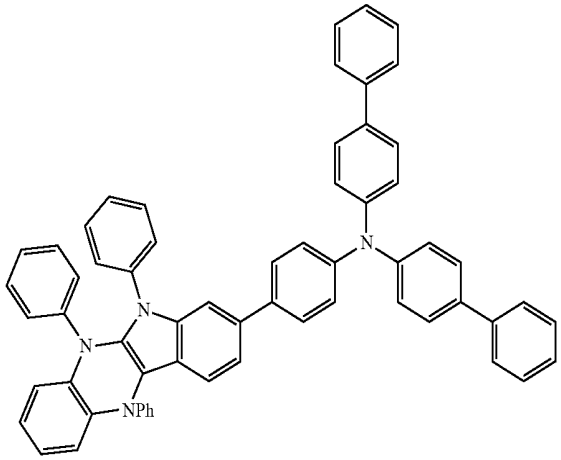
D23



D24

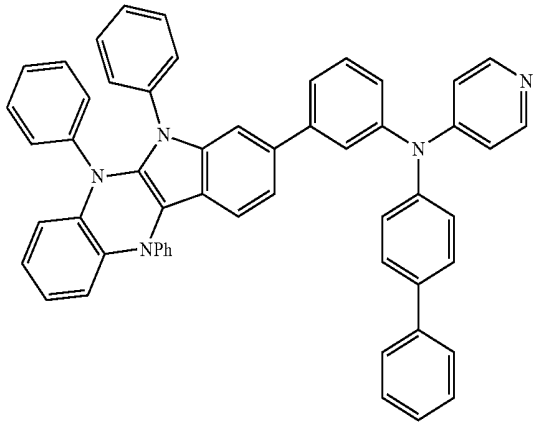


D25

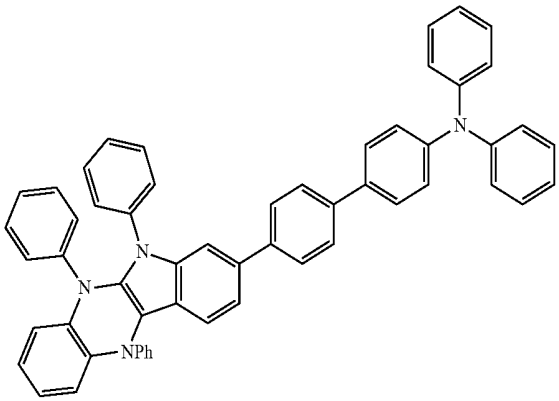


-continued

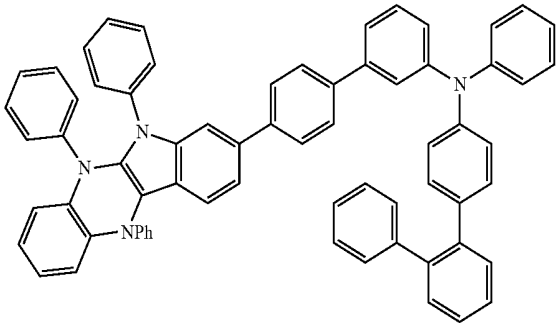
D26



D27

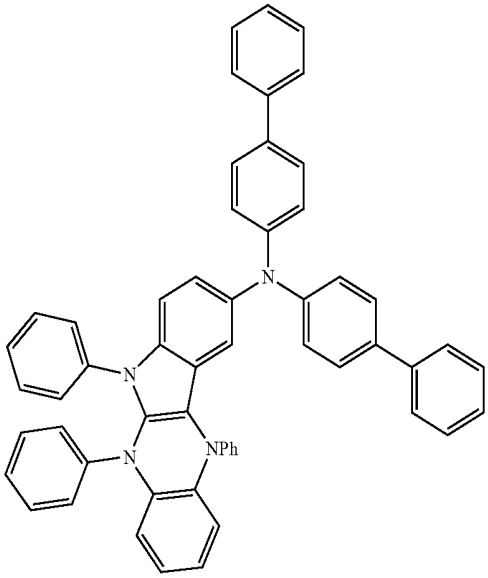


D28

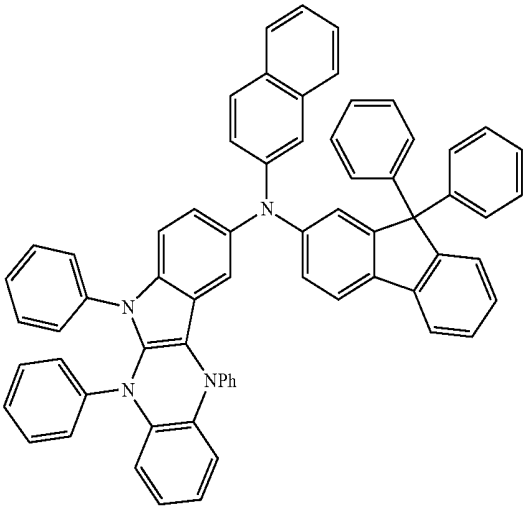


-continued

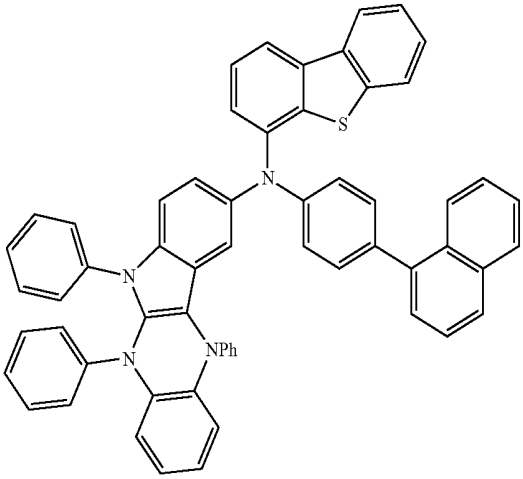
D29



D30

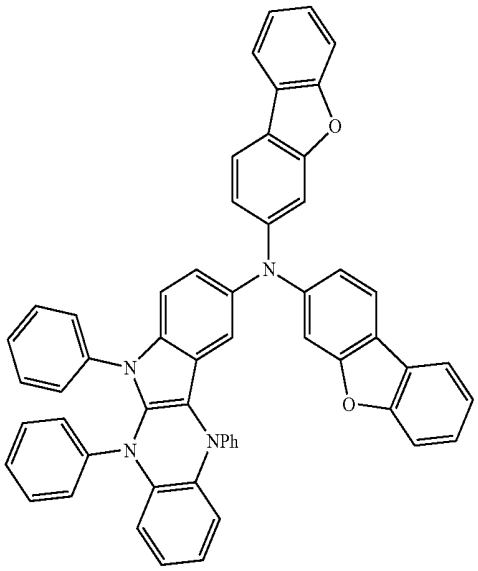


D31

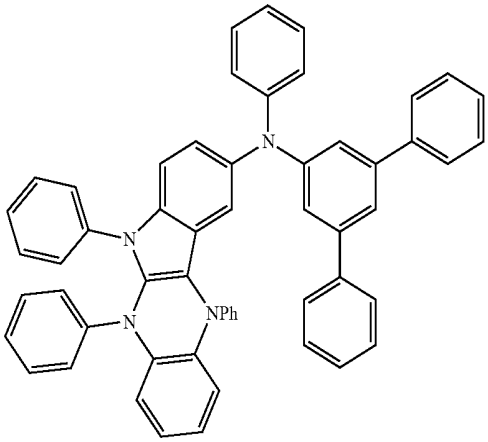


-continued

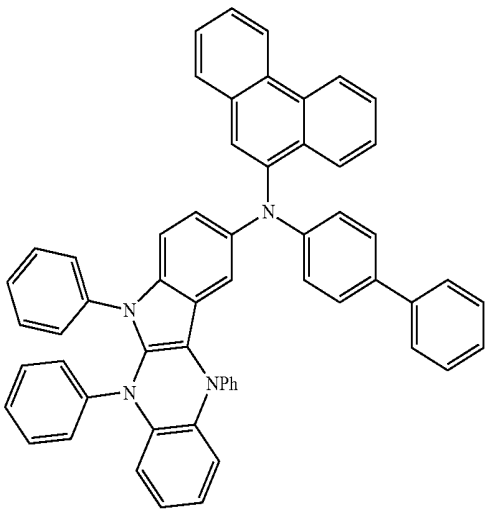
D32



D33

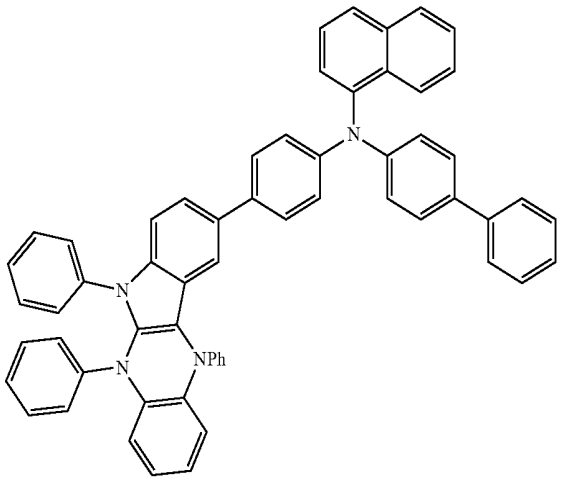


D34

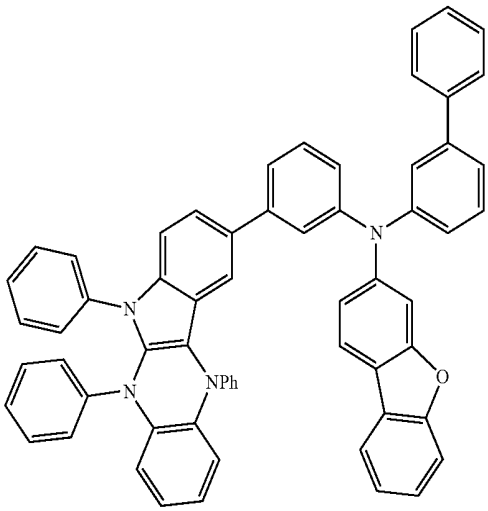


-continued

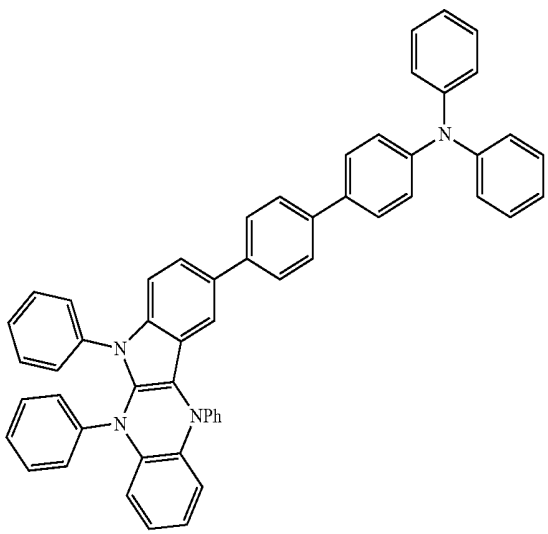
D35



D36

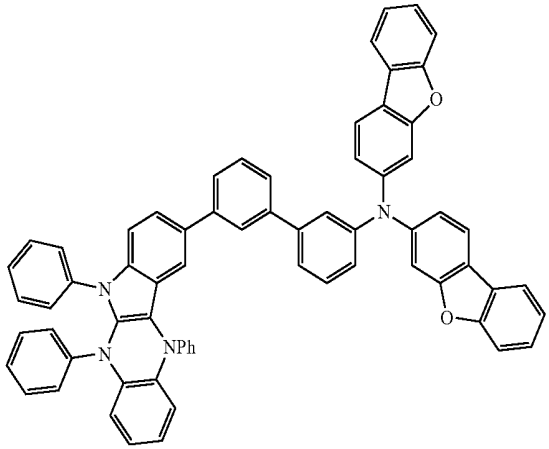


D37

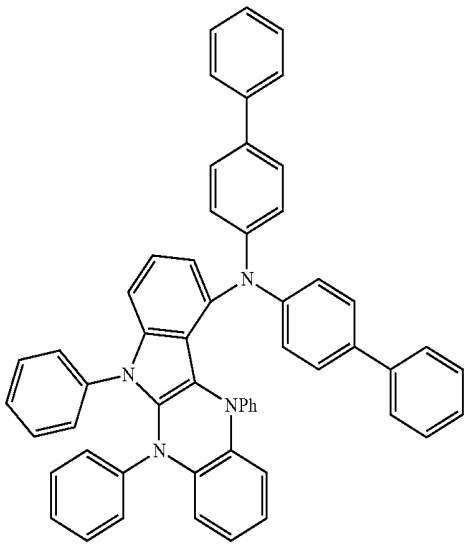


-continued

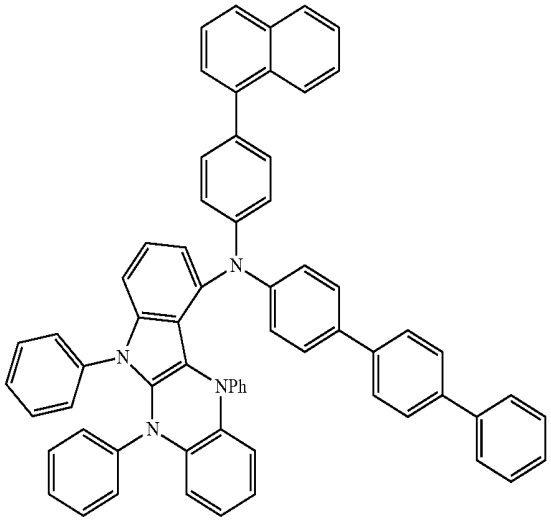
D38



D39

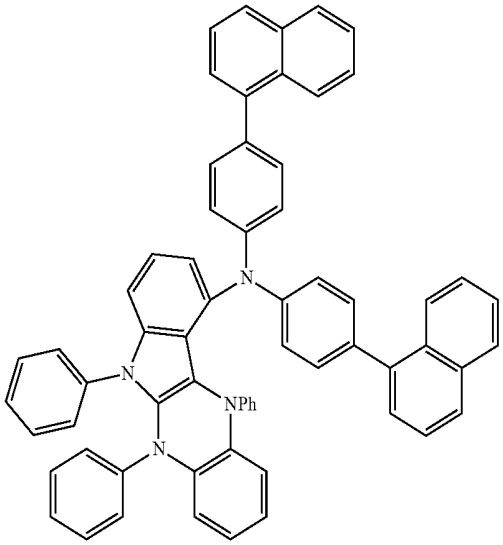


D40

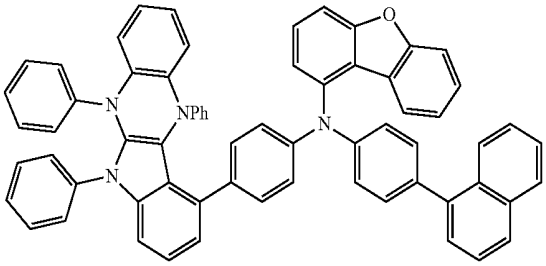


-continued

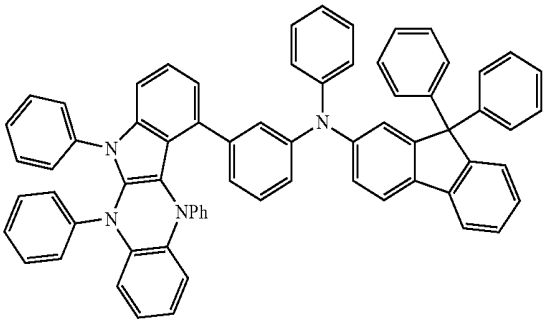
D41



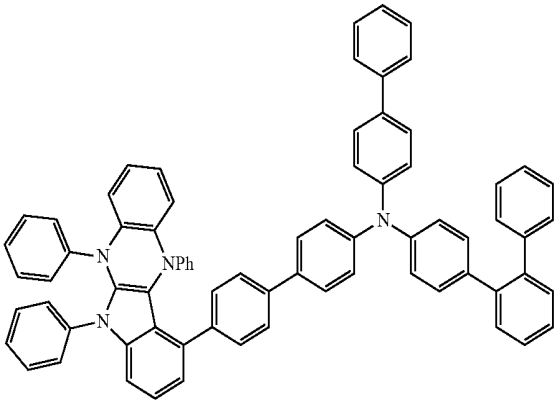
D42



D43

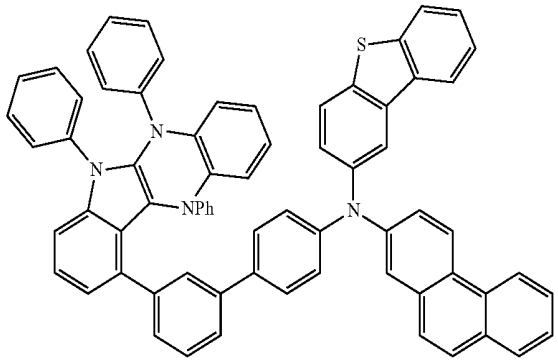


D44

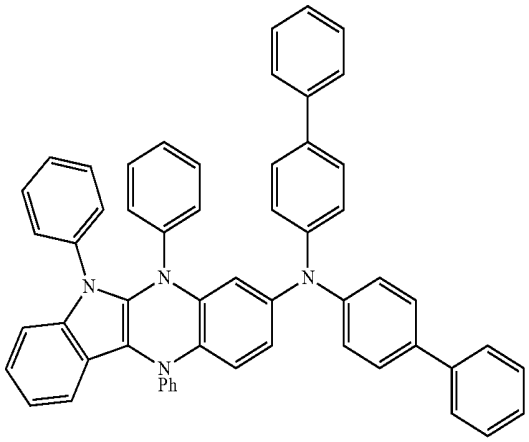


-continued

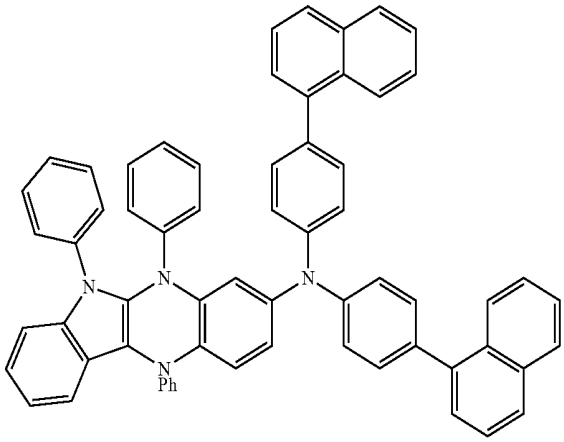
D45



D46

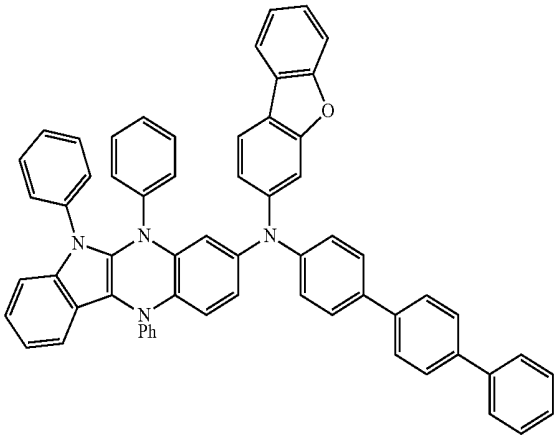


D47

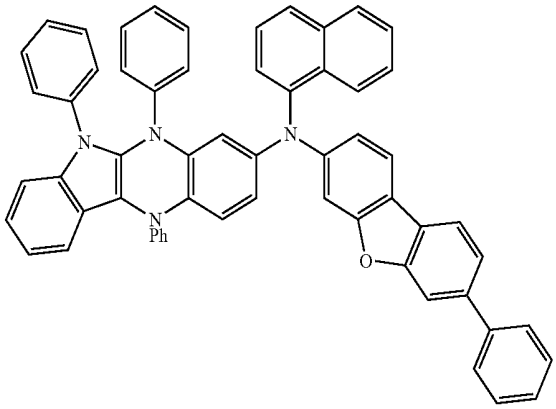


-continued

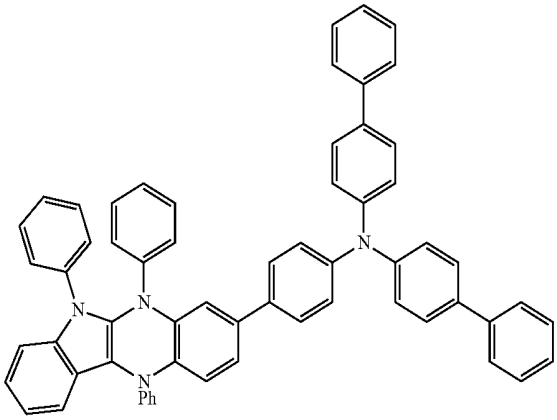
D48



D49

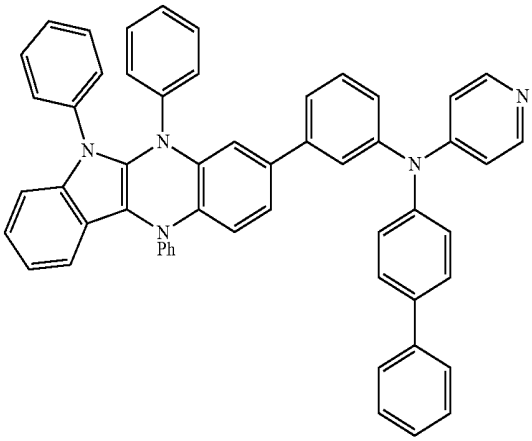


D50



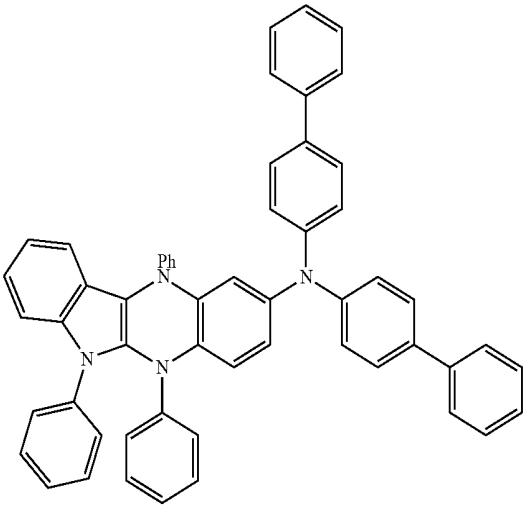
-continued

D51

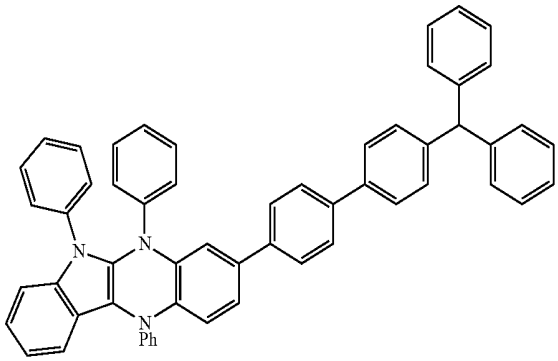


-continued

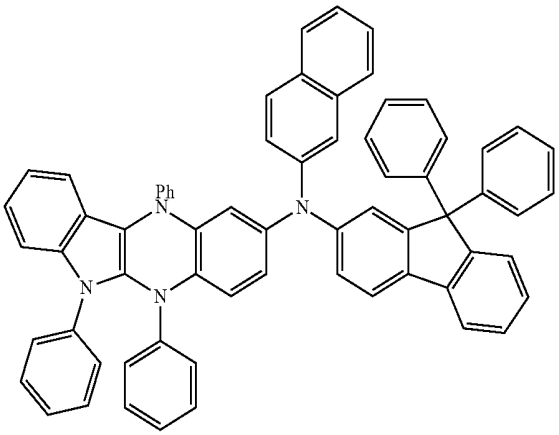
D54



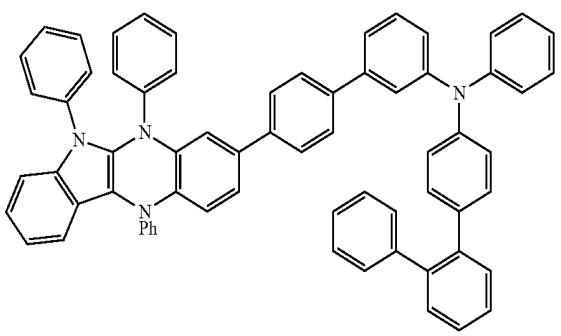
D52



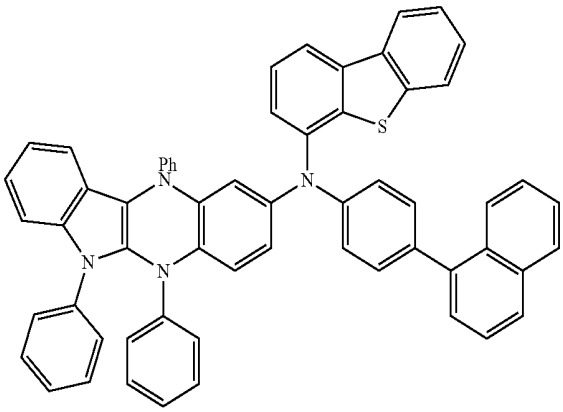
D55



D53

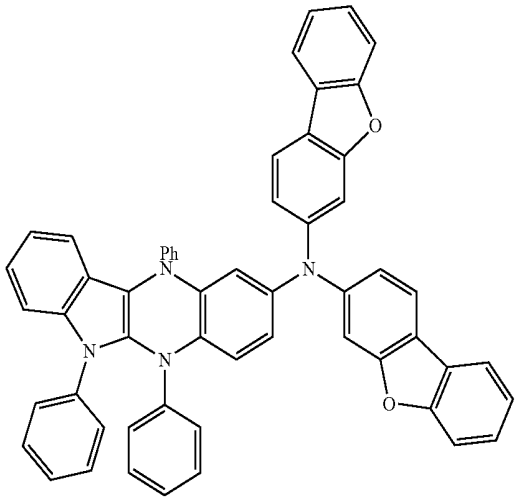


D56

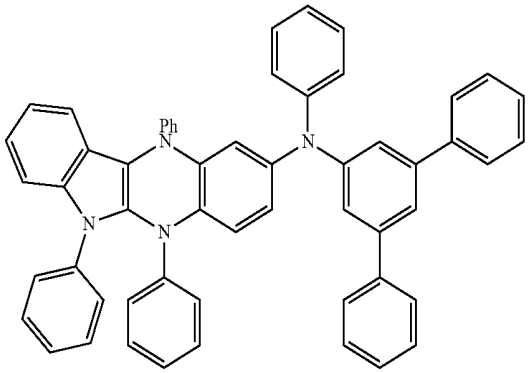


-continued

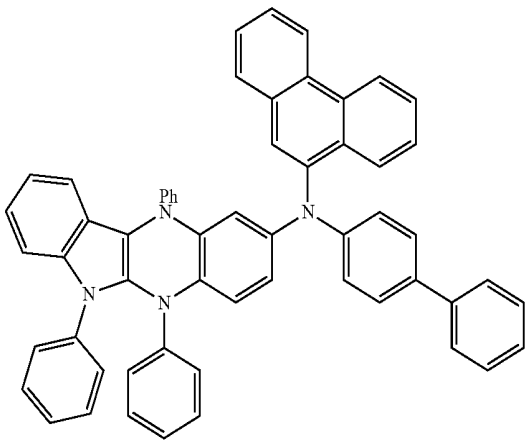
D57



D58

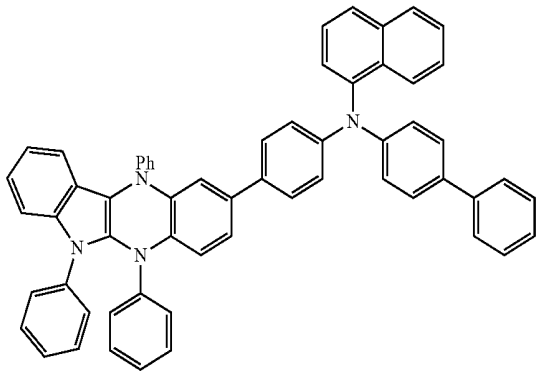


D59

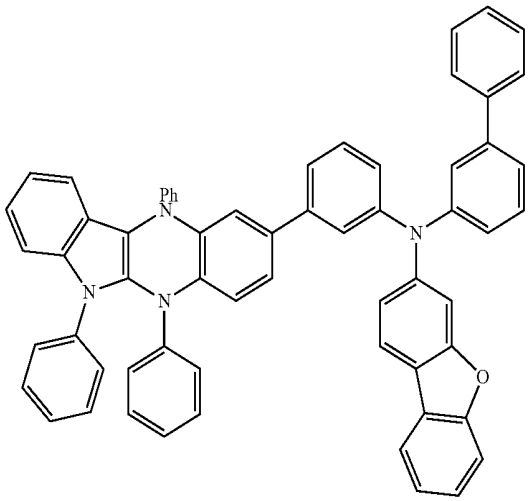


-continued

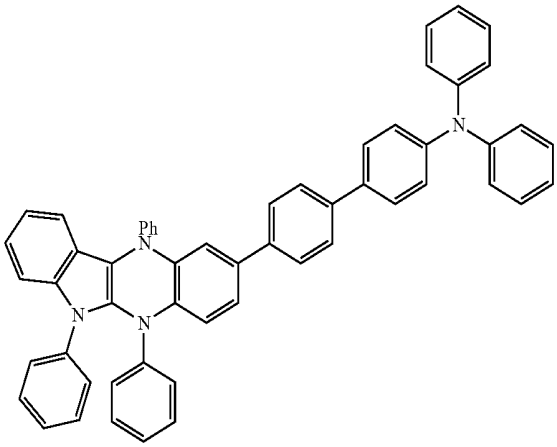
D60



D61

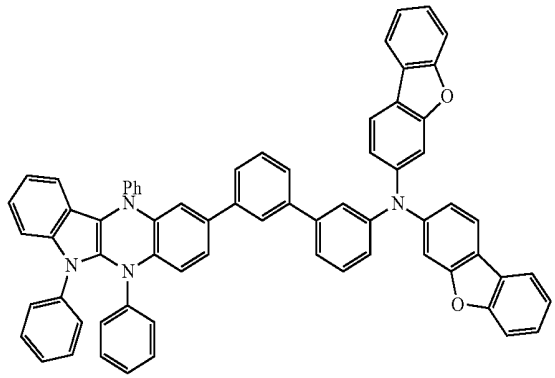


D62

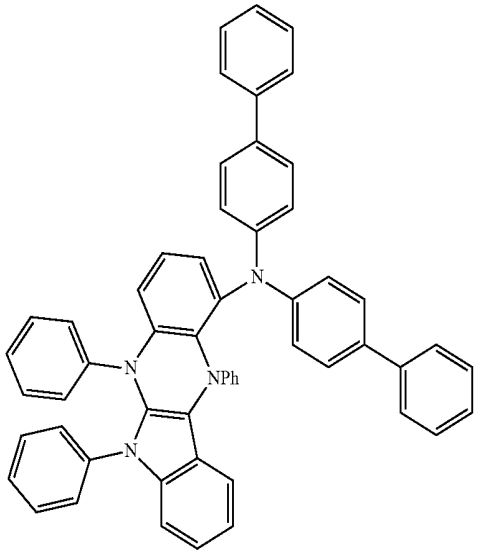


-continued

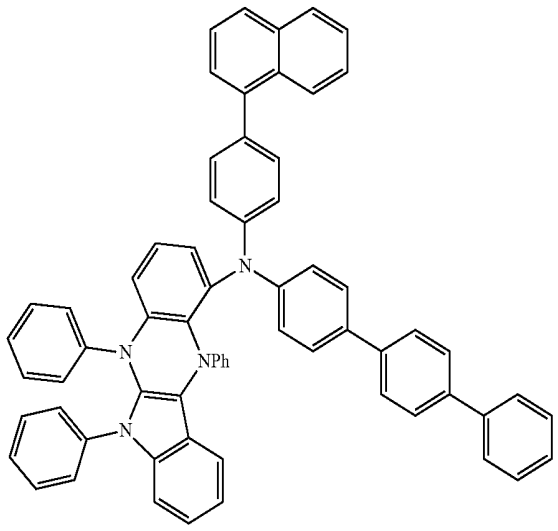
D63



D64

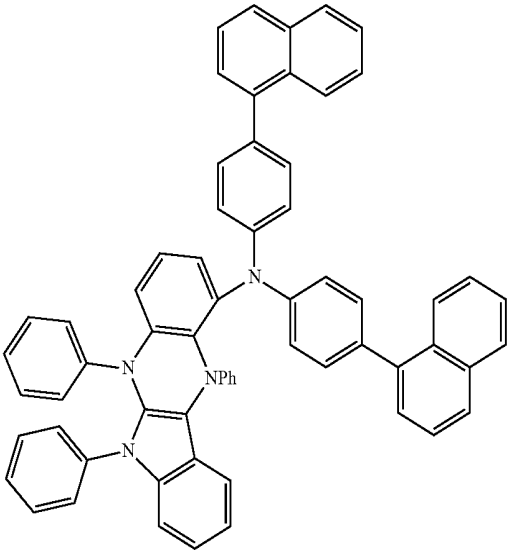


D65

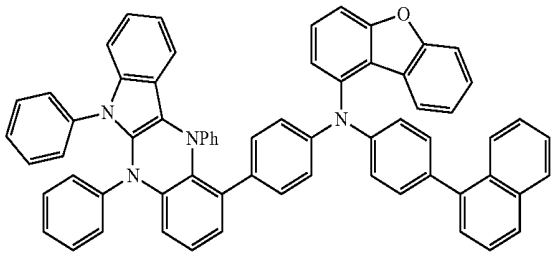


-continued

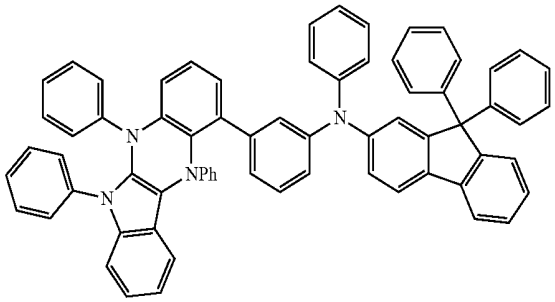
D66



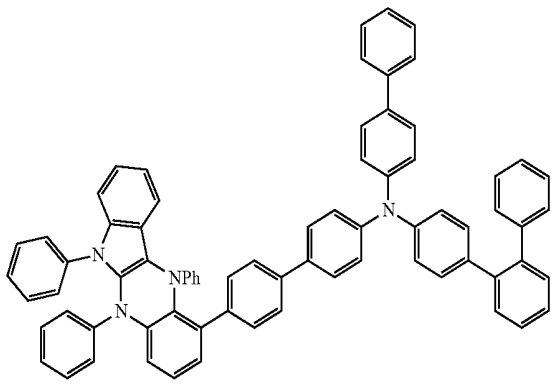
D67



D68

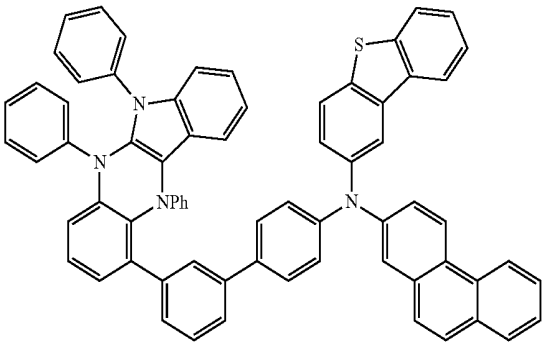


D69



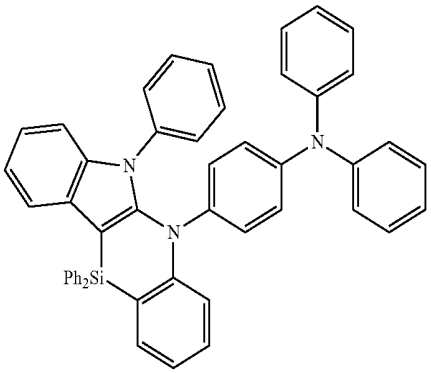
-continued

D70

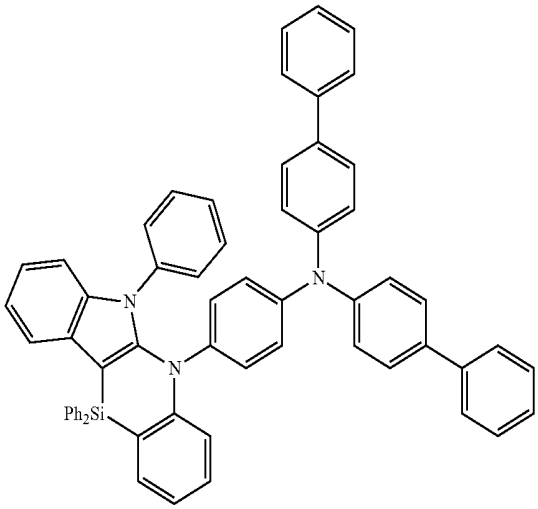


[Compound Group 5]

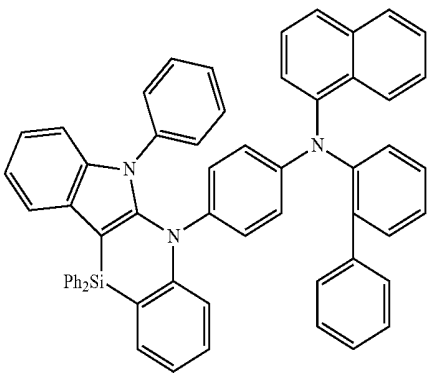
E1



E2

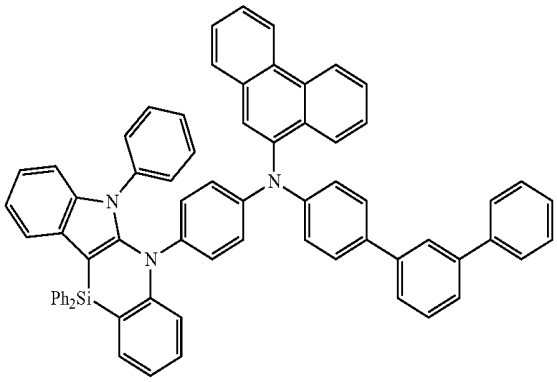


E3

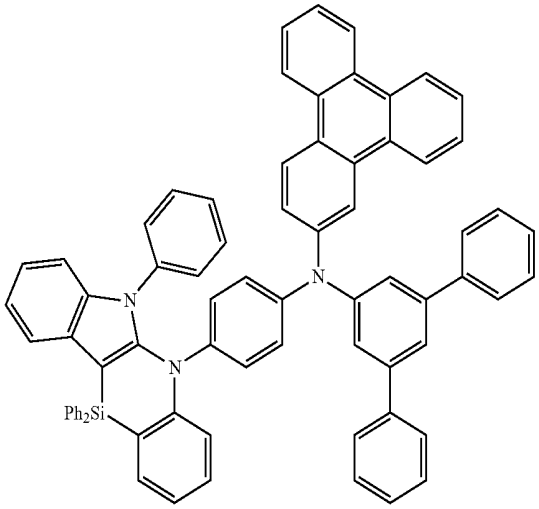


-continued

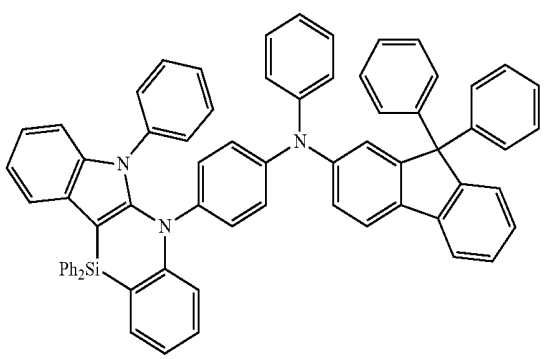
E4



E5

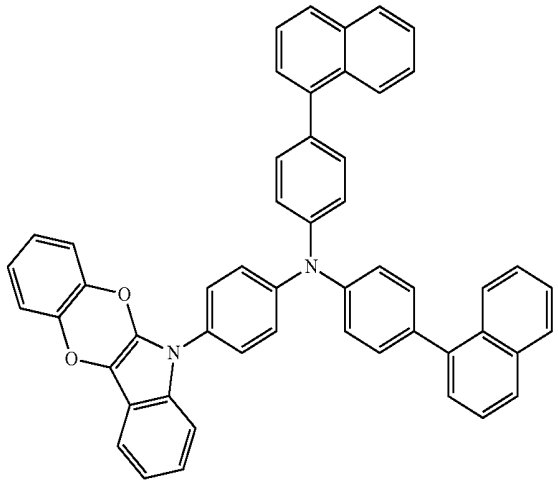


E6

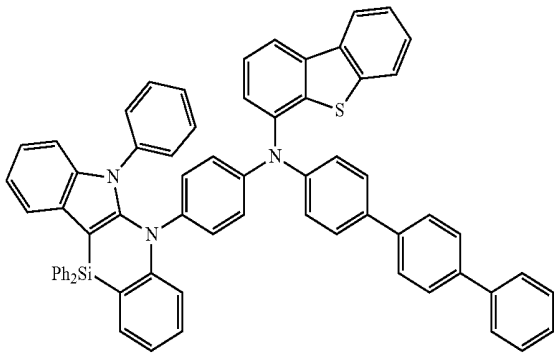


-continued

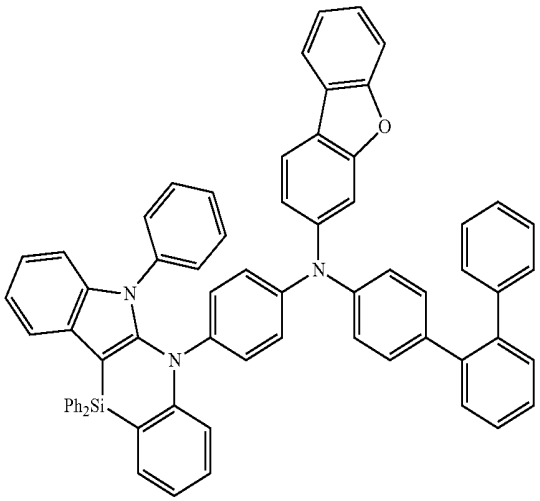
R2



E7

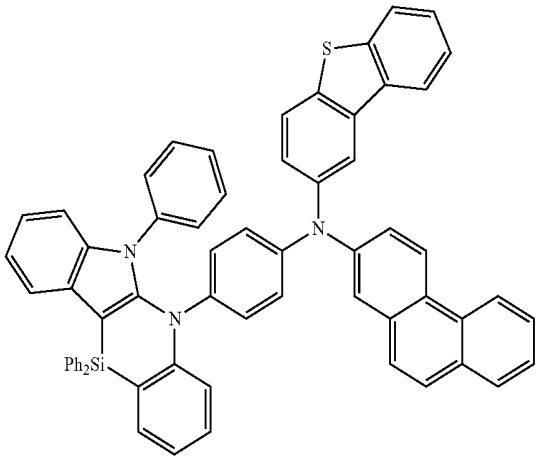


E8

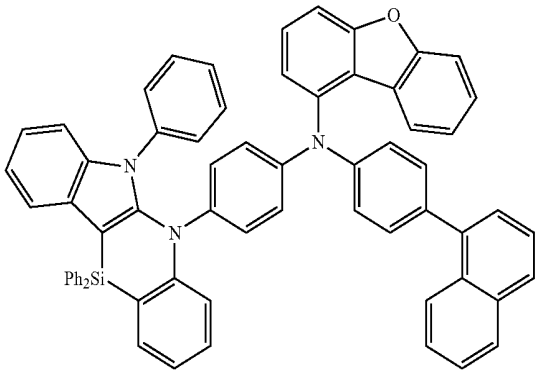


-continued

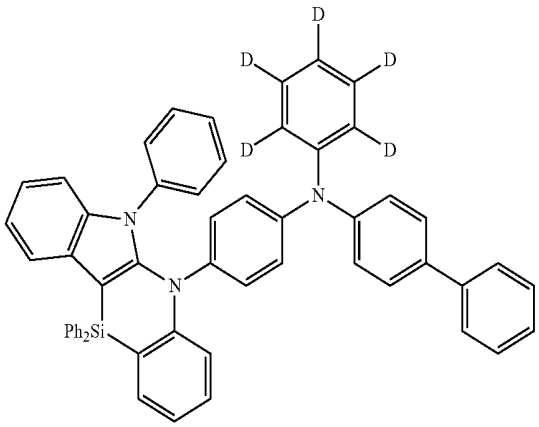
E9



E10

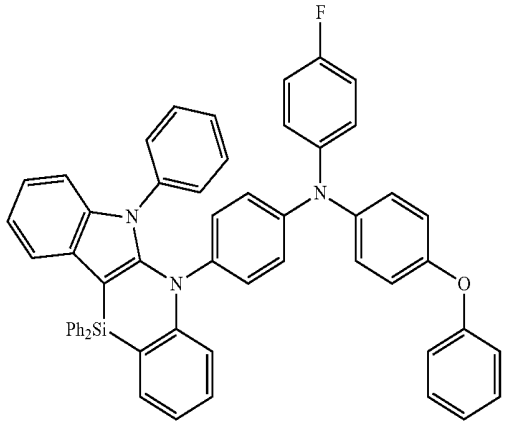


E11

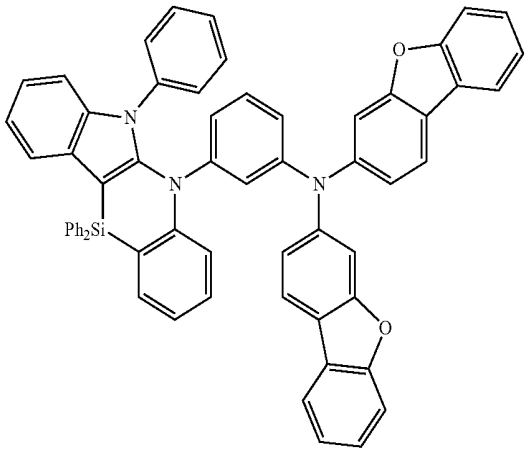


-continued

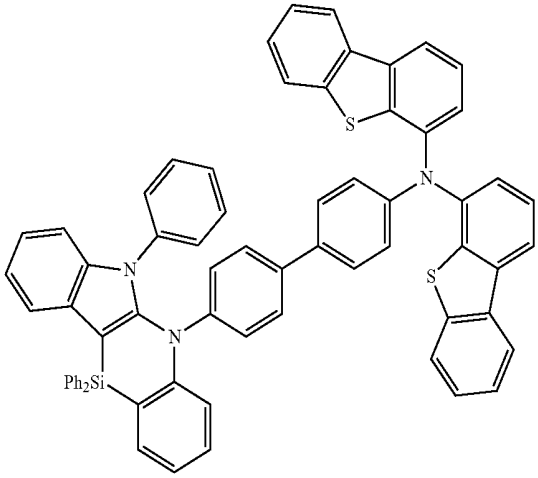
E12



E13

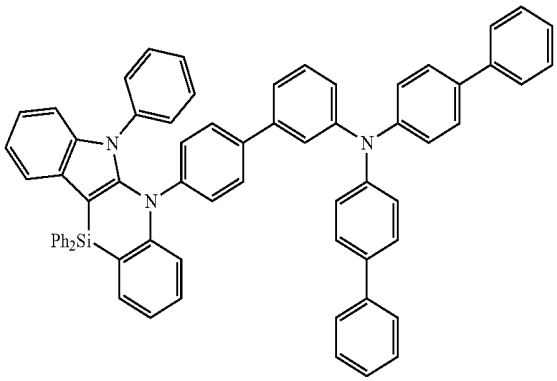


E14

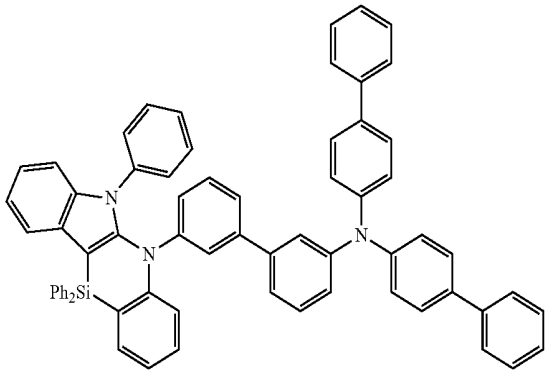


-continued

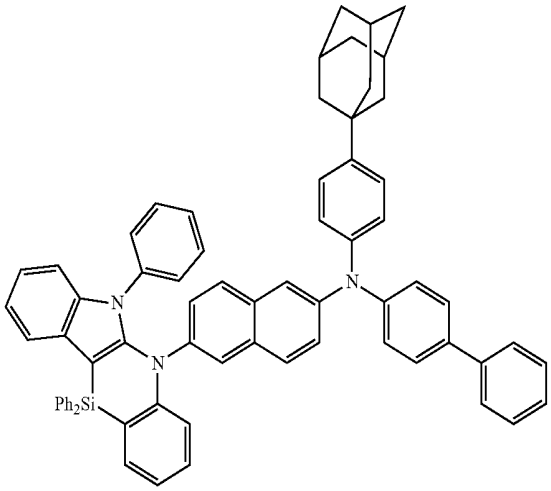
E15



E16

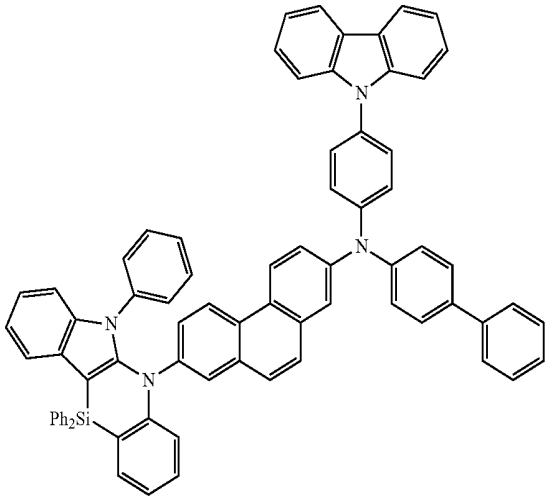


E17



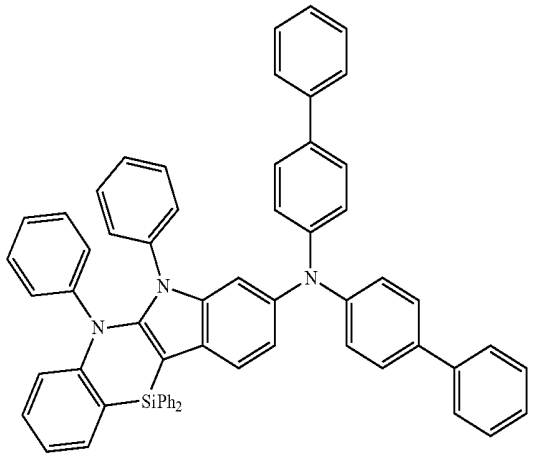
-continued

E18

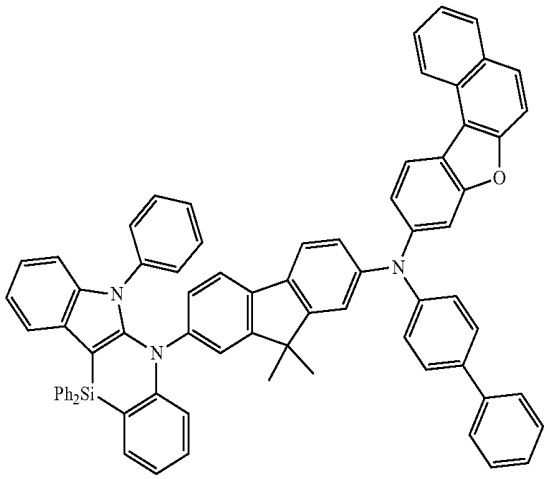


-continued

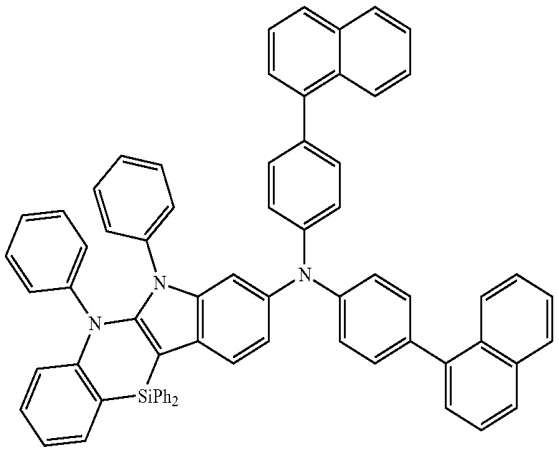
E21



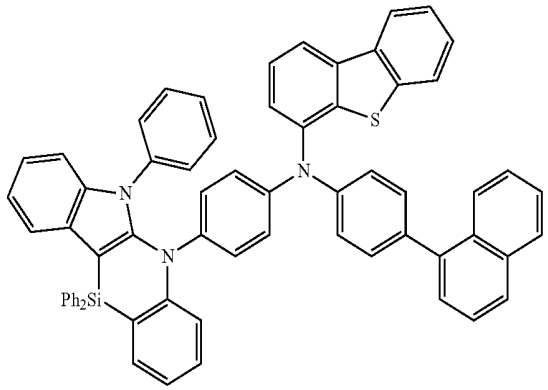
E19



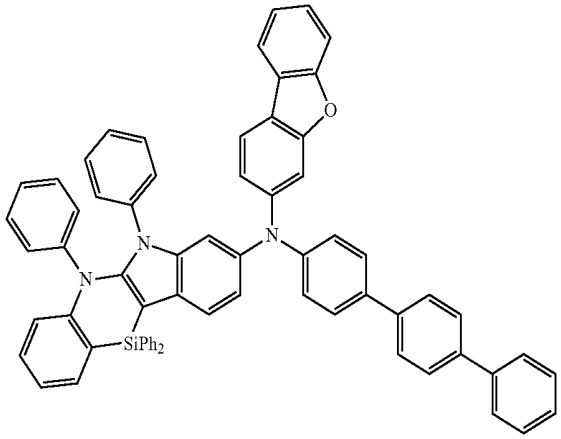
E22



E20

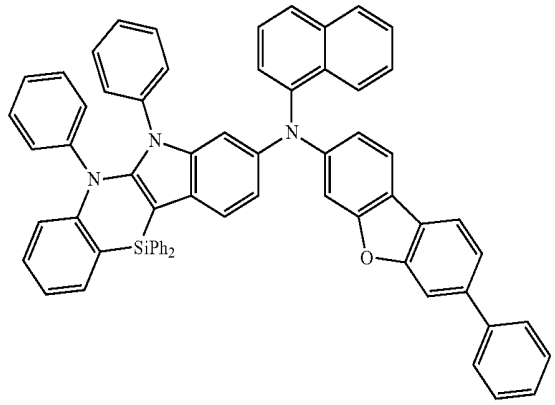


E23

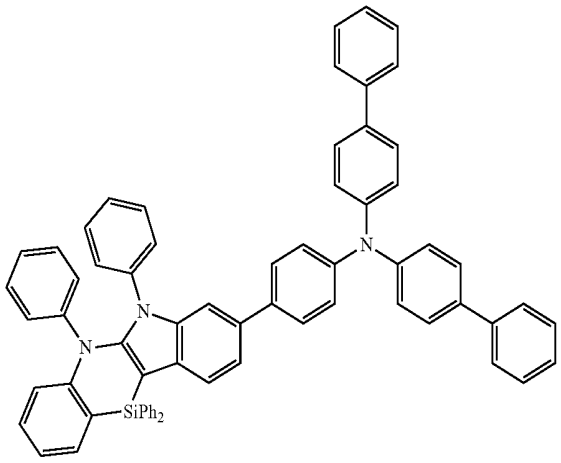


-continued

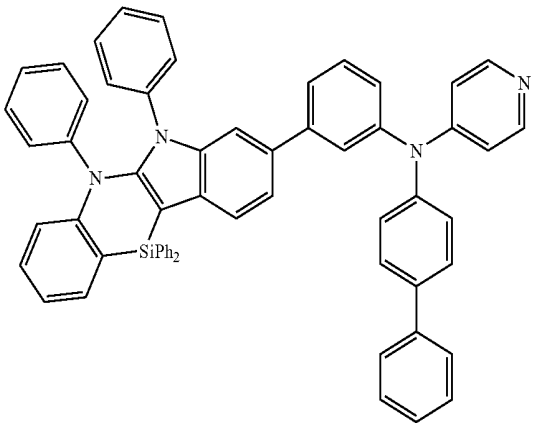
E24



E25

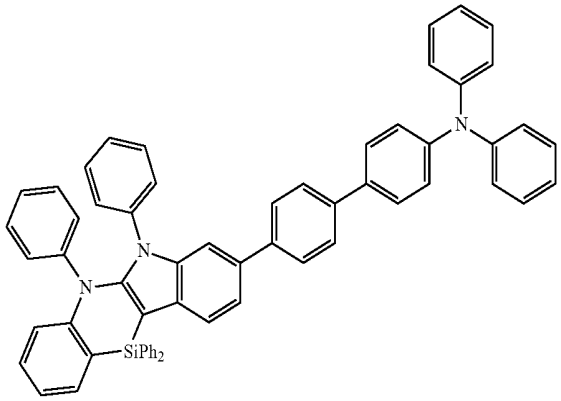


E26

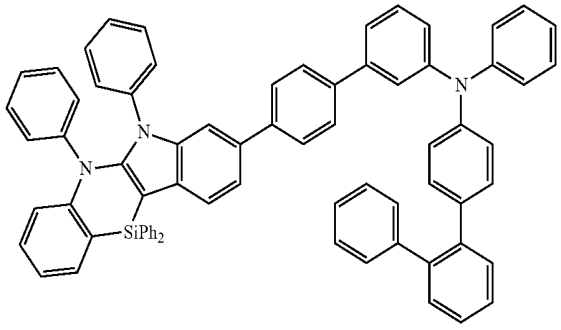


-continued

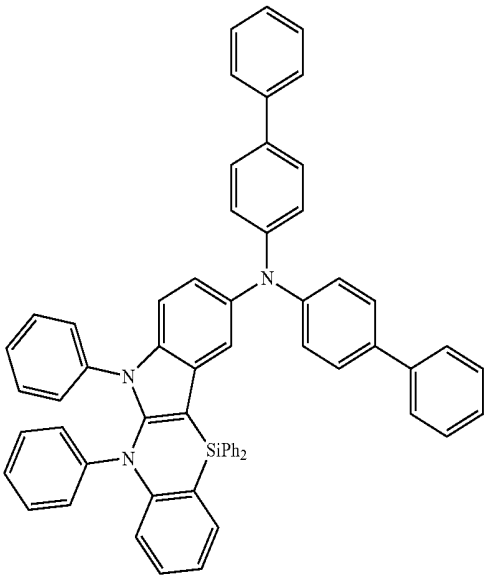
E27



E28

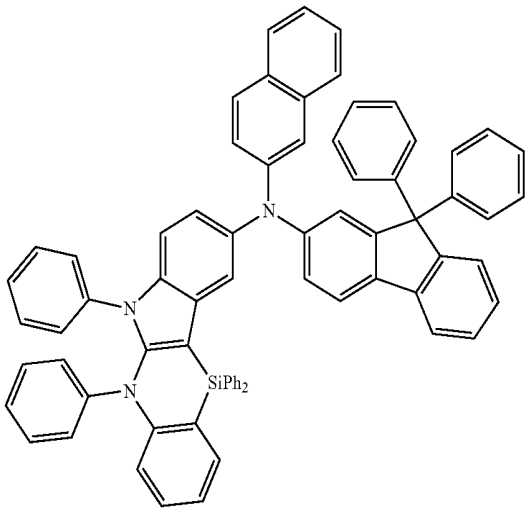


E29

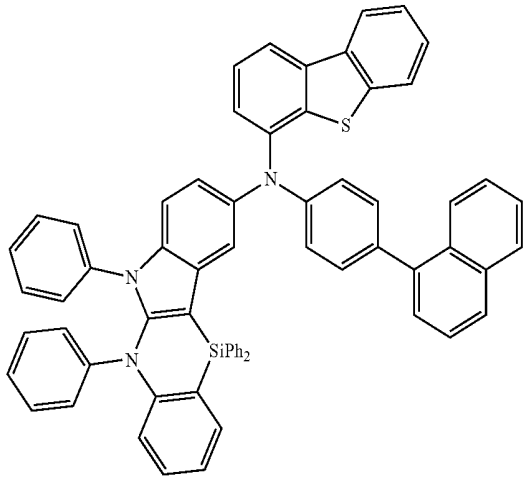


-continued

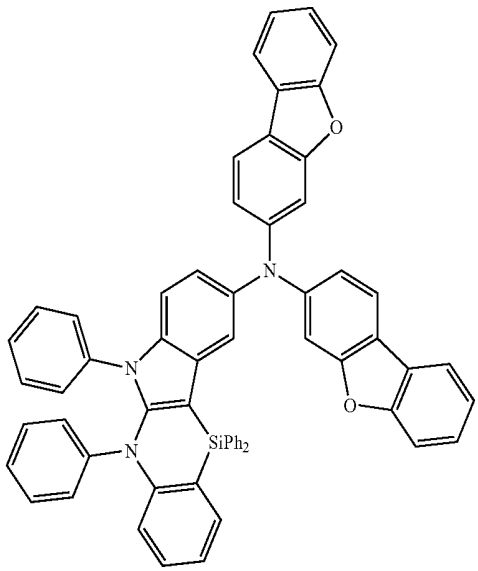
E30



E31

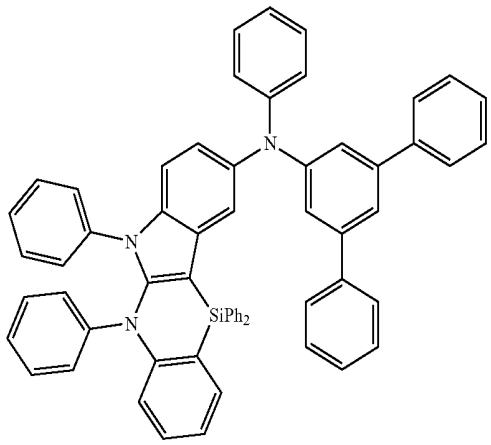


E32

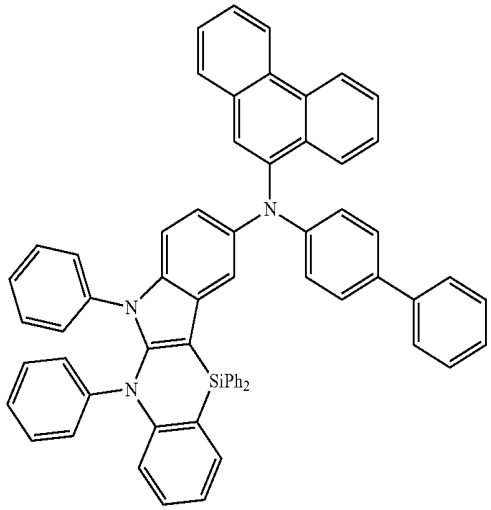


-continued

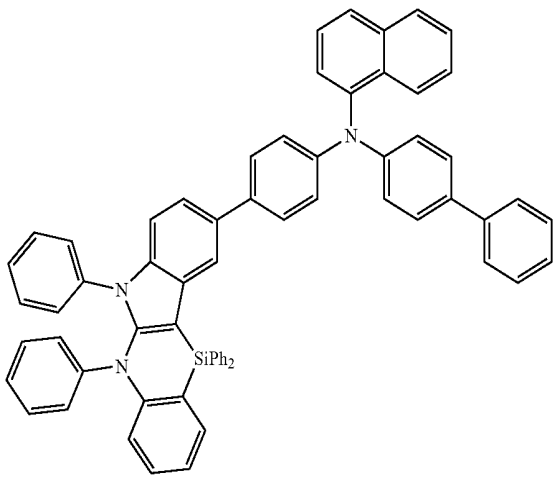
E33



E34

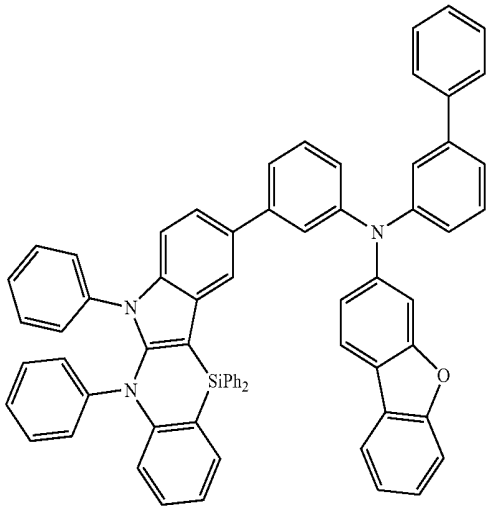


E35

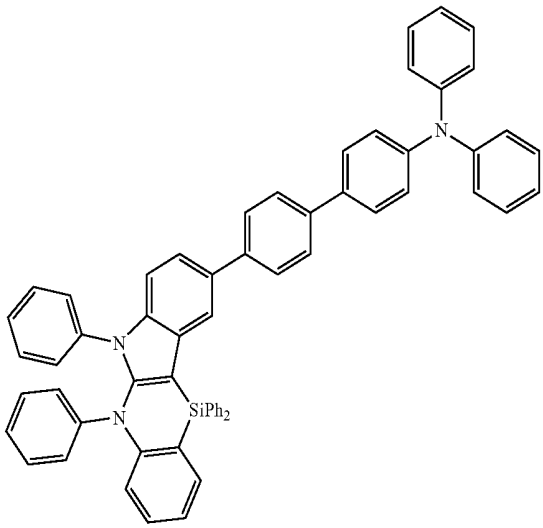


-continued

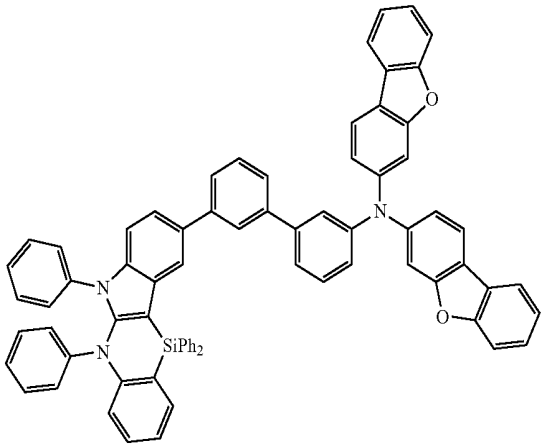
E36



E37

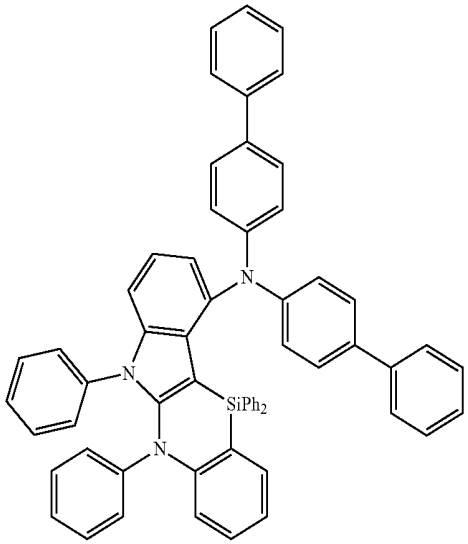


E38

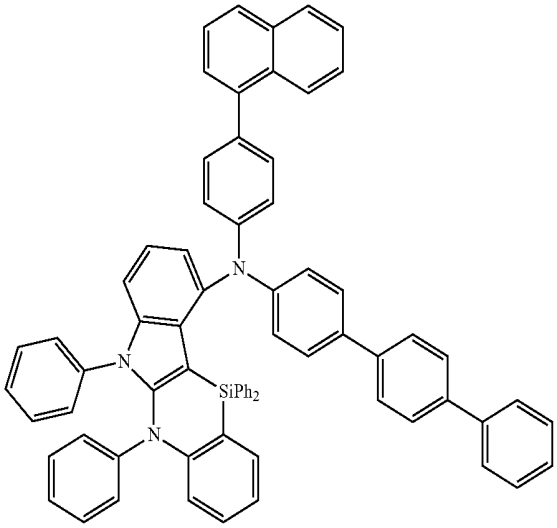


-continued

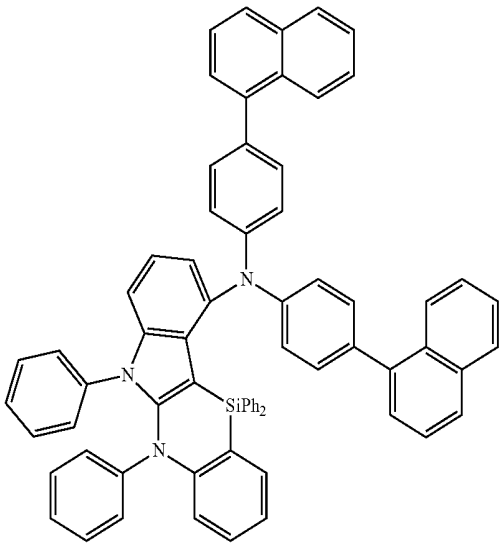
E39



E40

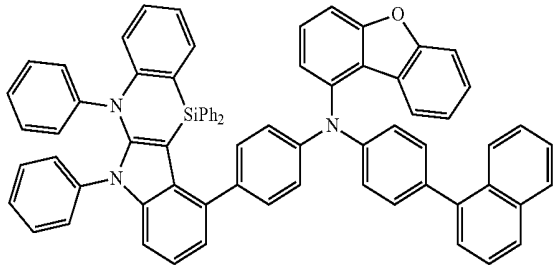


E41

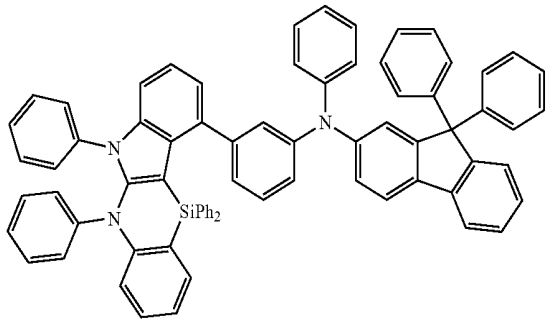


-continued

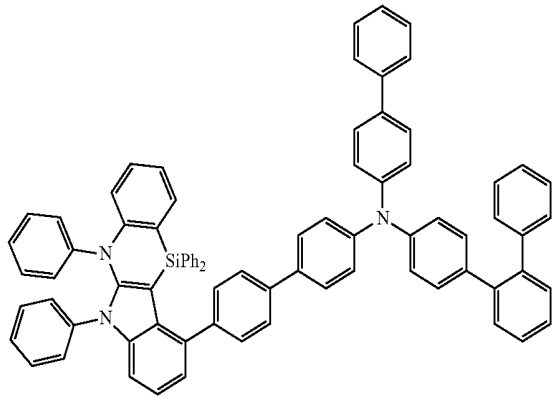
E42



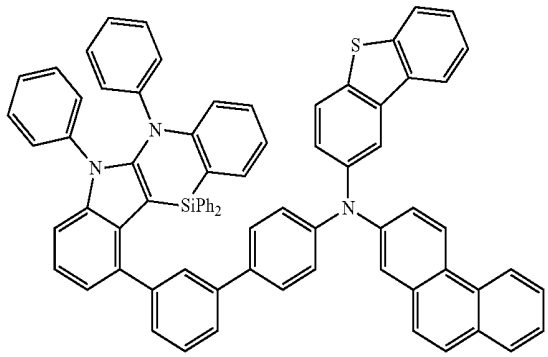
E43



E44

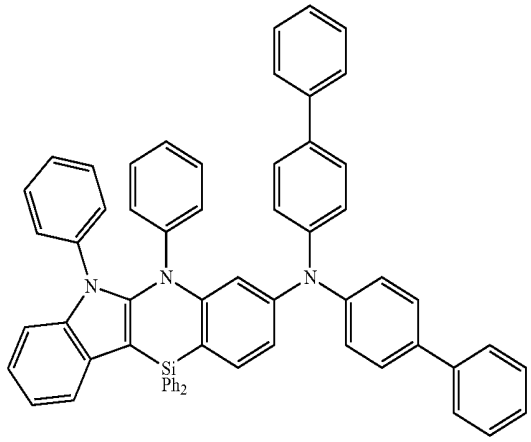


E45

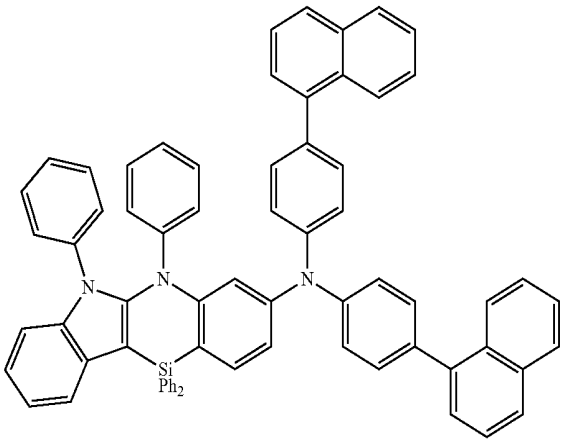


-continued

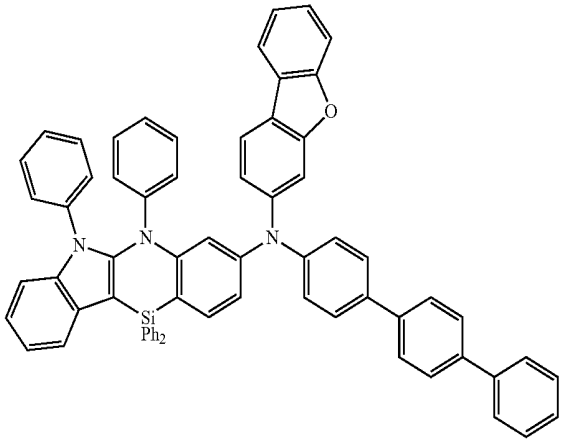
E46



E47

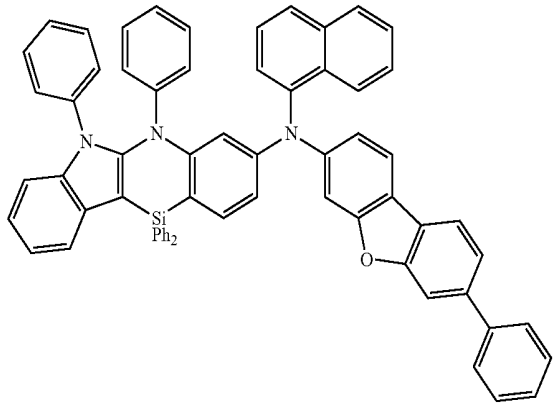


E48

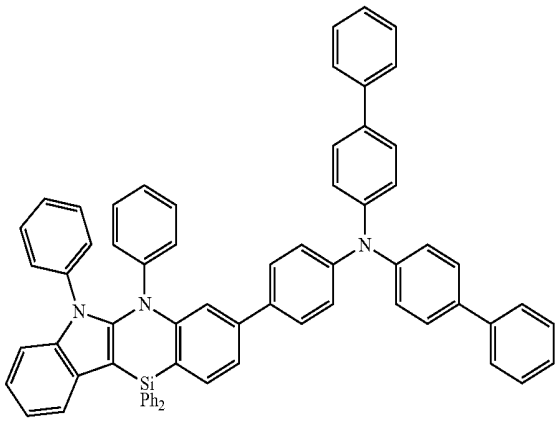


-continued

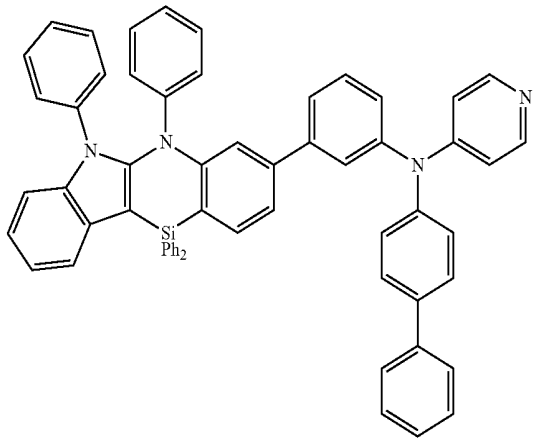
E49



E50

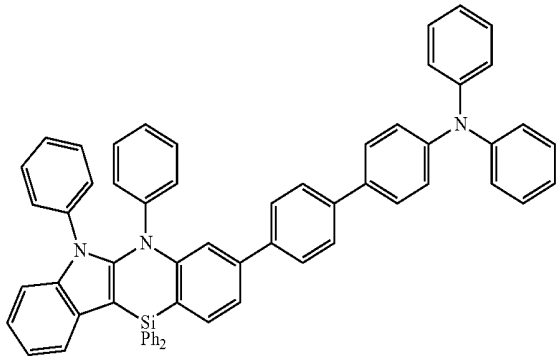


E51

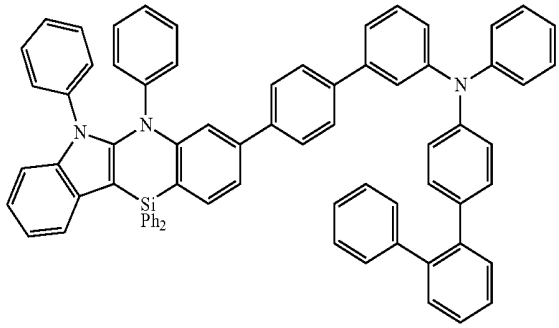


-continued

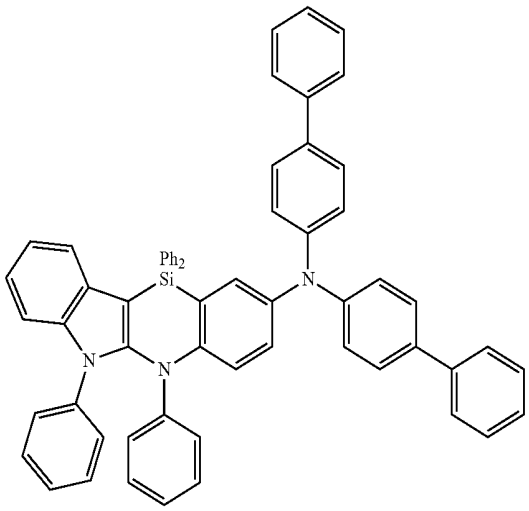
E52



E53

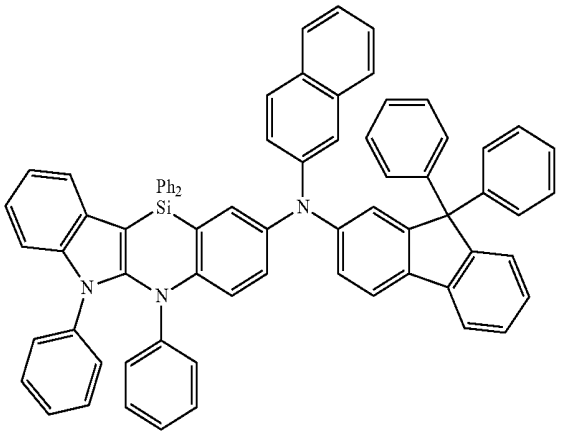


E54

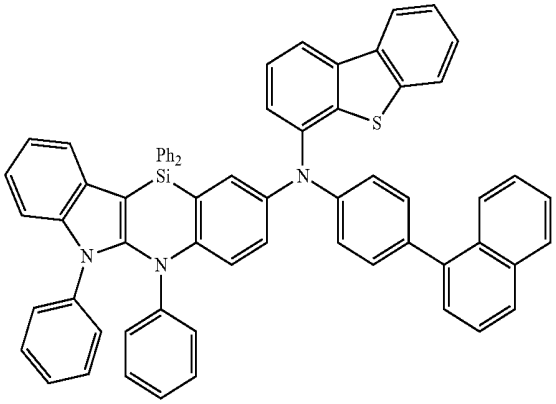


-continued

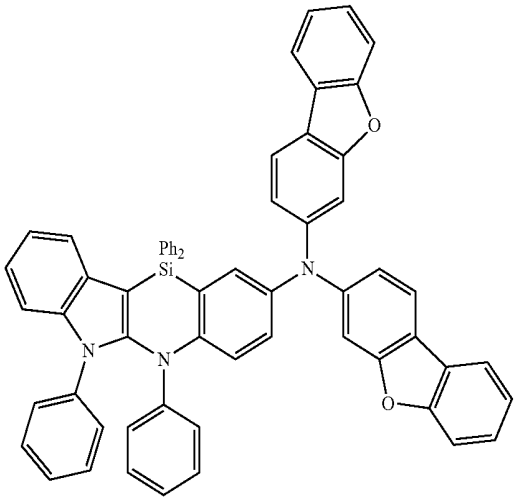
E55



E56

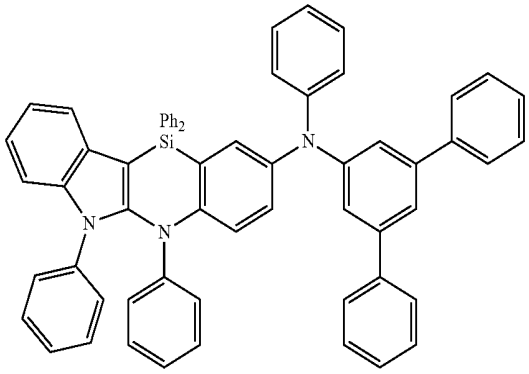


E57

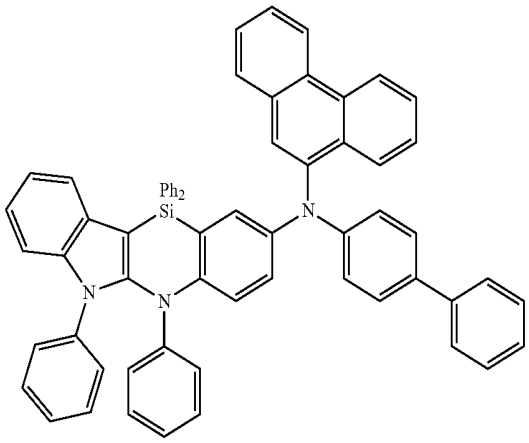


-continued

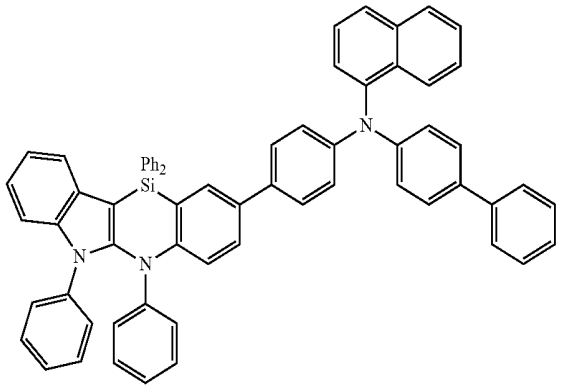
E58



E59

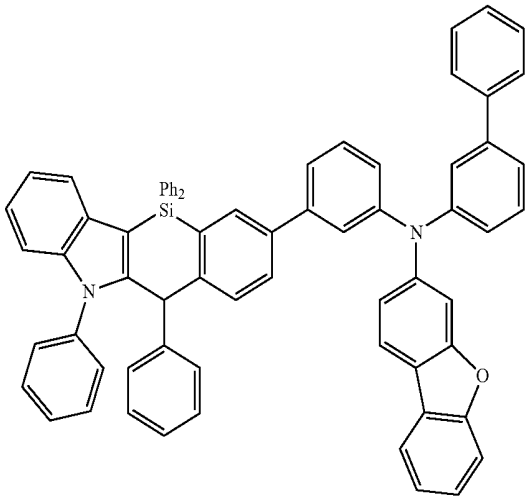


E60

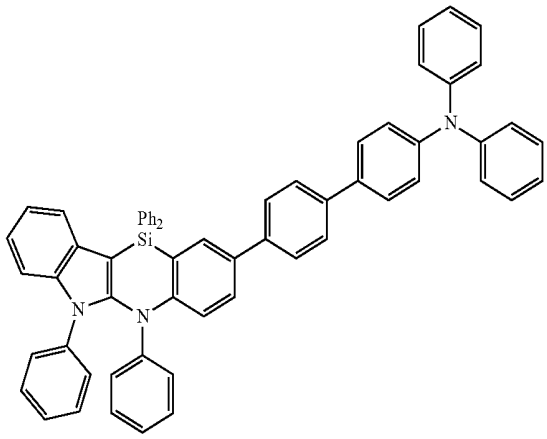


-continued

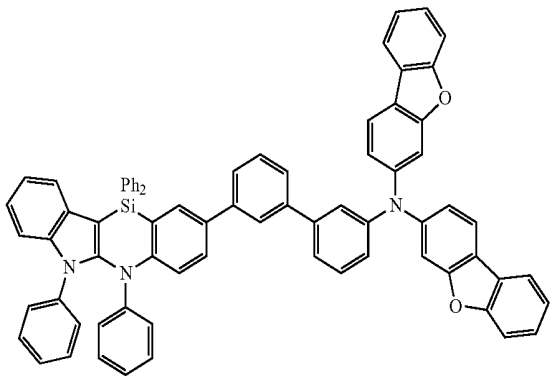
E61



E62

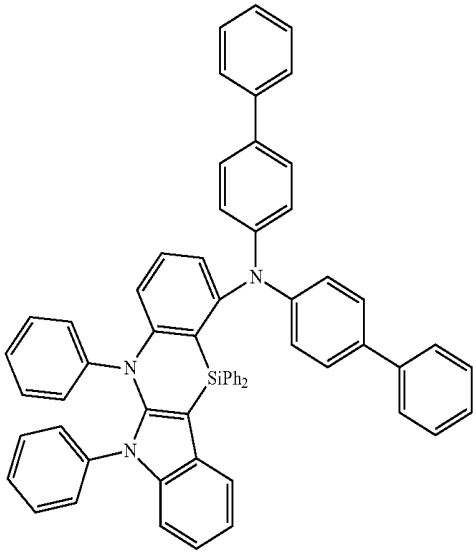


E63

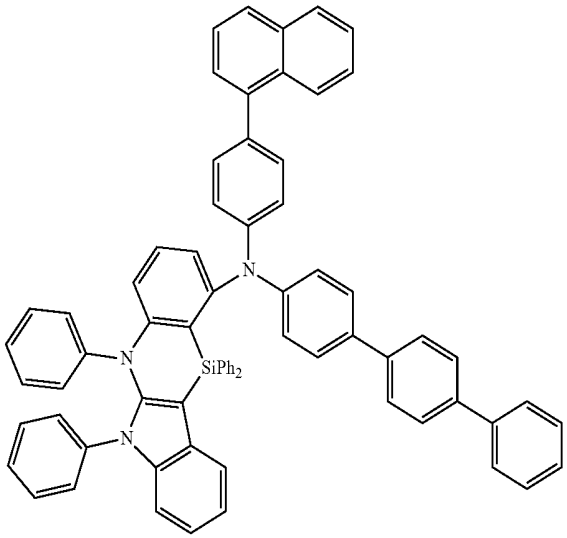


-continued

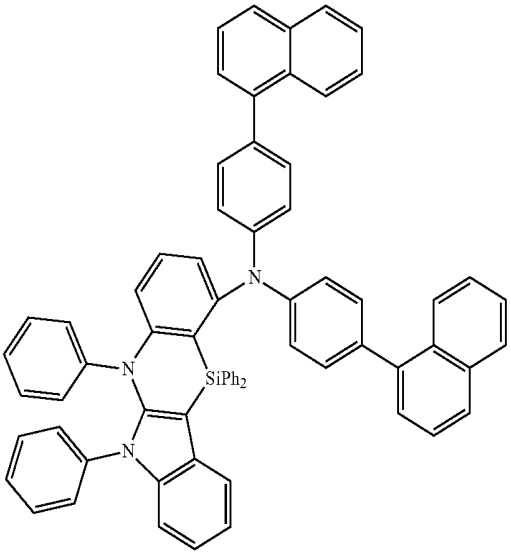
E64



E65

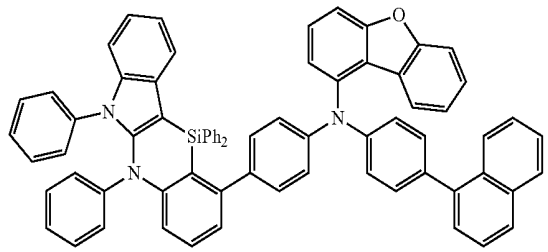


E66

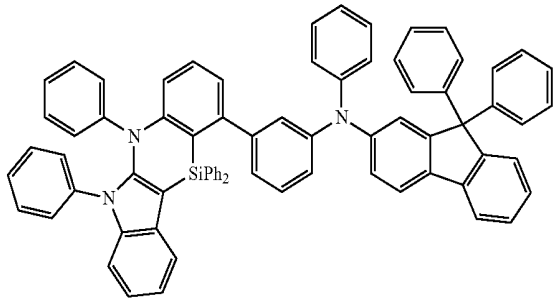


-continued

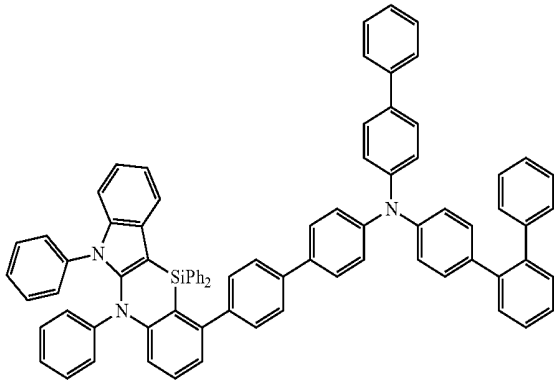
E67



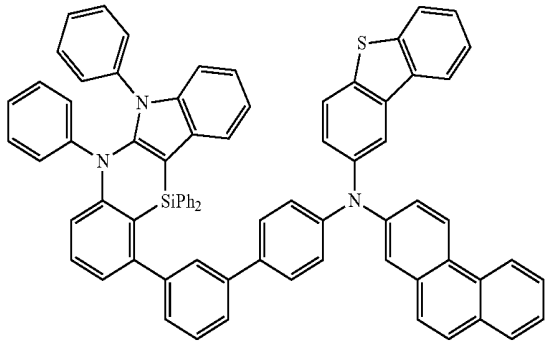
E68



E69

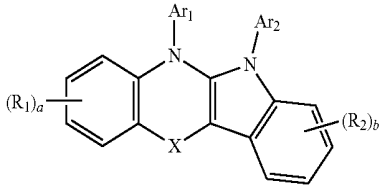


E70



15. A condensed cyclic compound represented by the following Formula 1:

[Formula 1]



wherein in Formula 1,

X is a direct linkage, O, S, NR_5, or SiR_6R_7,

each of Ar_1 and Ar_2 is independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring,

each of R_1 and R_2 is independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms,

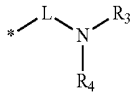
each of a and b is independently an integer of 0 to 4,

each of R_5, R_6, and R_7 is independently a substituted or unsubstituted alkyl group having 1 to 20 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring,

the substituted ones are substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted alkyl group having 1 to 40 carbon atoms, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and

any one of Ar_1, R_1 or R_2 is represented by the following Formula 2:

[Formula 2]



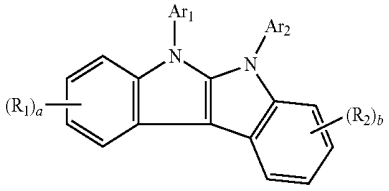
wherein in Formula 2,

L is a substituted or unsubstituted arylene group having 6 to 40 carbon atoms for forming a ring, and

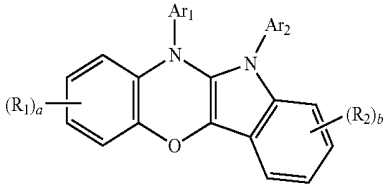
each of R_3 and R_4 is independently a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring, and the substituted ones are substituted with a hydrogen atom, a deuterium atom, a halogen atom, a cyano group, a substituted or unsubstituted cycloalkyl group having 3 to 40 carbon atoms for forming a ring, a substituted or unsubstituted aryl group having 6 to 40 carbon atoms for forming a ring, or a substituted or unsubstituted heteroaryl group having 2 to 40 carbon atoms for forming a ring.

16. The condensed cyclic compound of claim **15**, wherein Formula 1 is represented by any one of the following Formulae 1-1 to 1-5:

[Formula 1-1]

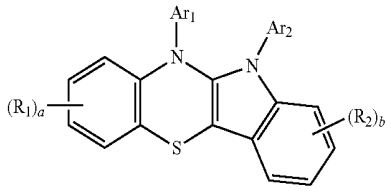


[Formula 1-2]

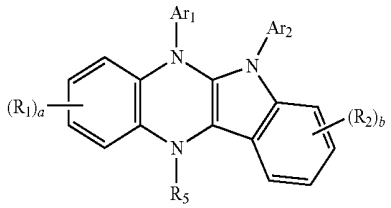


-continued

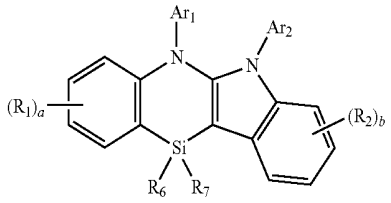
[Formula 1-3]



[Formula 1-4]



[Formula 1-5]

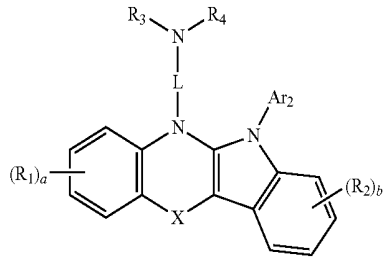


wherein in Formula 1-1 to 1-5,

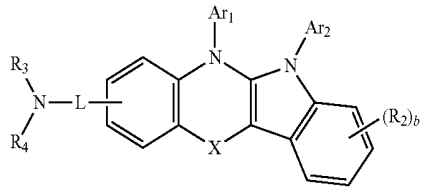
Ar_1, Ar_2, R_1, R_2, R_5 to R_7, a, and b are the same as defined in Formula 1.

17. The condensed cyclic compound of claim **15**, wherein Formula 1 is represented by any one of the following Formulae 3-1 to 3-3:

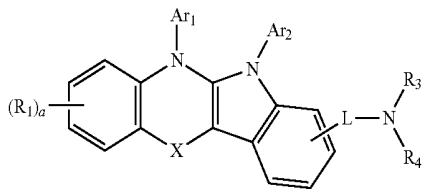
[Formula 3-1]



[Formula 3-2]



[Formula 3-3]



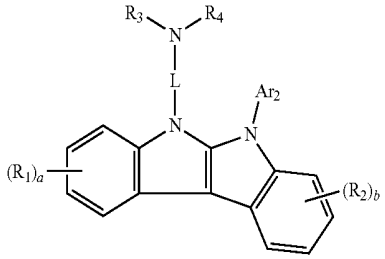
wherein in Formula 3-1 to 3-3,

X, Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formulae 1 and 2.

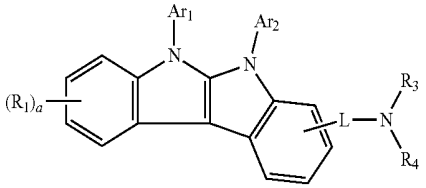
18. The condensed cyclic compound of claim **15**, wherein the compound represented by Formula 1 is a hole transport material.

19. The condensed cyclic compound of claim **16**, wherein Formula 1-1 is represented by the following Formula 4-1 or 4-2:

[Formula 4-1]



[Formula 4-2]

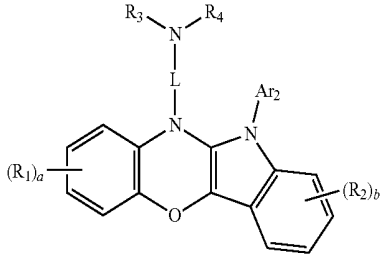


wherein in Formula 4-1 and 4-2,

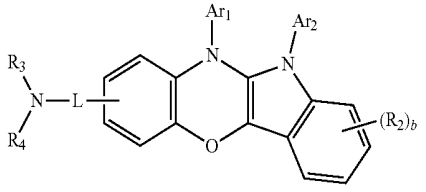
Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formulae 1 and 2.

20. The condensed cyclic compound of claim **16**, wherein Formula 1-2 is represented by any one of the following Formulae 5-1 to 5-3:

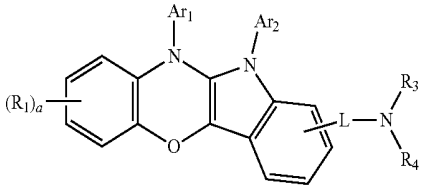
[Formula 5-1]



[Formula 5-2]



[Formula 5-3]

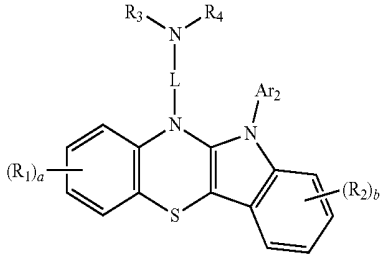


wherein in Formula 5-1 to 5-3,

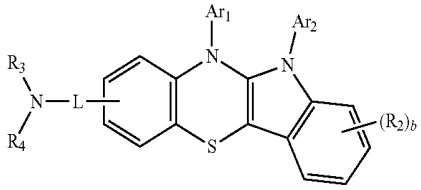
Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formulae 1 and 2.

21. The condensed cyclic compound of claim **16**, wherein Formula 1-3 is represented by any one of the following Formulae 6-1 to 6-3:

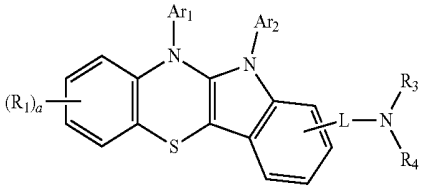
[Formula 6-1]



[Formula 6-2]



[Formula 6-3]

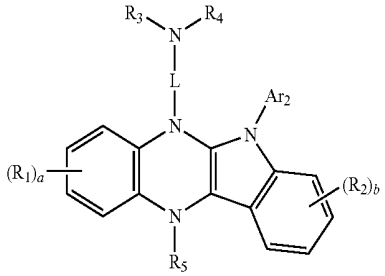


wherein in Formula 6-1 to 6-3,

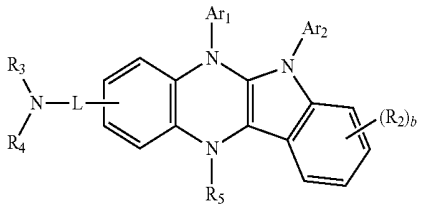
Ar_1, Ar_2, R_1 to R_4, L, a, and b are the same as defined in Formulae 1 and 2.

22. The condensed cyclic compound of claim **16**, wherein Formula 1-4 is represented by any one of the following Formulae 7-1 to 7-3:

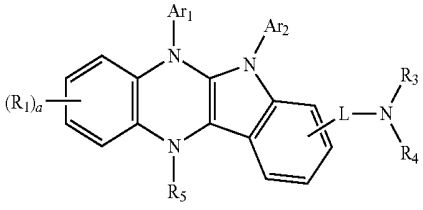
[Formula 7-1]



[Formula 7-2]



[Formula 7-3]

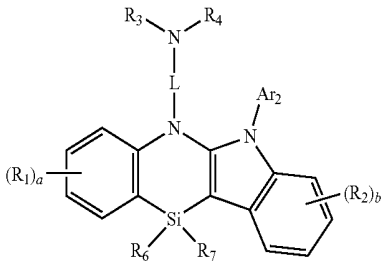


wherein in Formula 7-1 to 7-3,

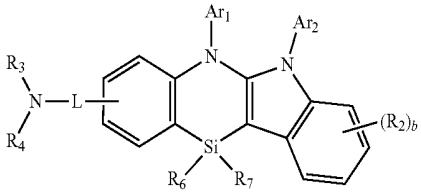
Ar_1, Ar_2, R_1 to R_5, L, a, and b are the same as defined in Formulae 1 and 2.

23. The condensed cyclic compound of claim **16**, wherein Formula 1-5 is represented by any one of the following Formulae 8-1 to 8-3:

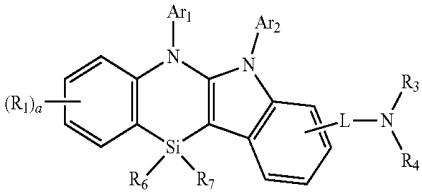
[Formula 8-1]



[Formula 8-2]



[Formula 8-3]



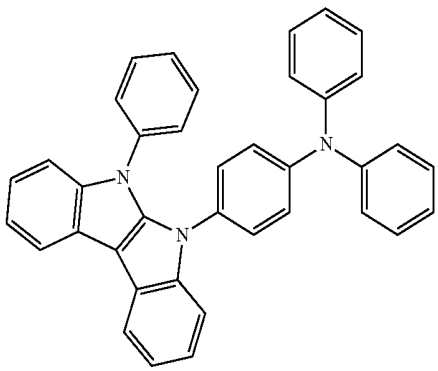
wherein in Formula 8-1 to 8-3,

Ar_1, Ar_2, R_1 to R_4, R_6, R_7, L, a, and b are the same as defined in Formulae 1 and 2.

24. The condensed cyclic compound of claim **15**, wherein the compound represented by Formula 1 is any one selected from the group consisting of compounds represented in following Compound Groups 1 to 5:

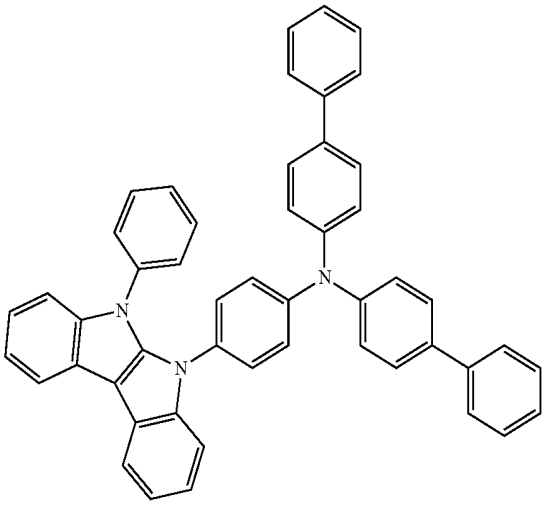
[Compound Group 1]

A1

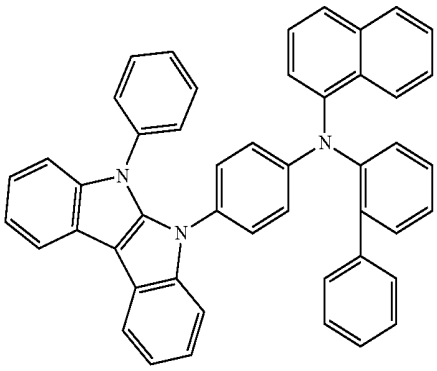


-continued

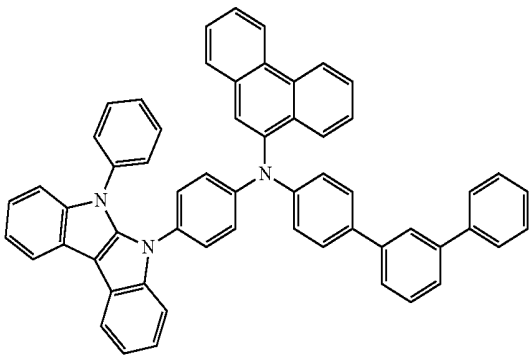
A2



A3

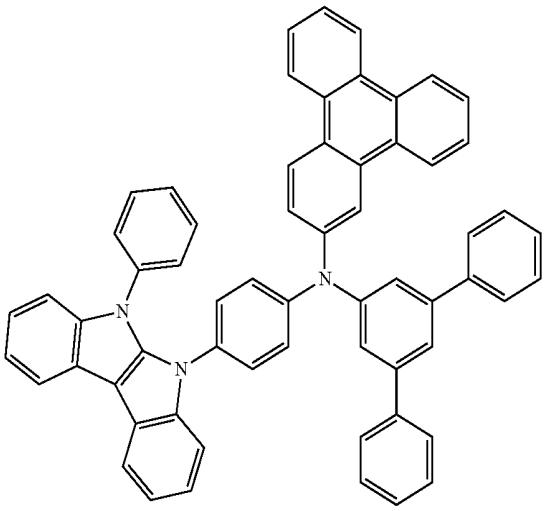


A4

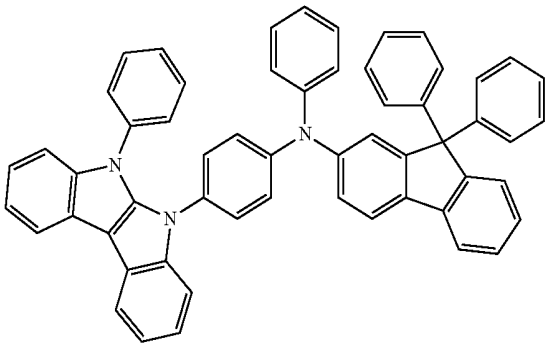


-continued

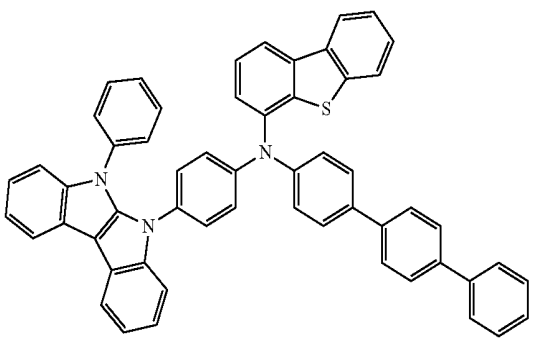
A5



A6

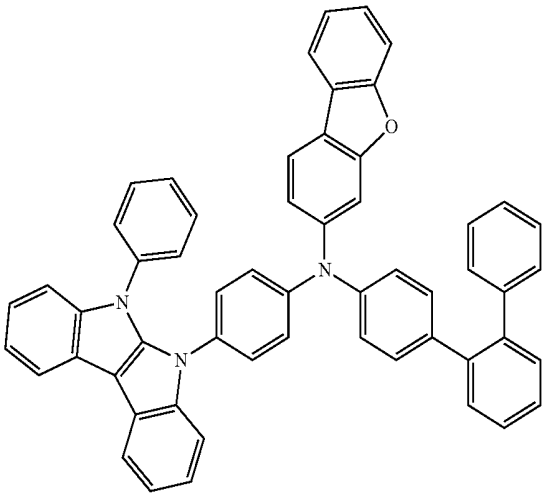


A7

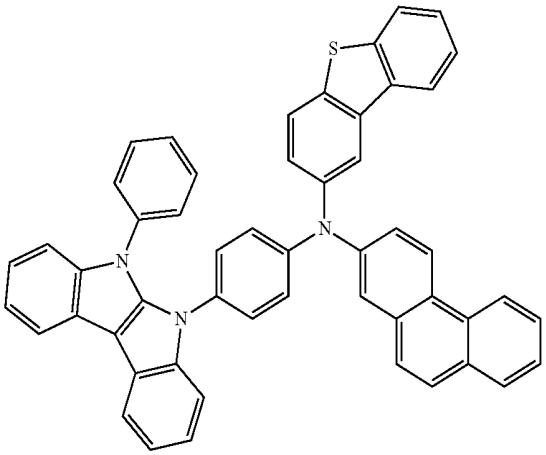


-continued

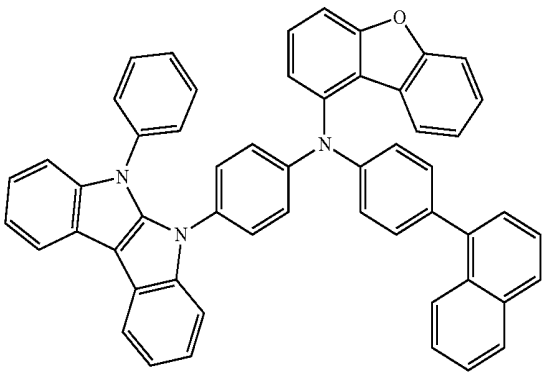
A8



A9

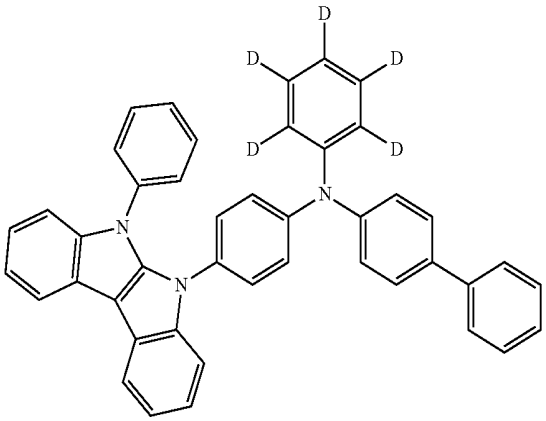


A10

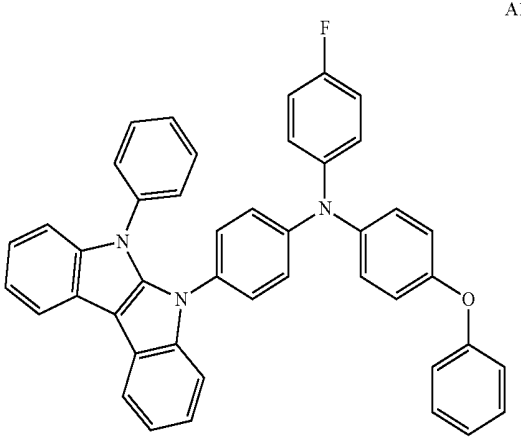


-continued

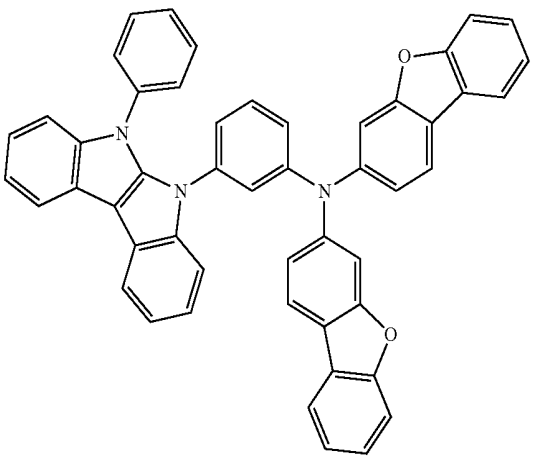
A11



A12

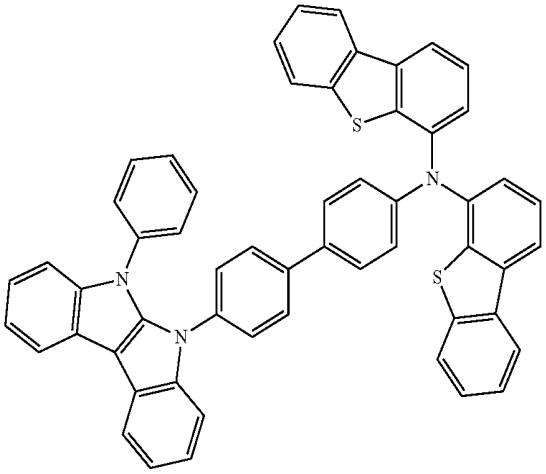


A13

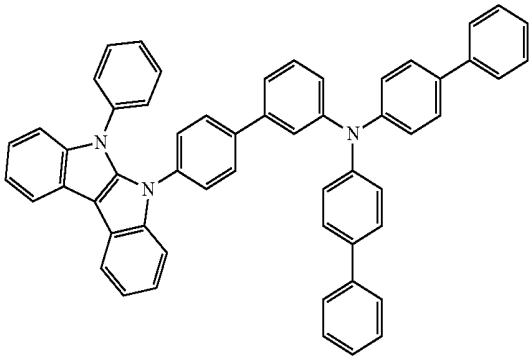


-continued

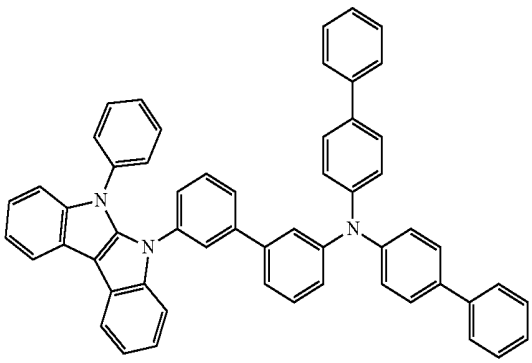
A14



A15

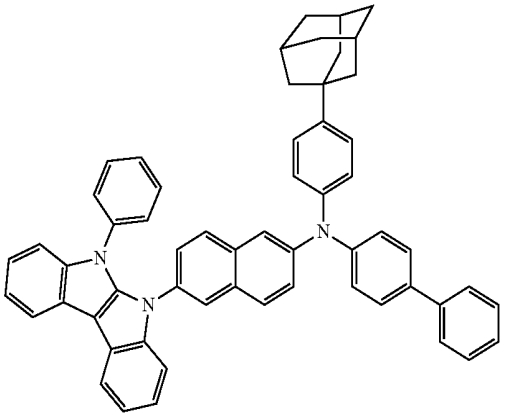


A16

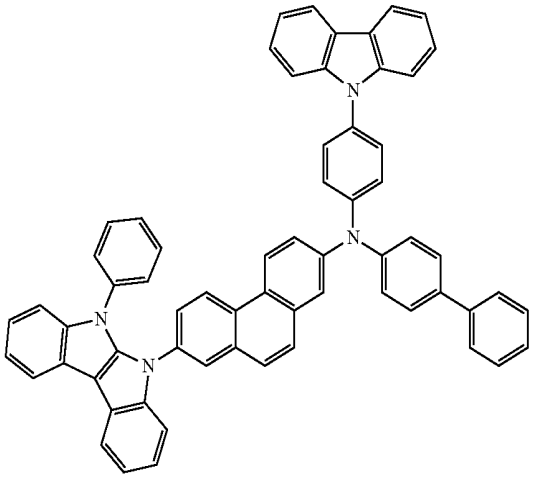


-continued

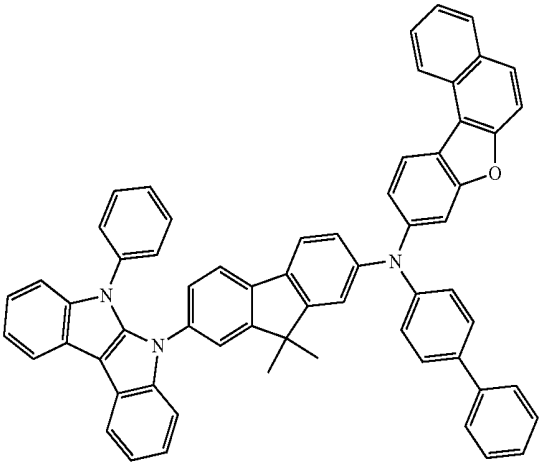
A17



A18

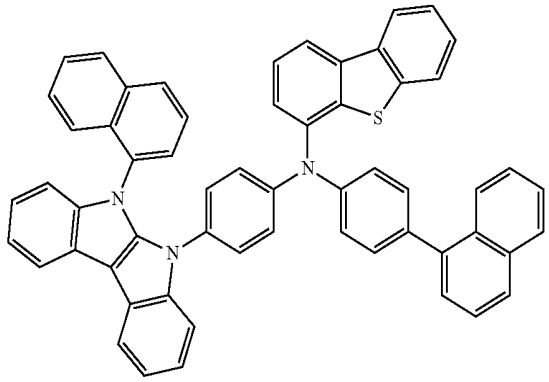


A19

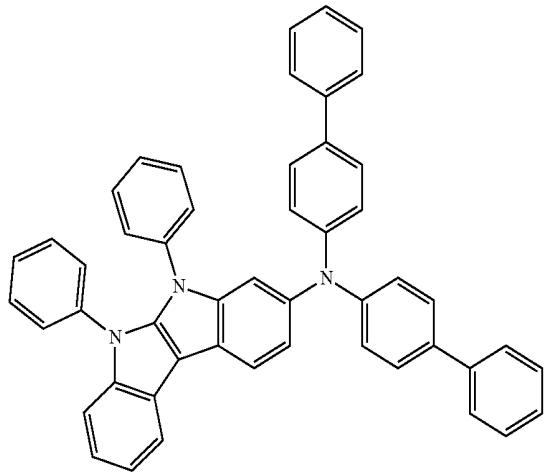


-continued

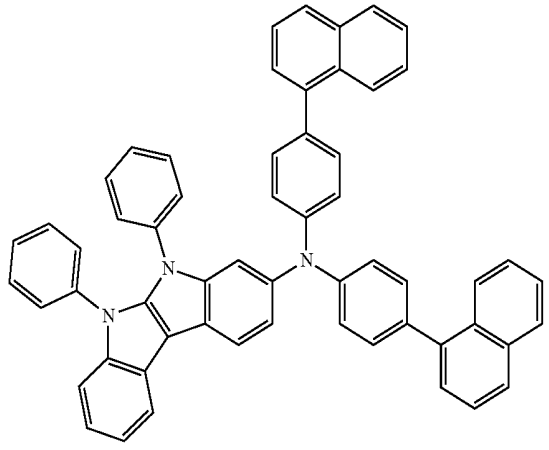
A20



A21

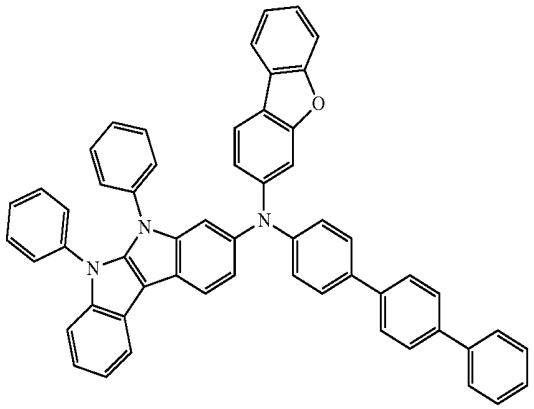


A22

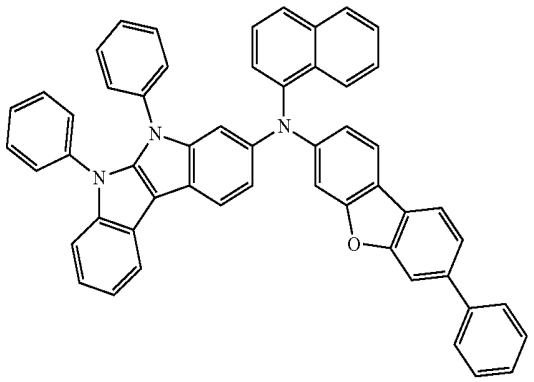


-continued

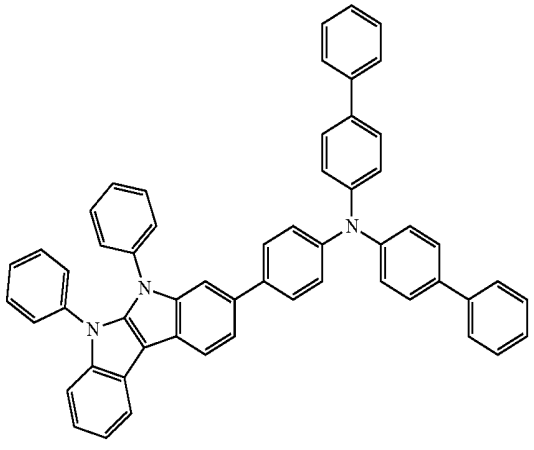
A23



A24

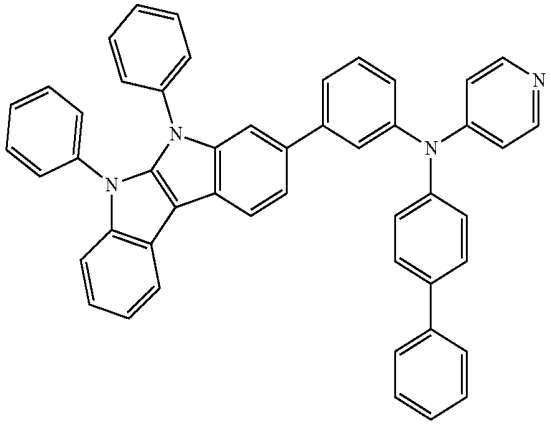


A25

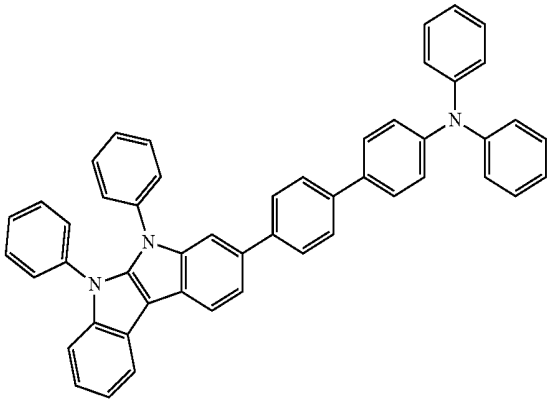


-continued

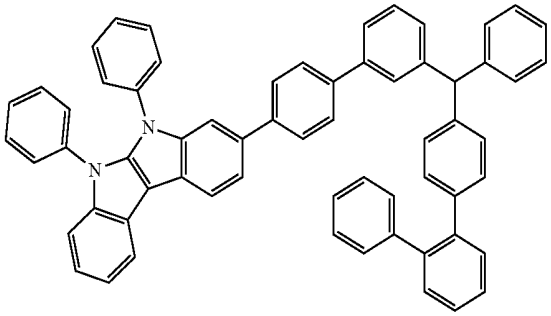
A26



A27

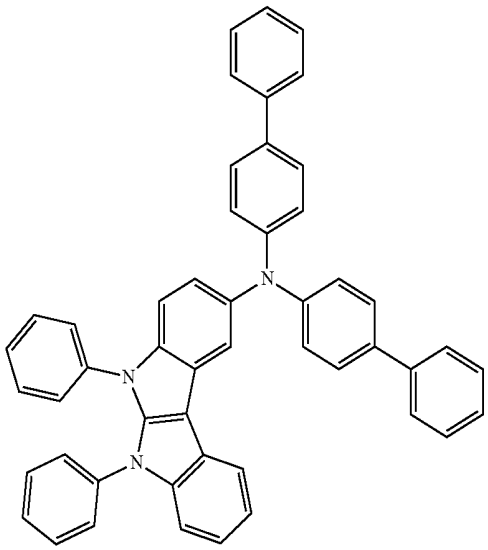


A28

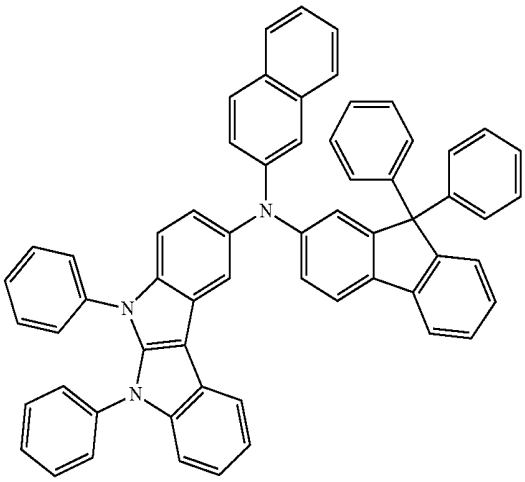


-continued

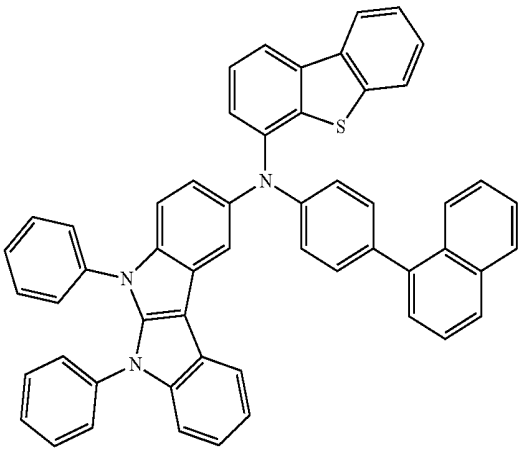
A29



A30

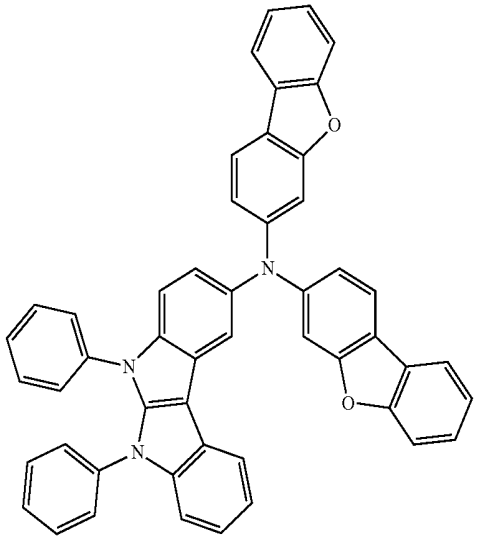


A31

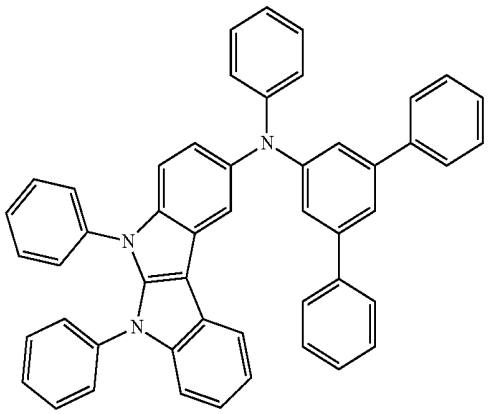


-continued

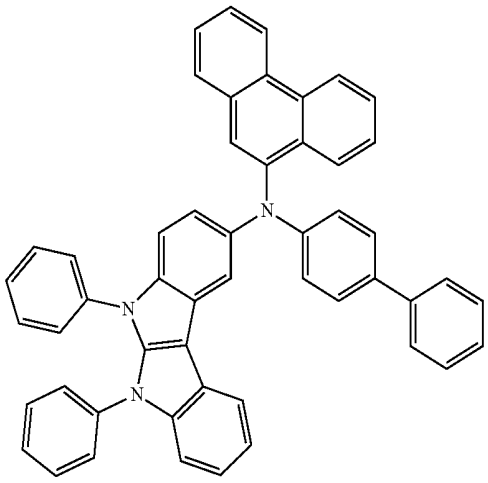
A32



A33

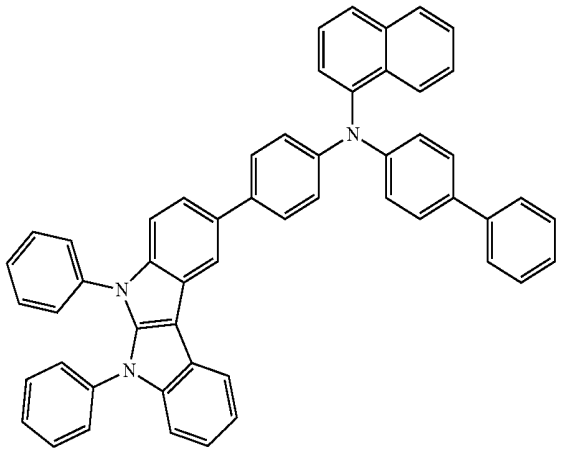


A34

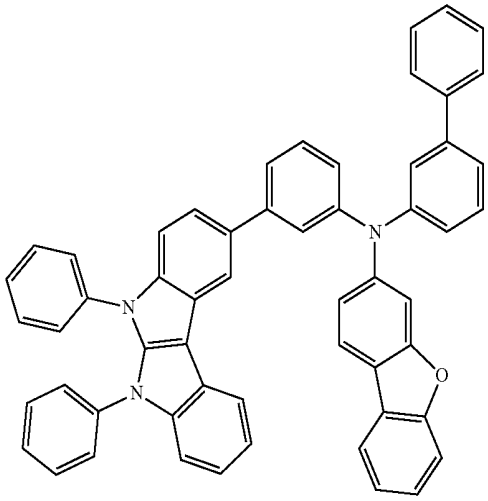


-continued

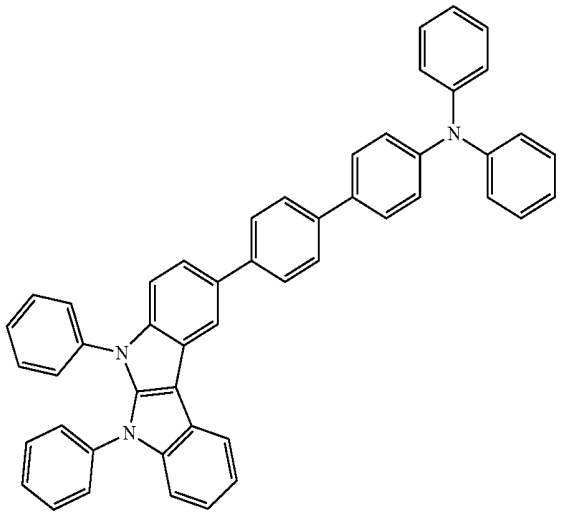
A35



A36

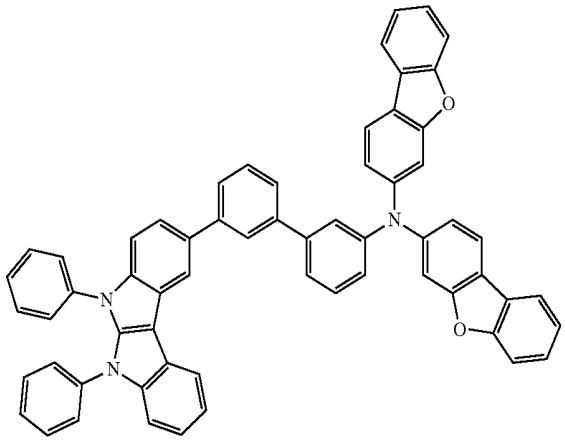


A37

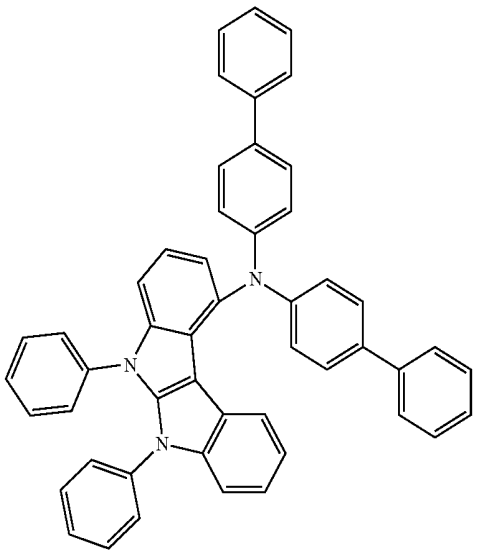


-continued

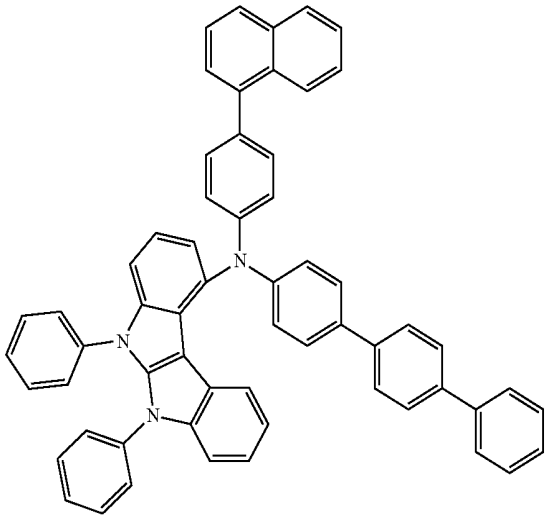
A38



A39

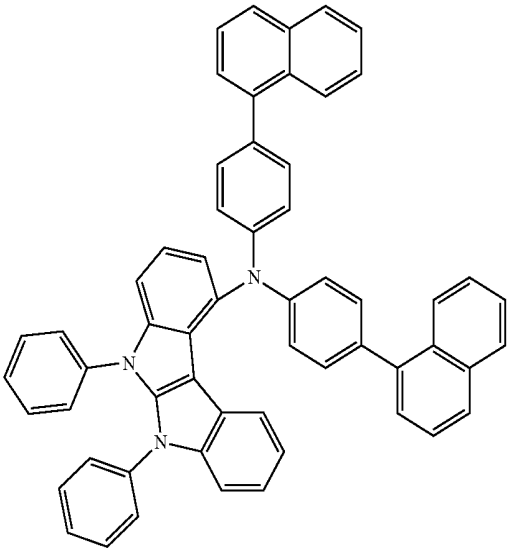


A40

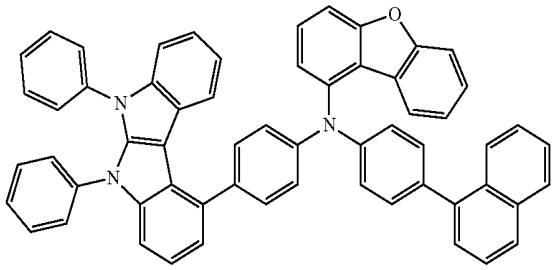


-continued

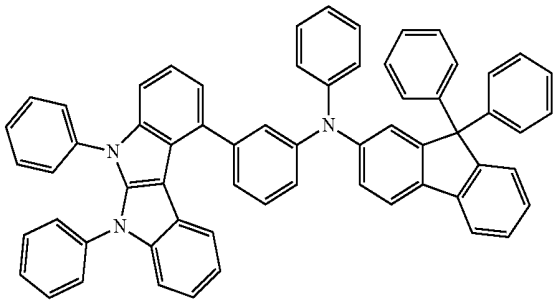
A41



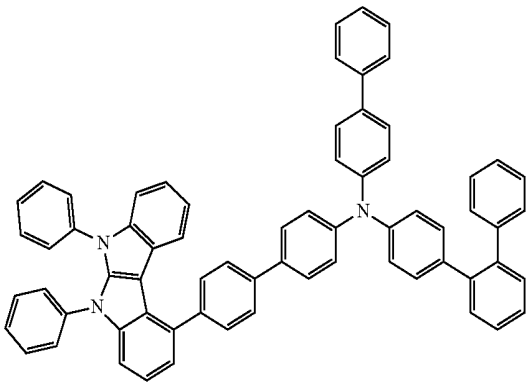
A42



A43

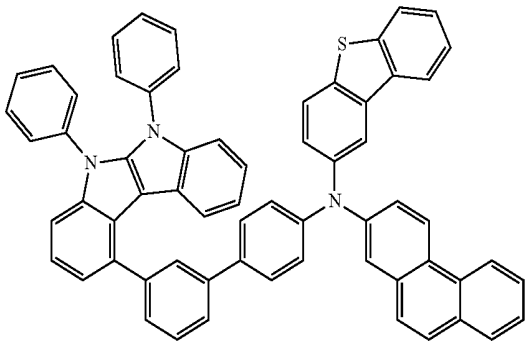


A44

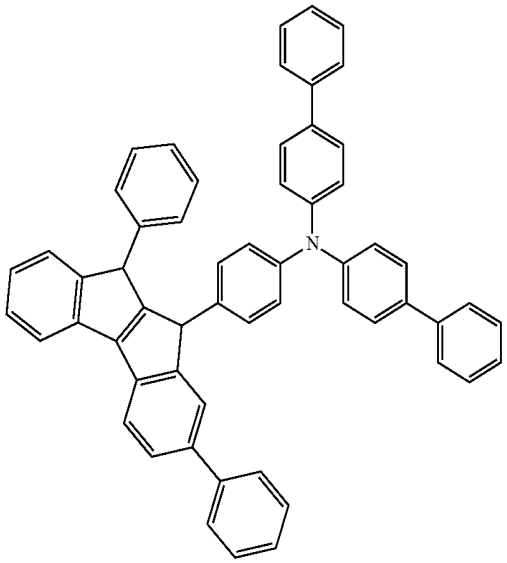


-continued

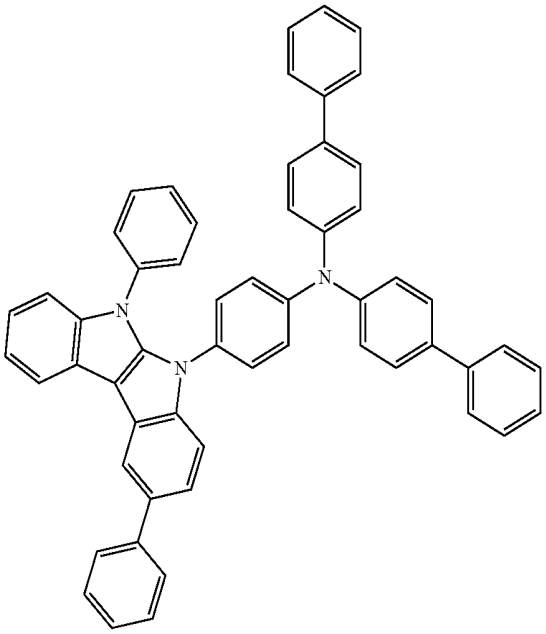
A45



A46

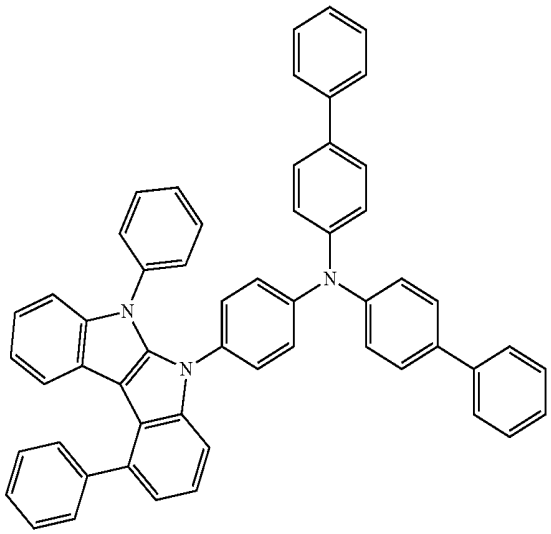


A47

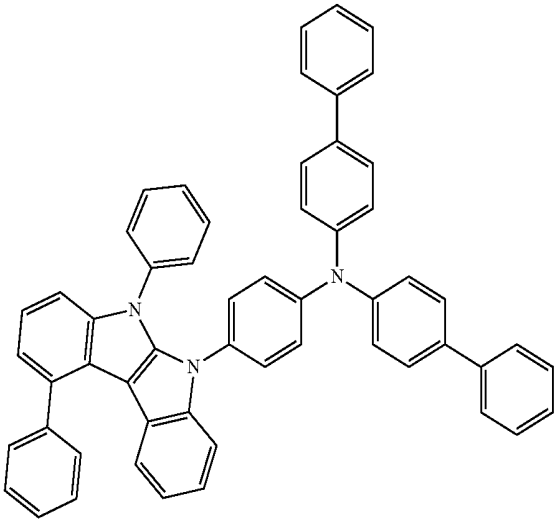


-continued

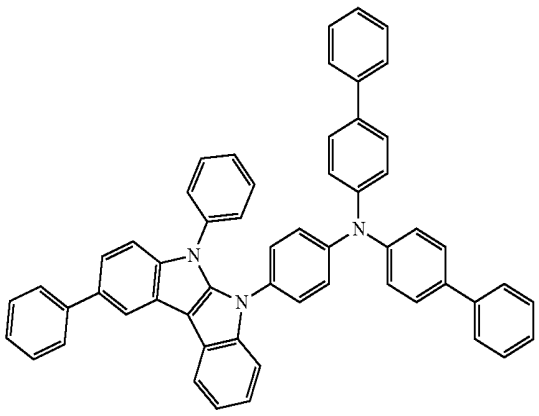
A48



A49

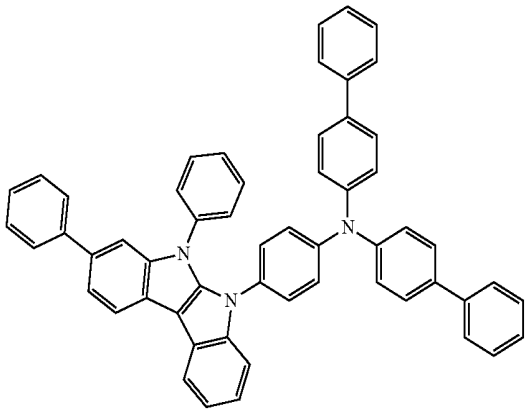


A50

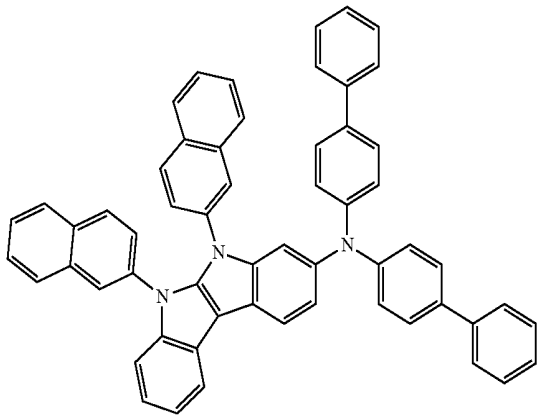


-continued

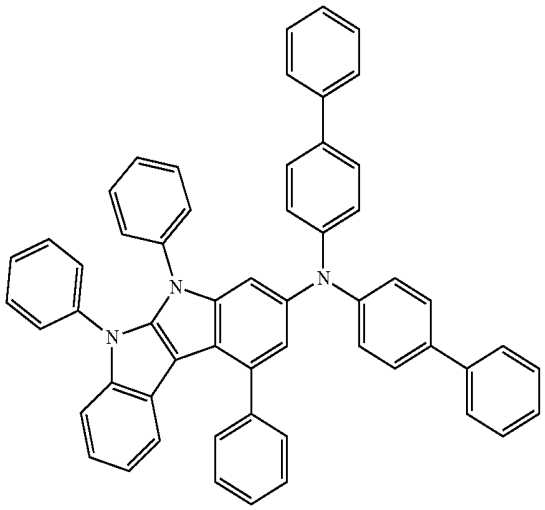
A51



A52

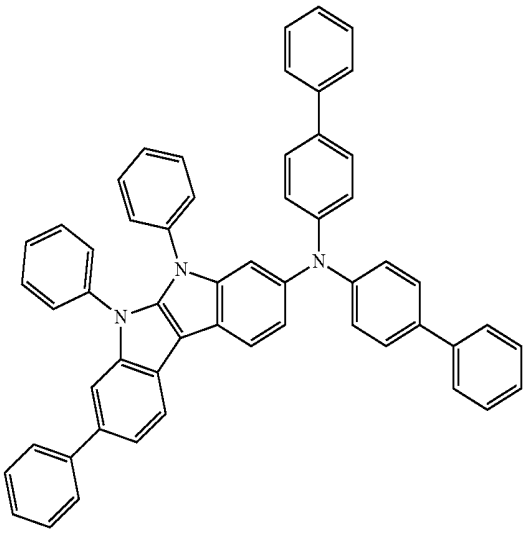


A53

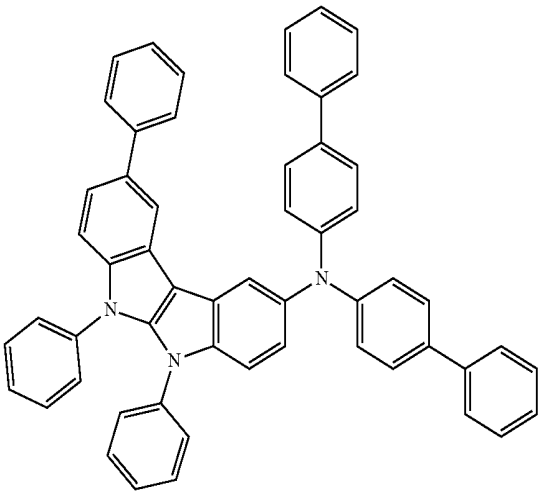


-continued

A54

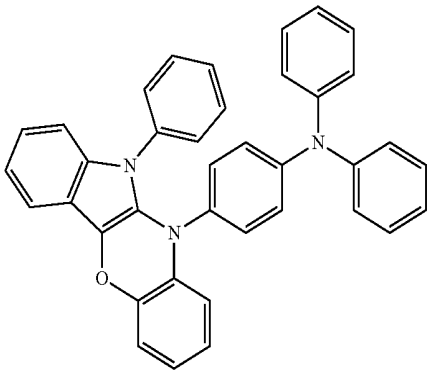


A55



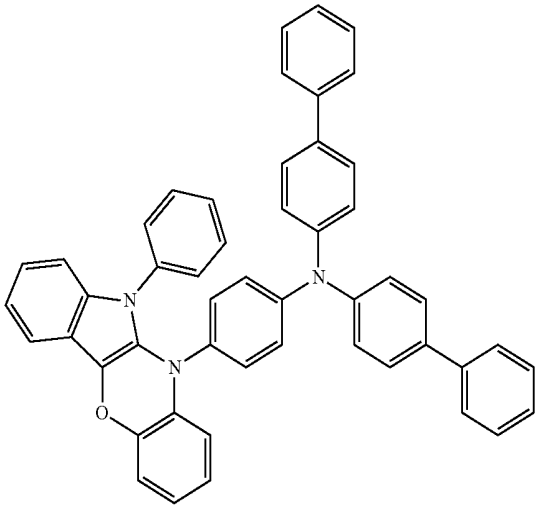
[Compound Group 2]

B1

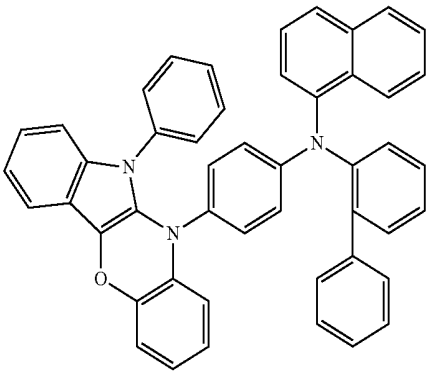


-continued

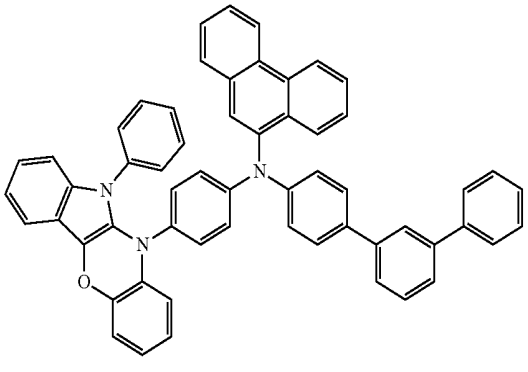
B2



B3

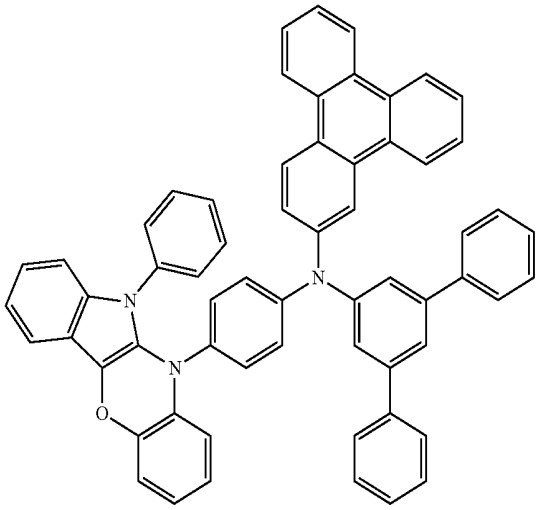


B4

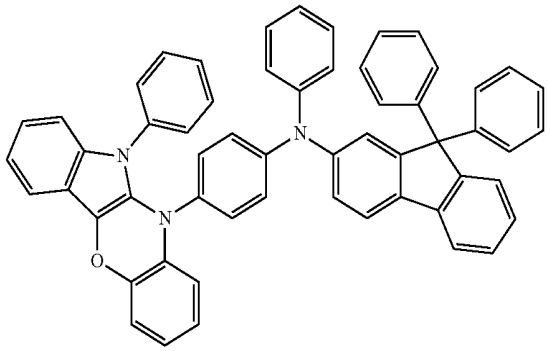


-continued

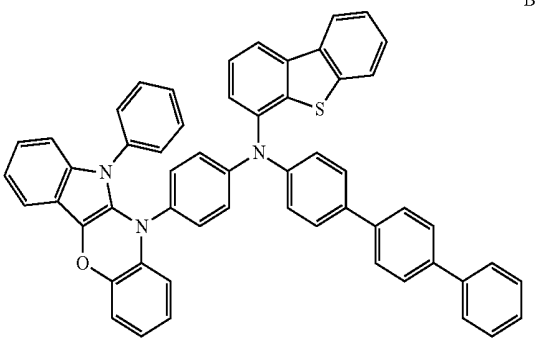
B5



B6

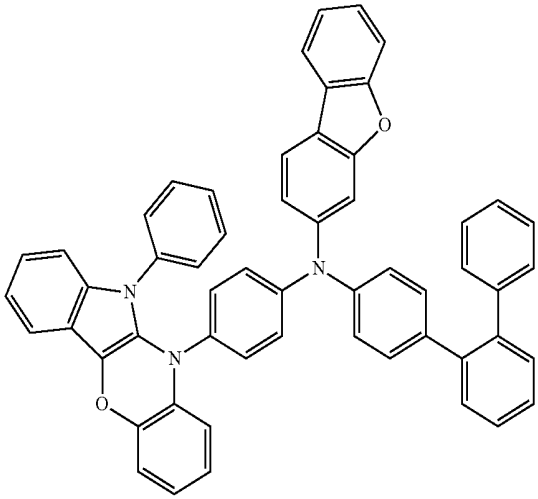


B7

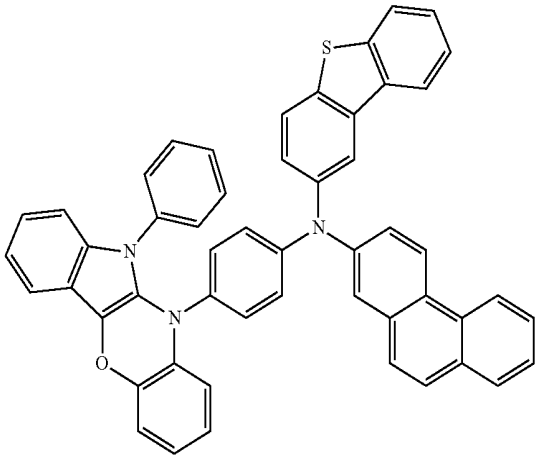


-continued

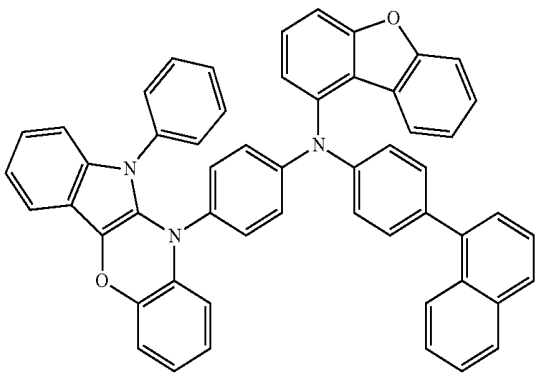
B8



B9

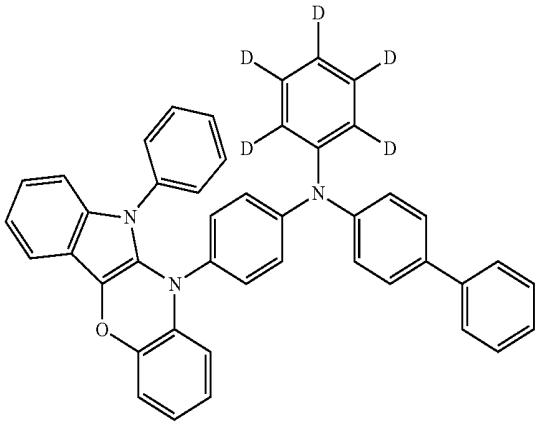


B10

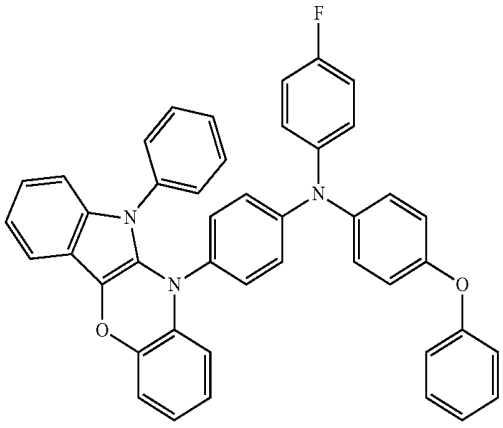


-continued

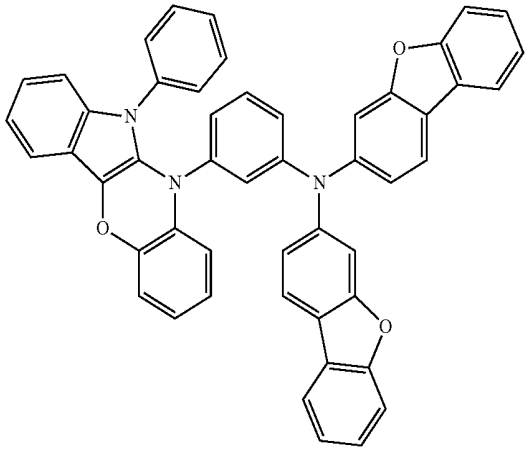
B11



B12

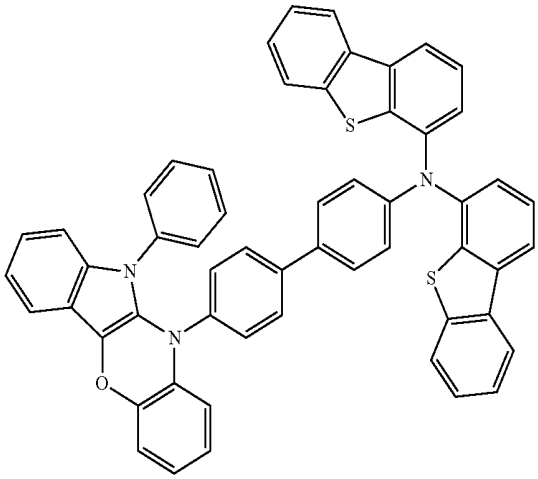


B13

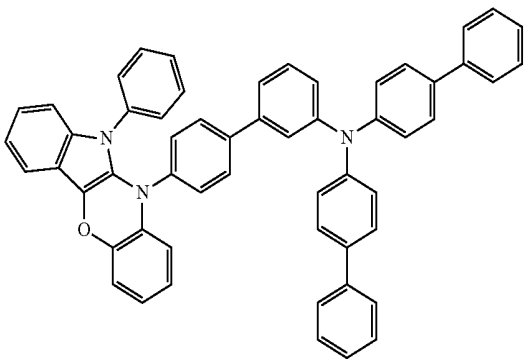


-continued

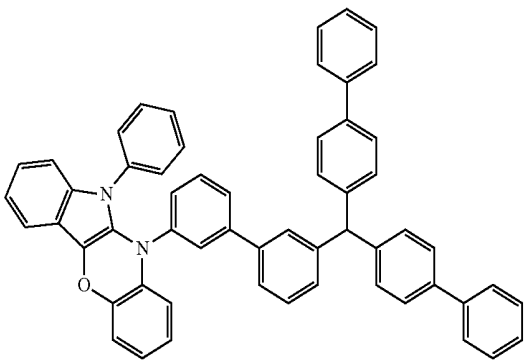
B14



B15

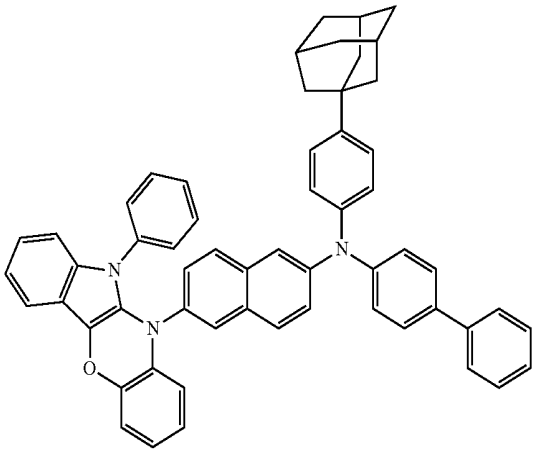


B16

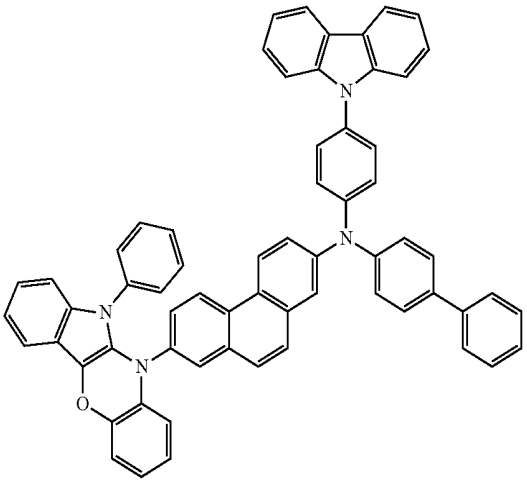


-continued

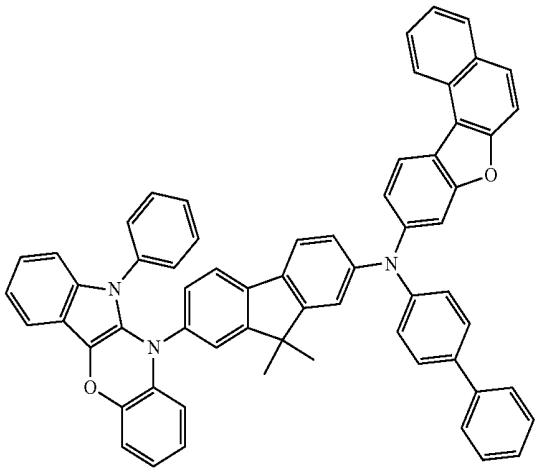
B17



B18

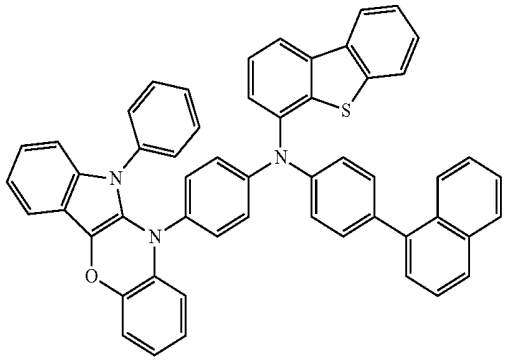


B19

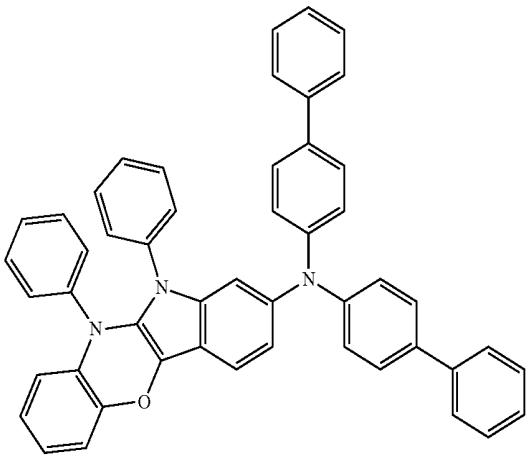


-continued

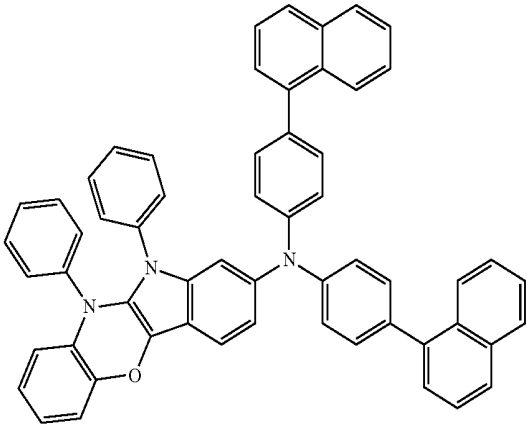
B20



B21

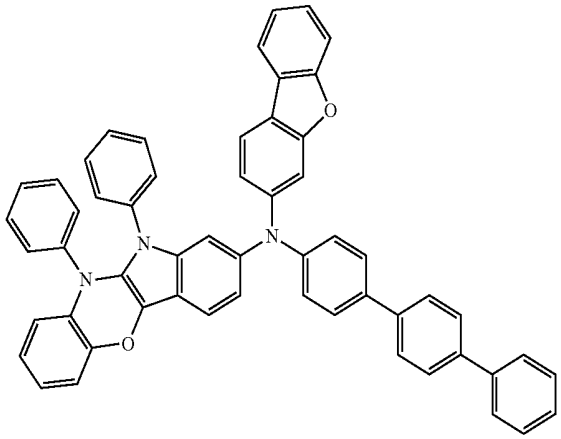


B22

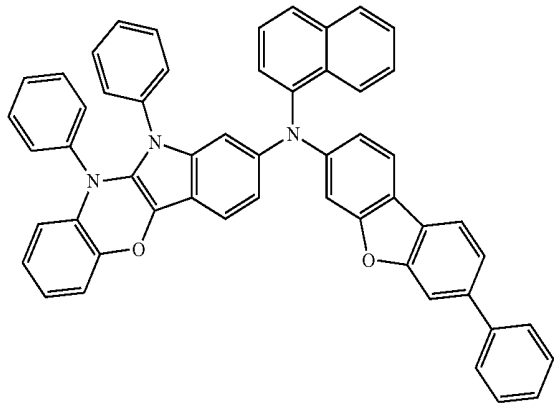


-continued

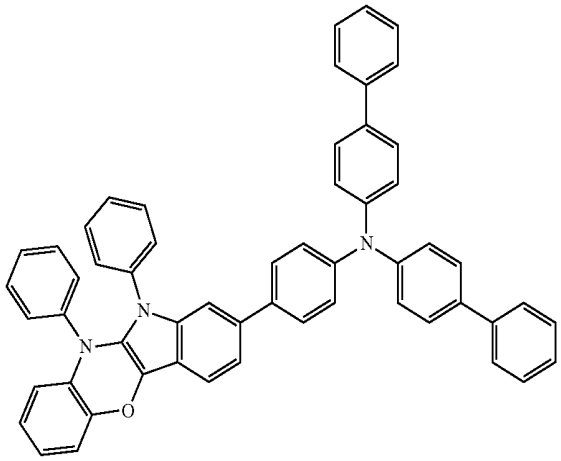
B23



B24

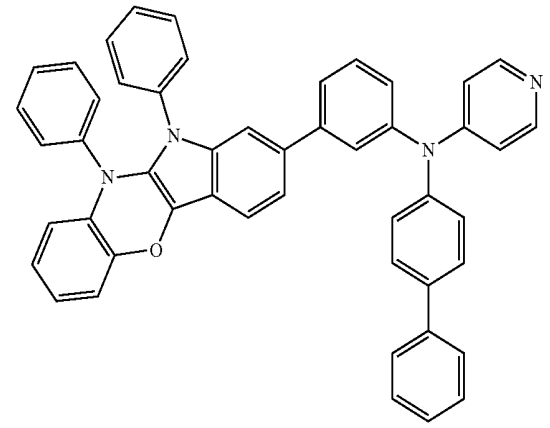


B25

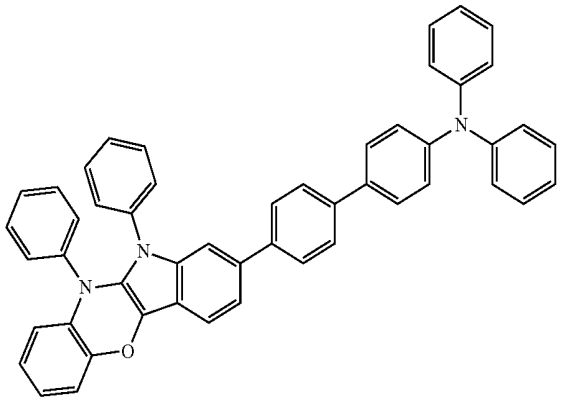


-continued

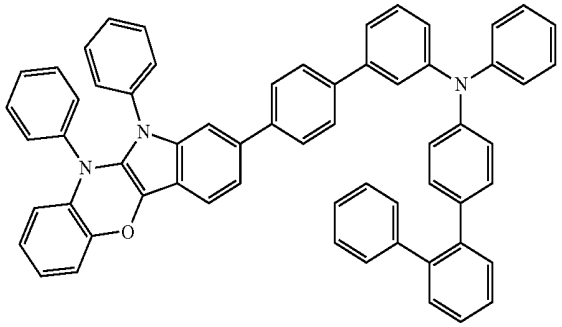
B26



B27

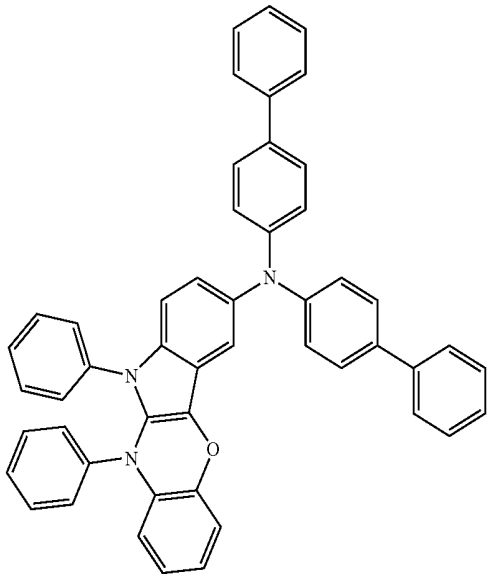


B28

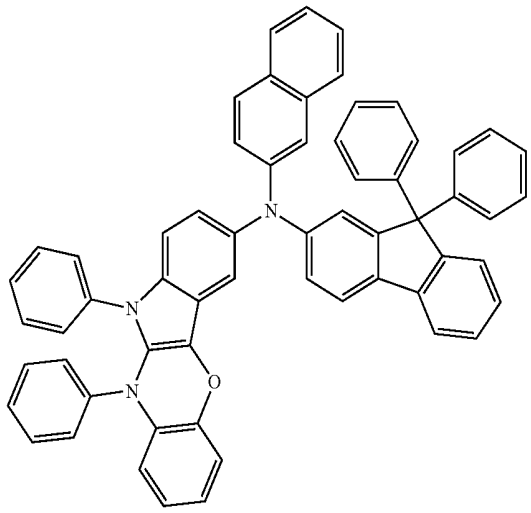


-continued

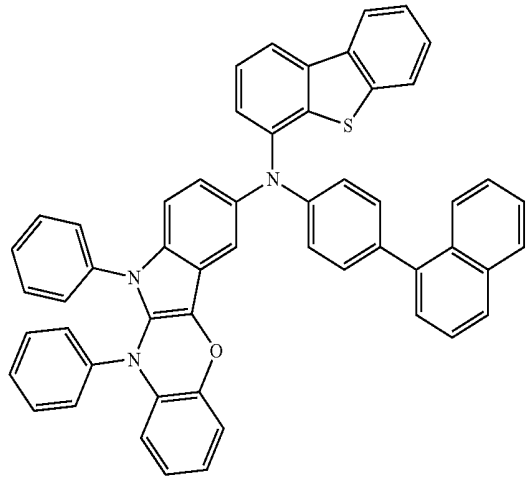
B29



B30

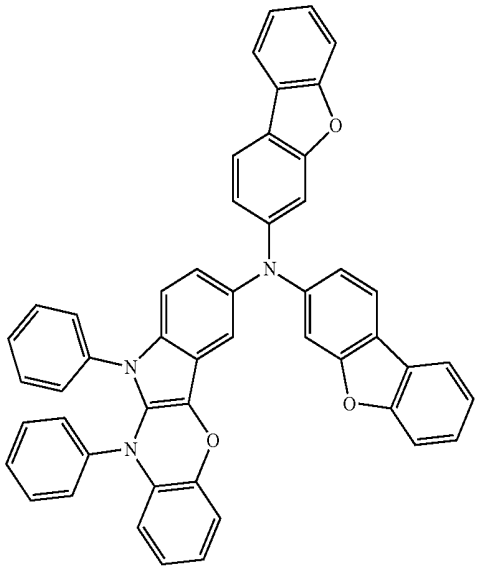


B31

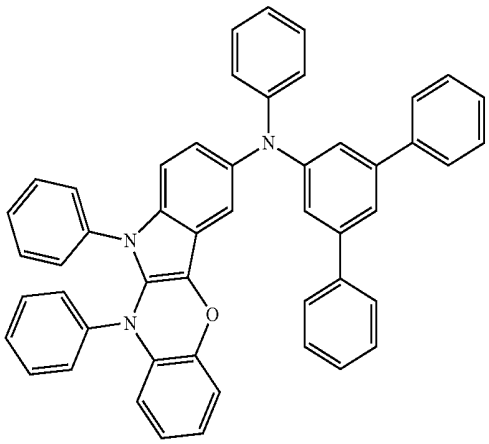


-continued

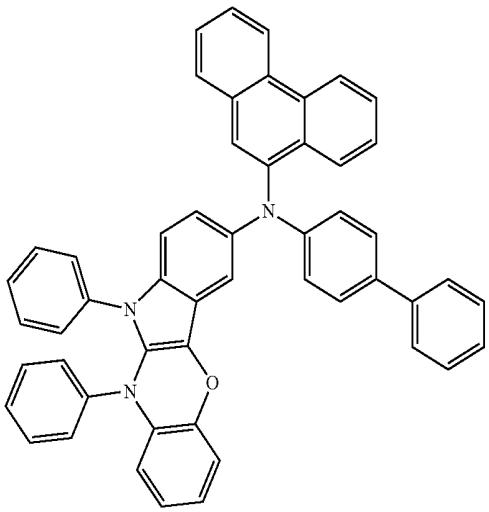
B32



B33

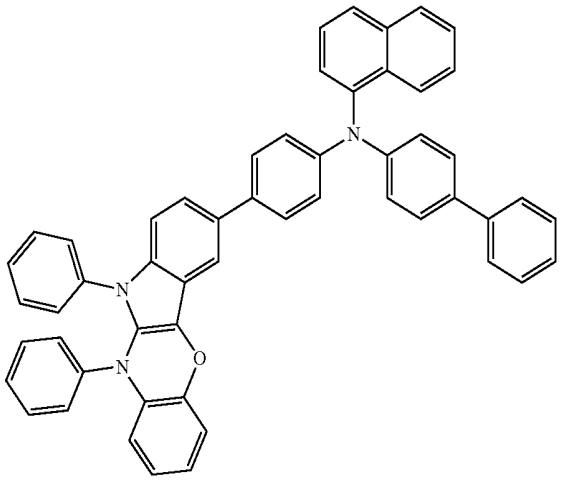


B34

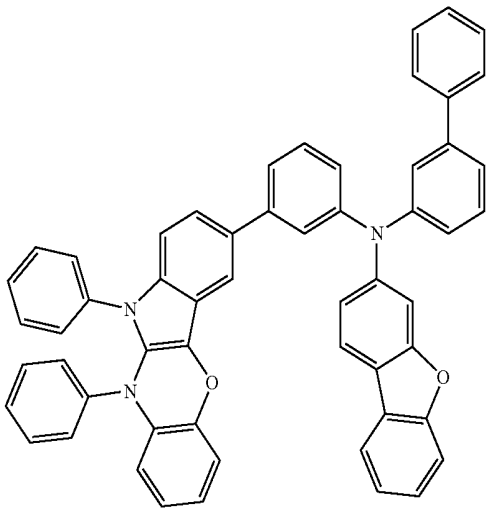


-continued

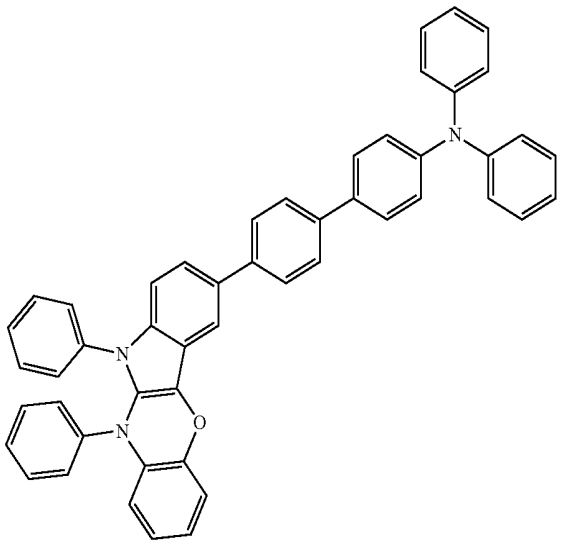
B35



B36

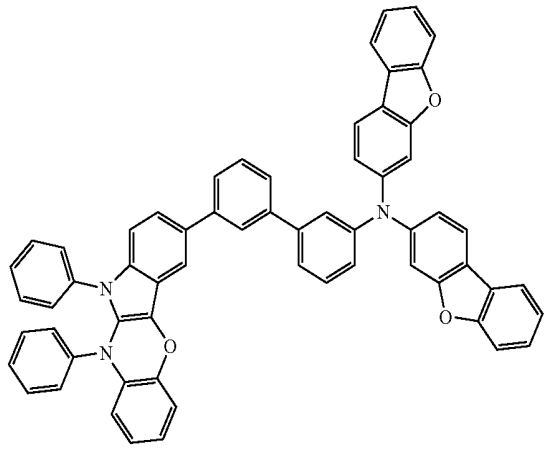


B37

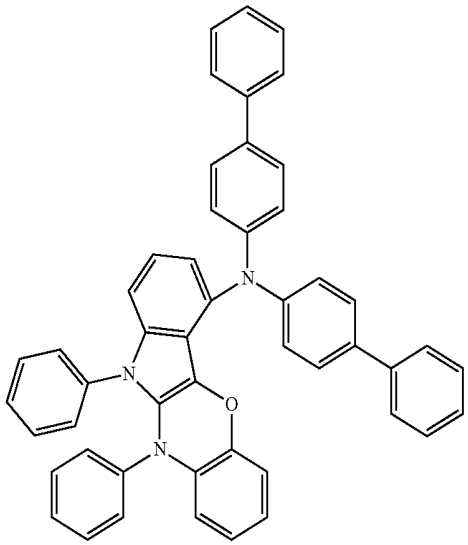


-continued

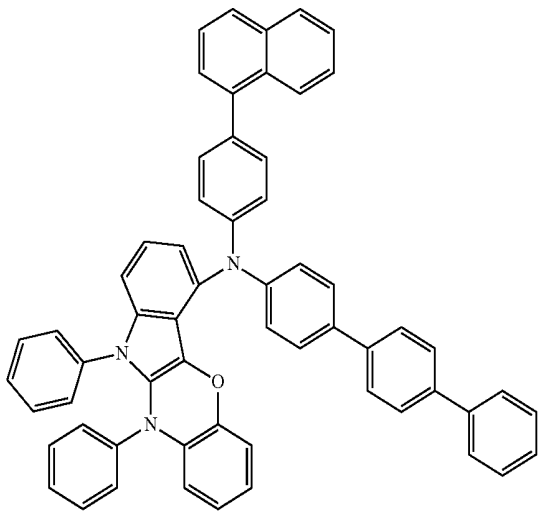
B38



B39

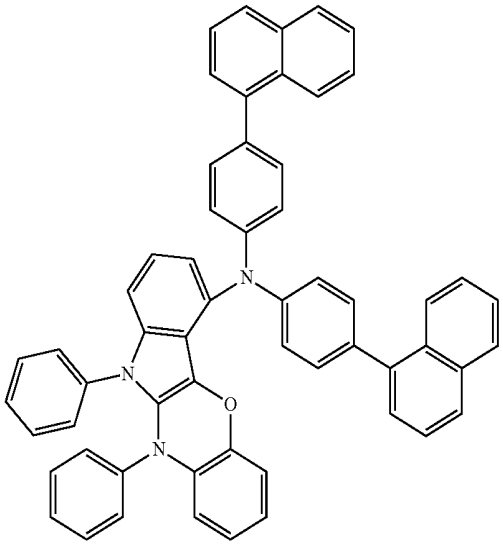


B40

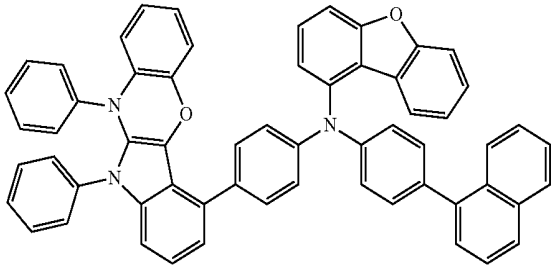


-continued

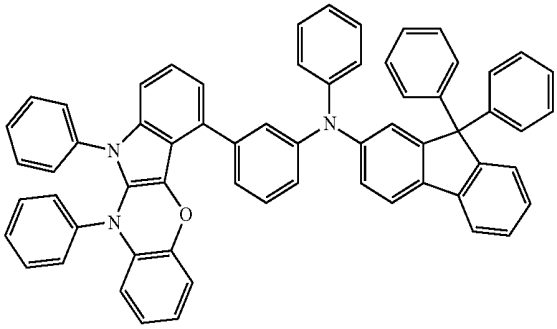
B41



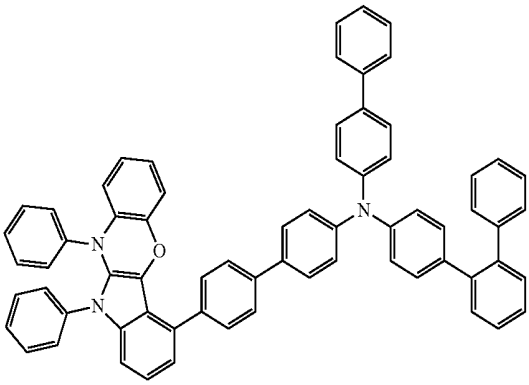
B42



B43

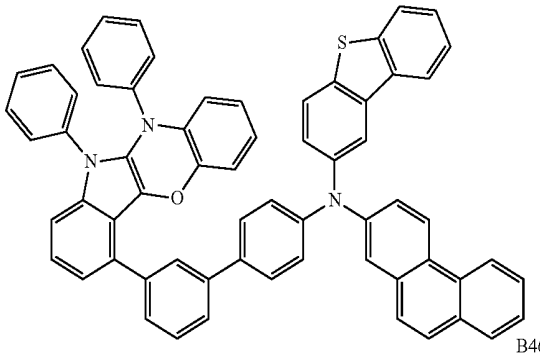


B44

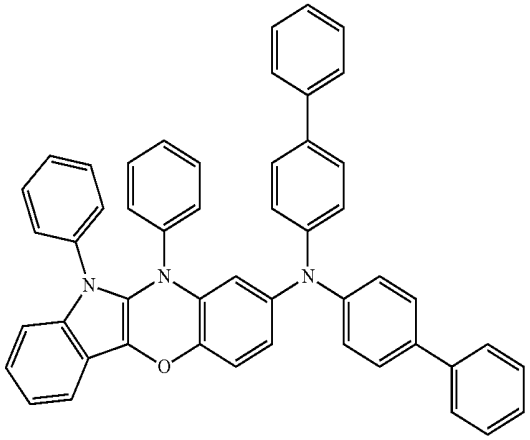


-continued

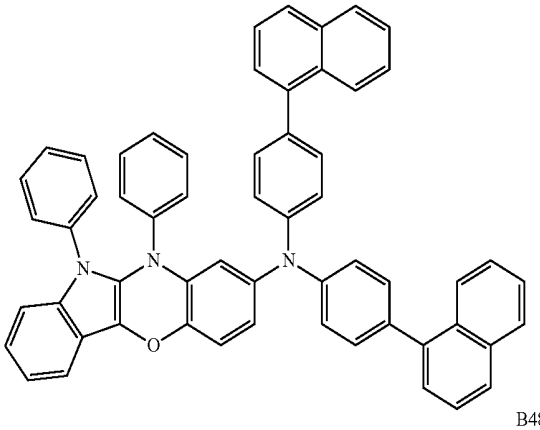
B45



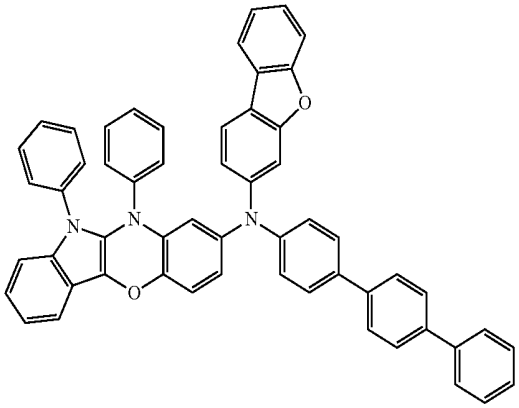
B46



B47

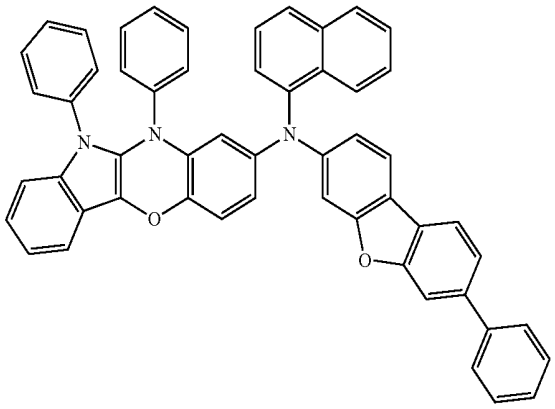


B48

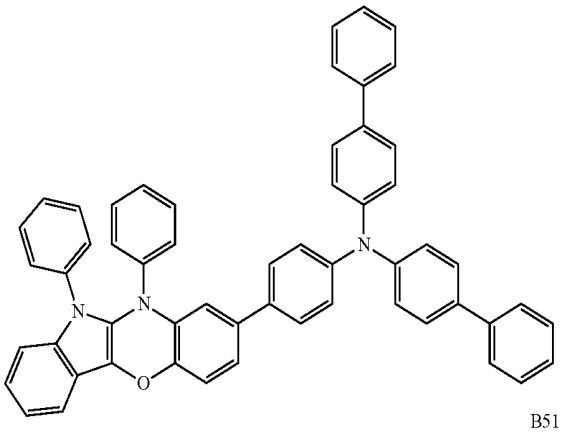


-continued

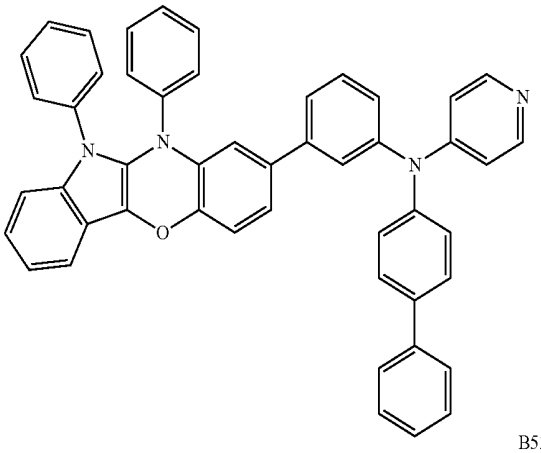
B49



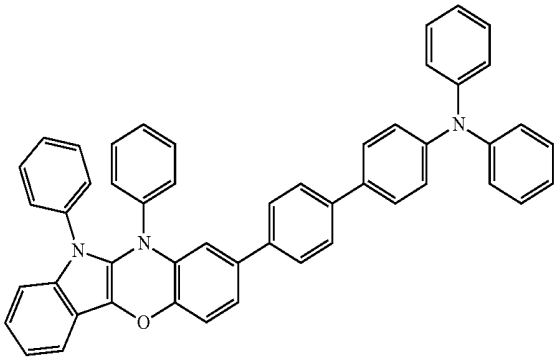
B50



B51

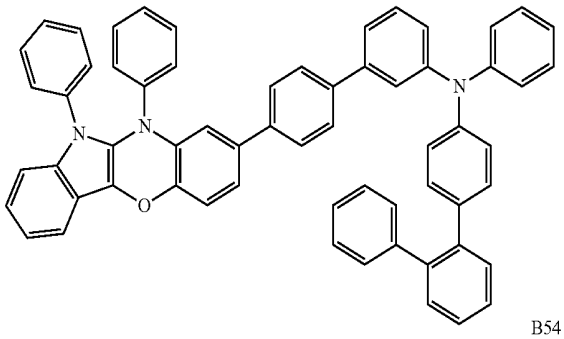


B52

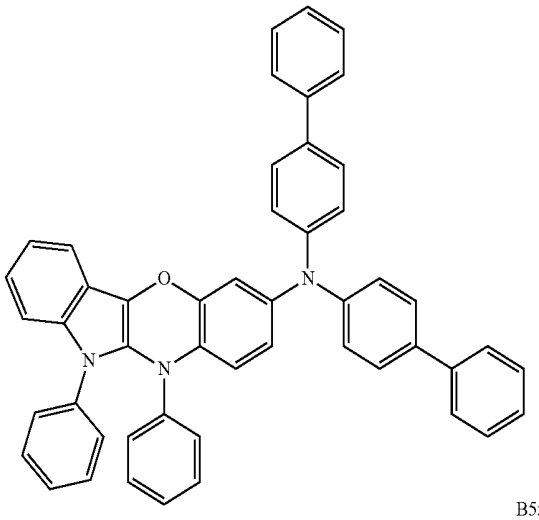


-continued

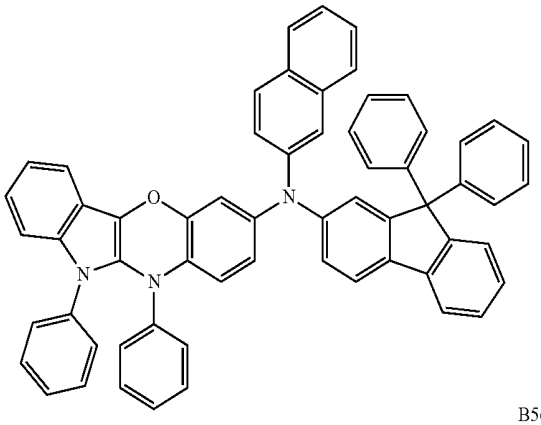
B53



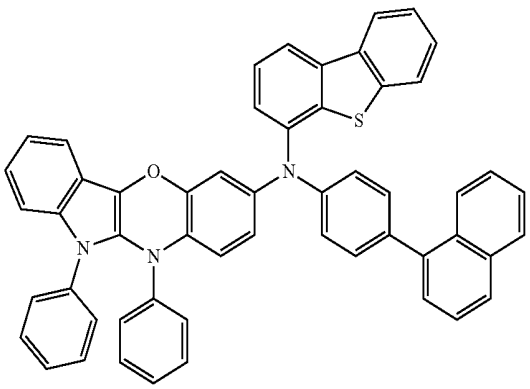
B54



B55

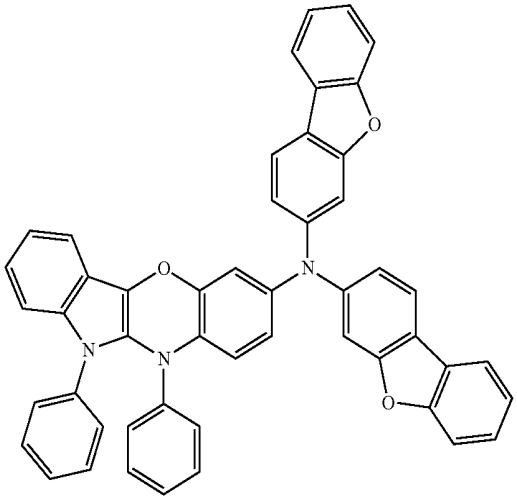


B56

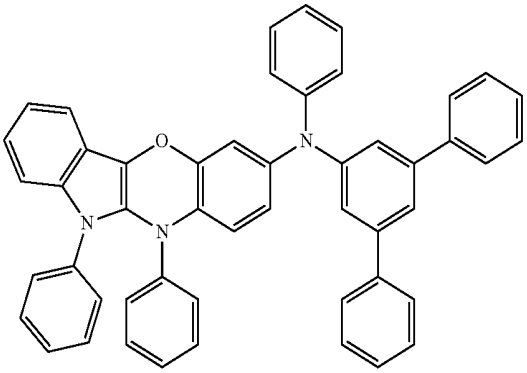


-continued

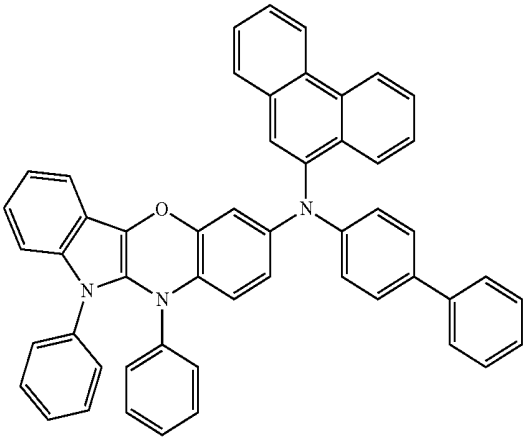
B57



B58

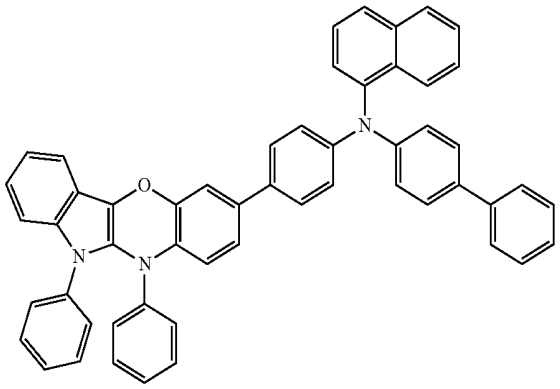


B59

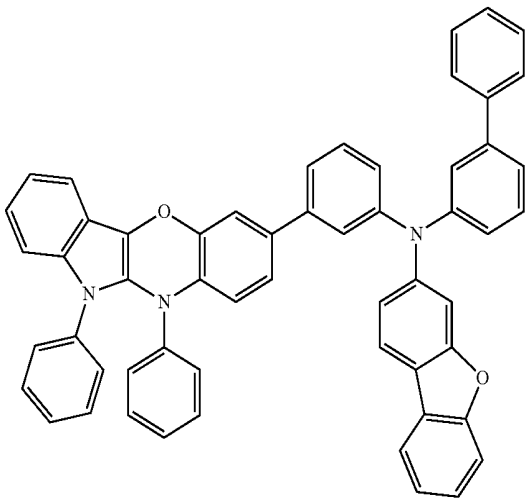


-continued

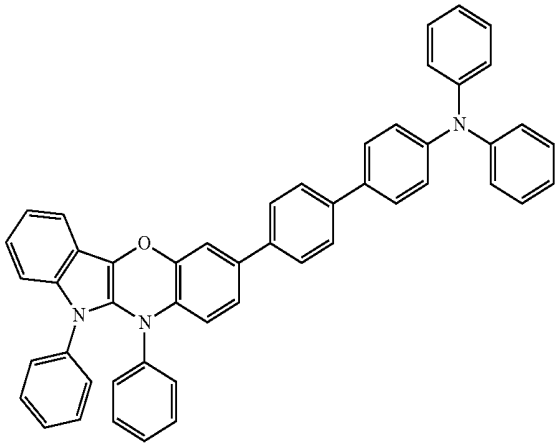
B60



B61

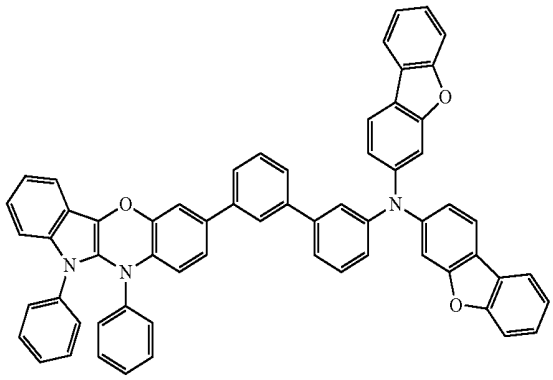


B62

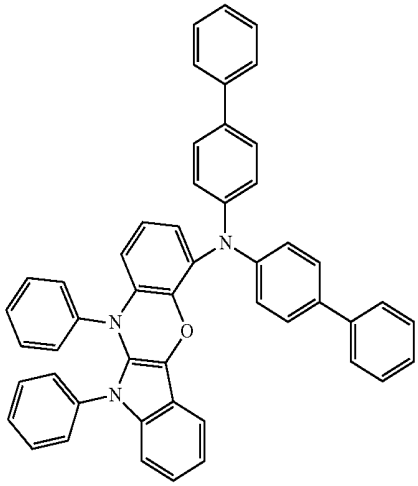


-continued

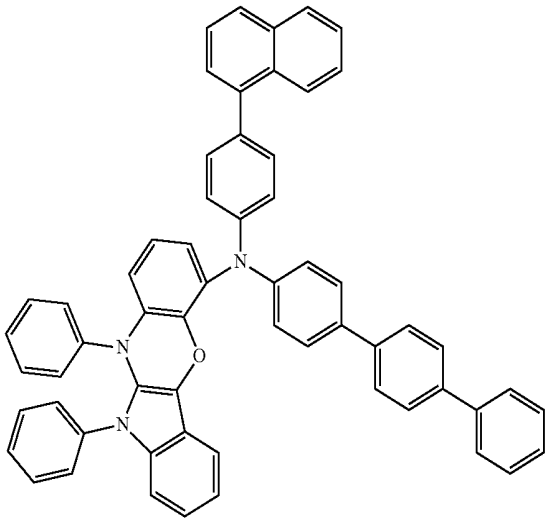
B63



B64

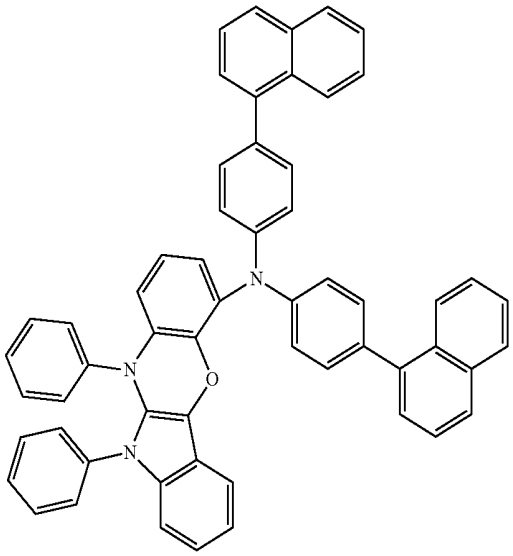


B65

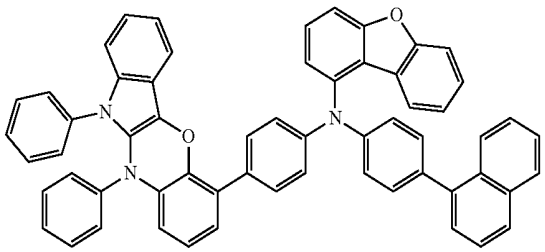


-continued

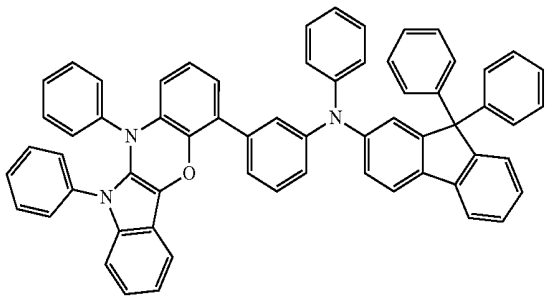
B66



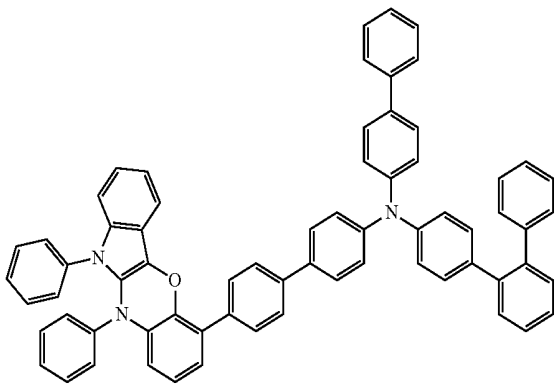
B67



B68

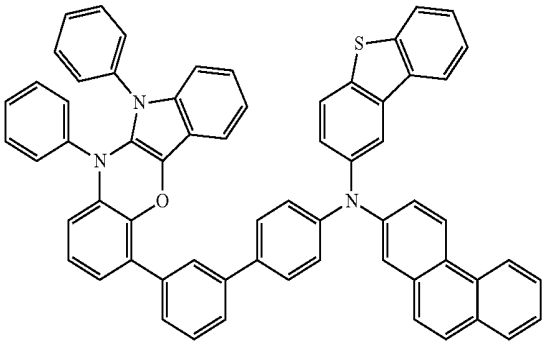


B69



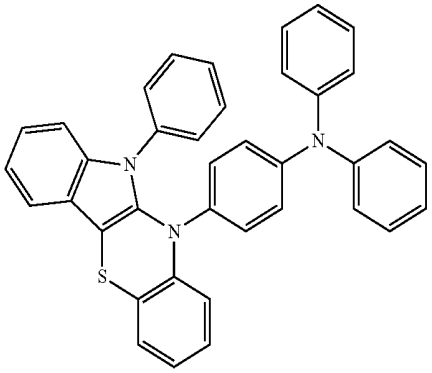
-continued

B70

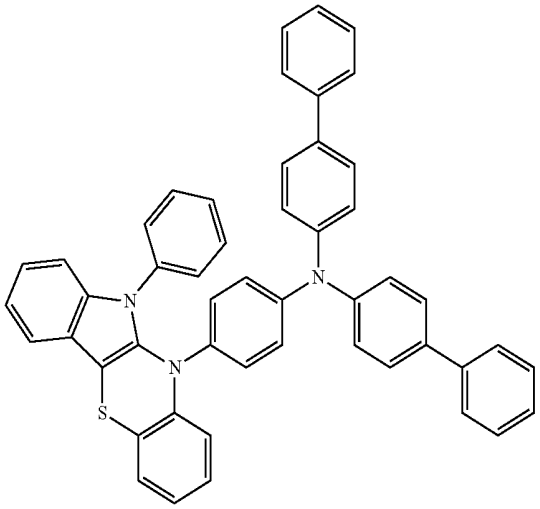


[Compound Group 3]

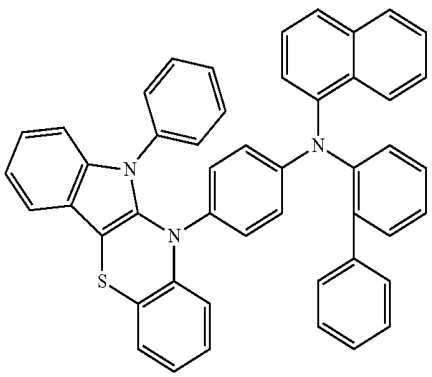
C1



C2

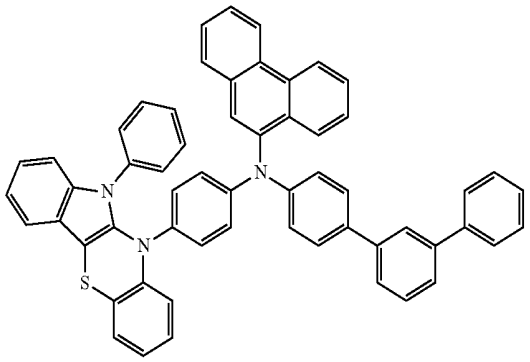


C3

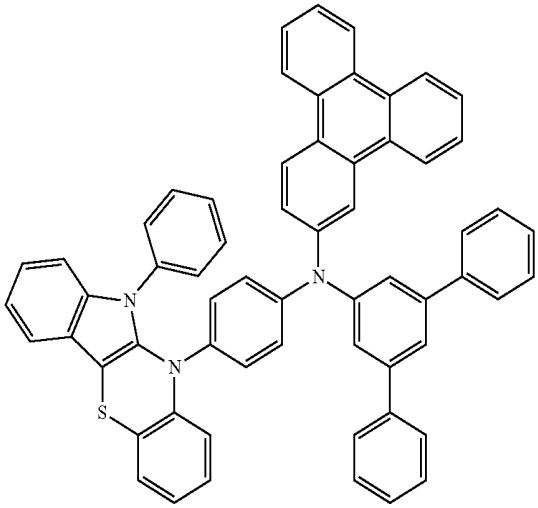


-continued

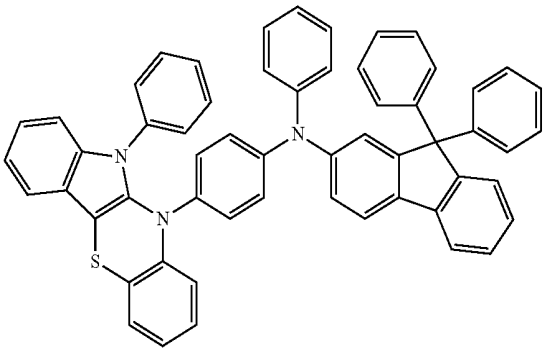
C4



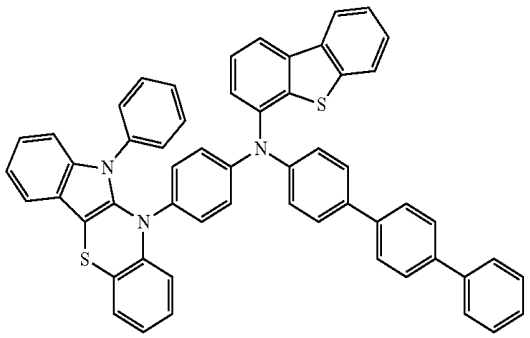
C5



C6

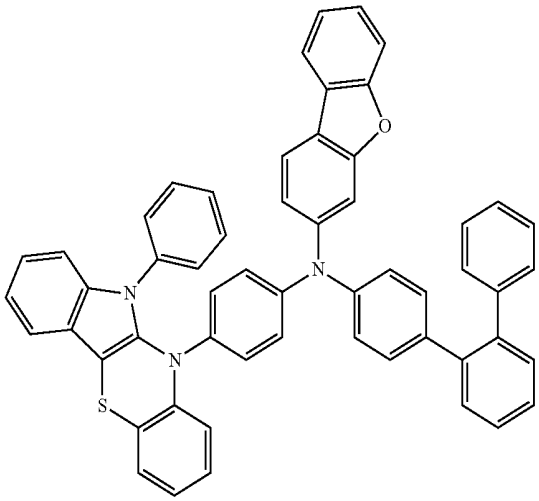


C7

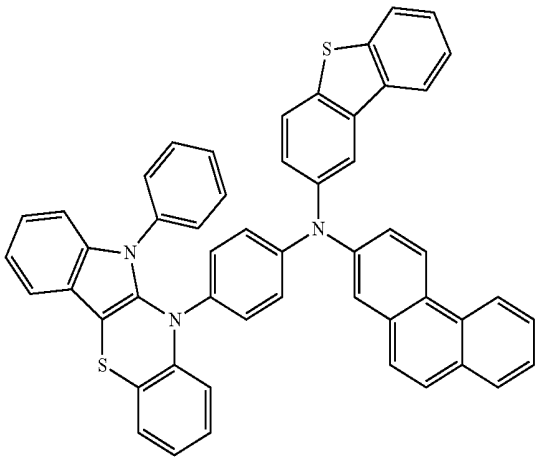


-continued

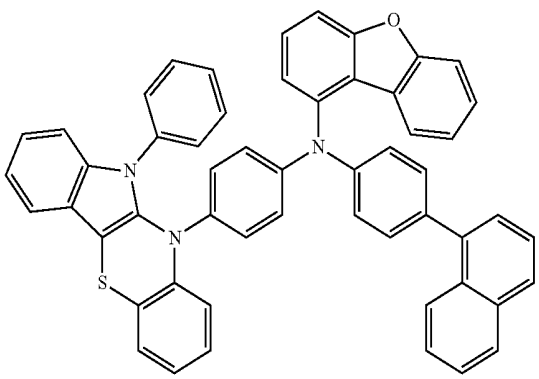
C8



C9

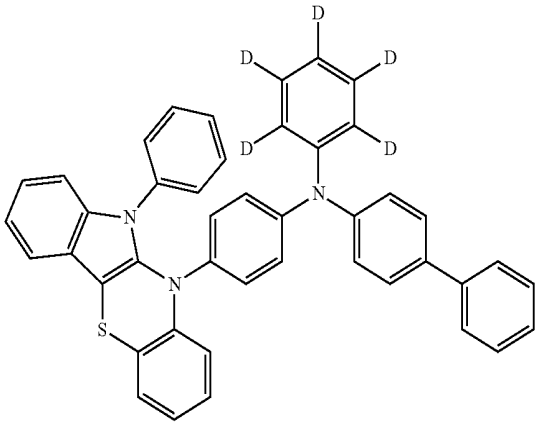


C10

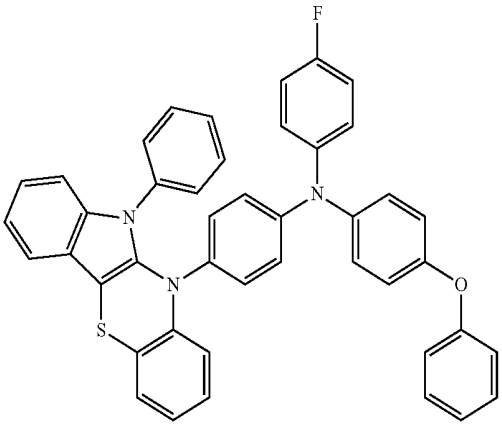


-continued

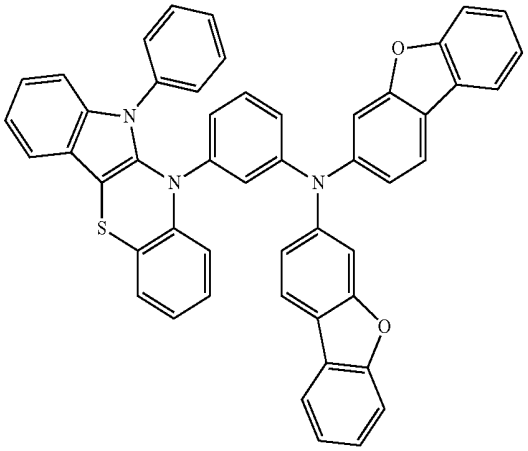
C11



C12

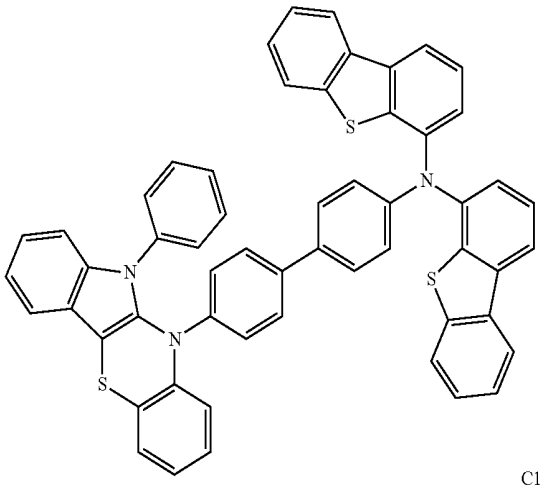


C13

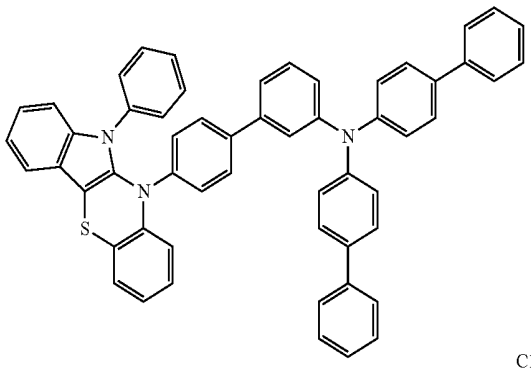


-continued

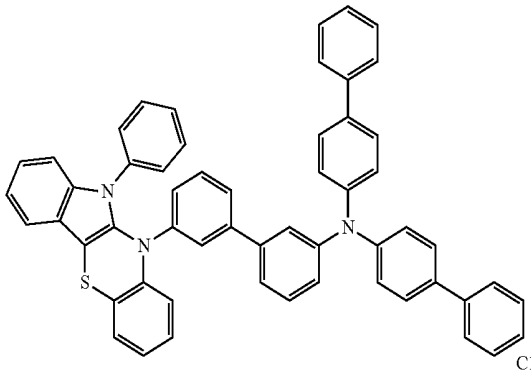
C14



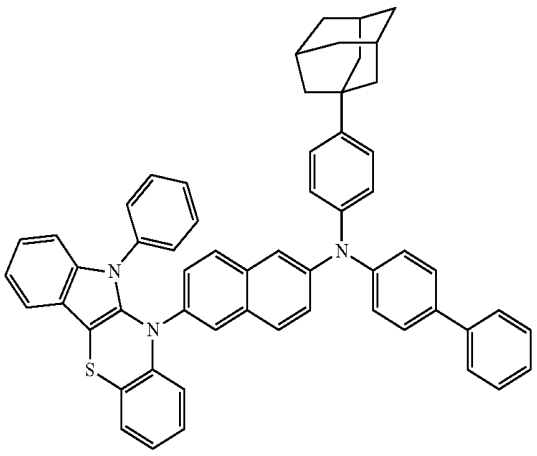
C15



C16

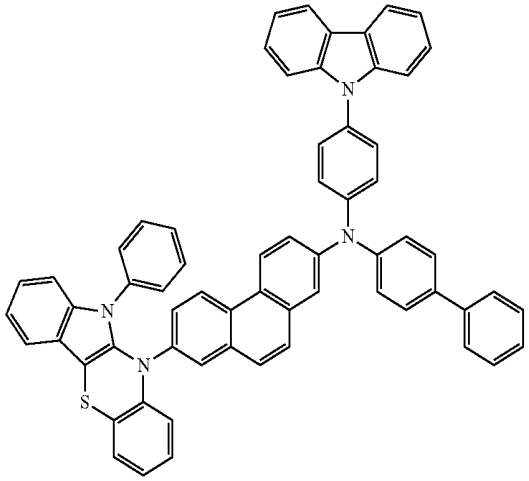


C17

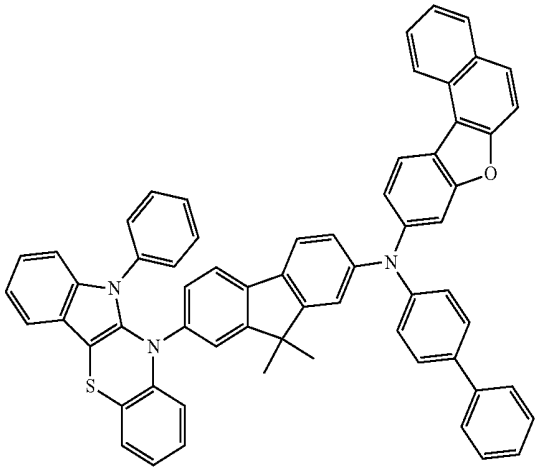


-continued

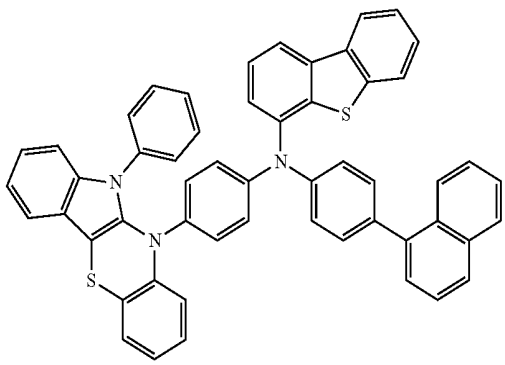
C18



C19

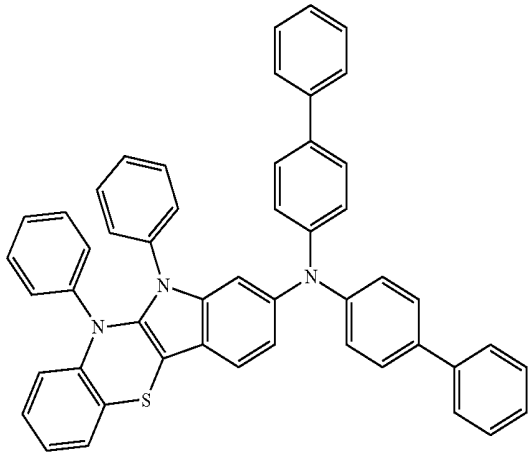


C20

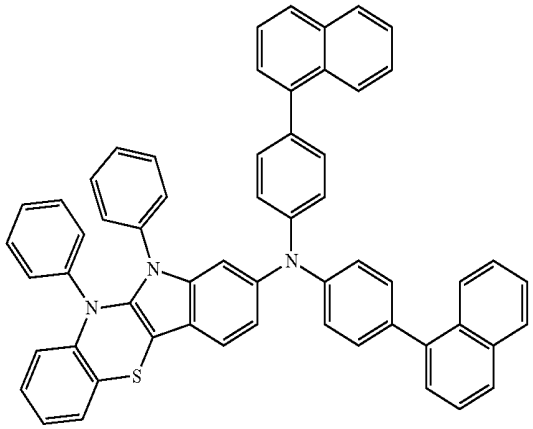


-continued

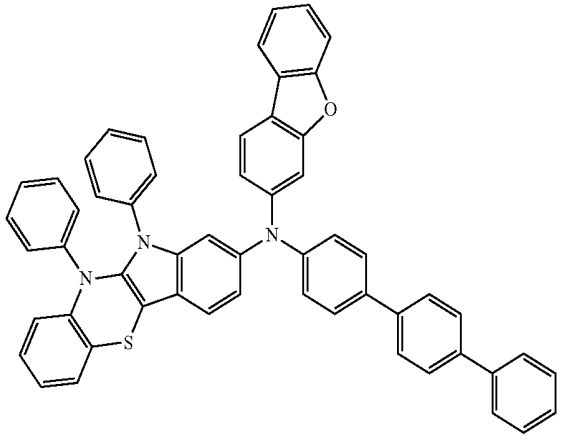
C21



C22

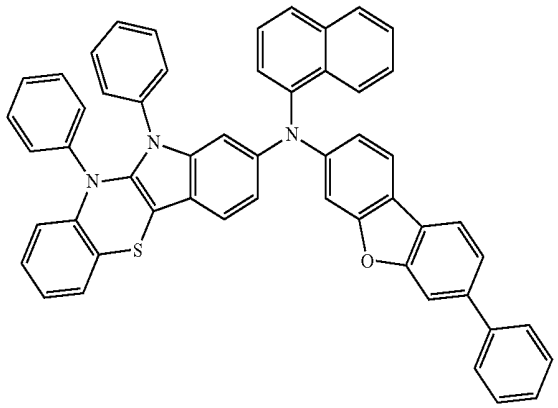


C23

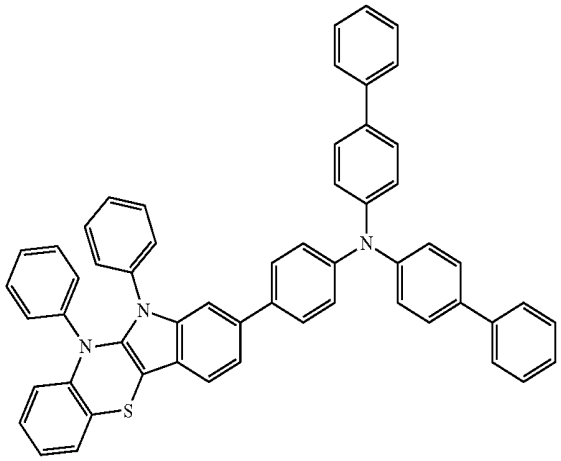


-continued

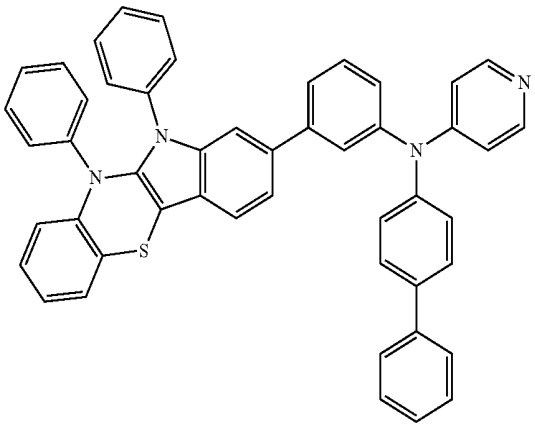
C24



C25

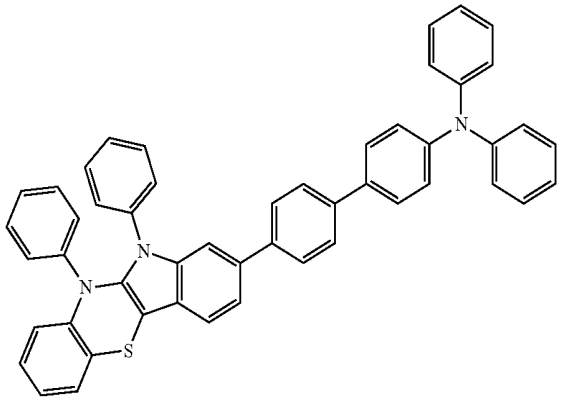


C26

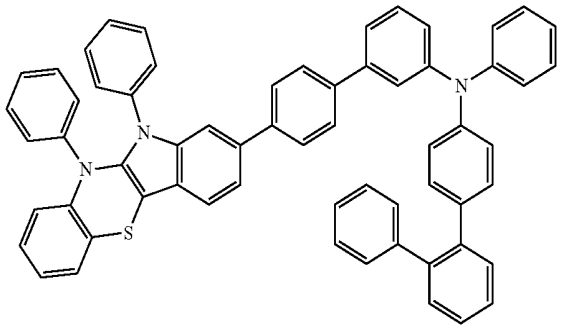


-continued

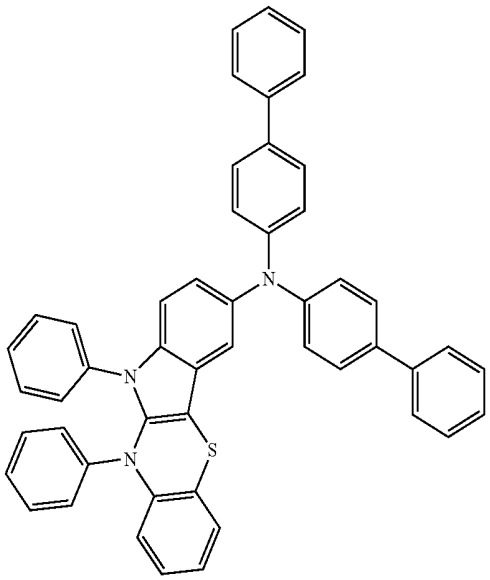
C27



C28

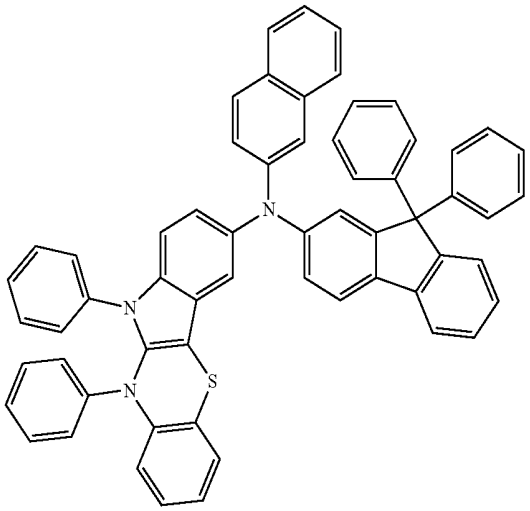


C29

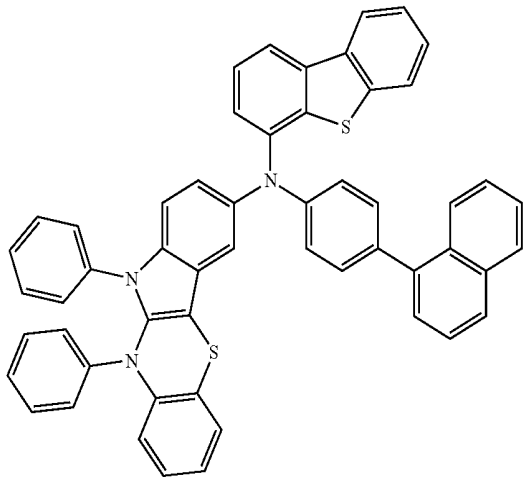


-continued

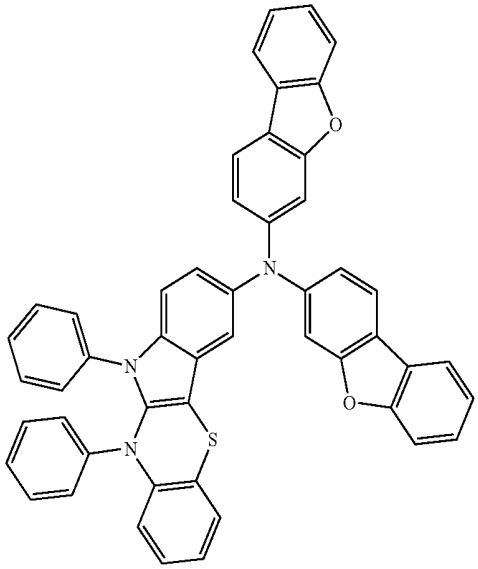
C30



C31

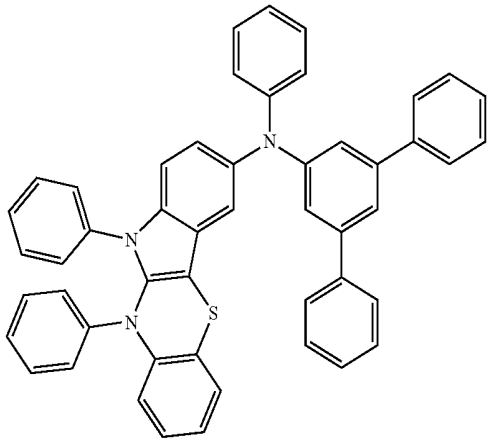


C32

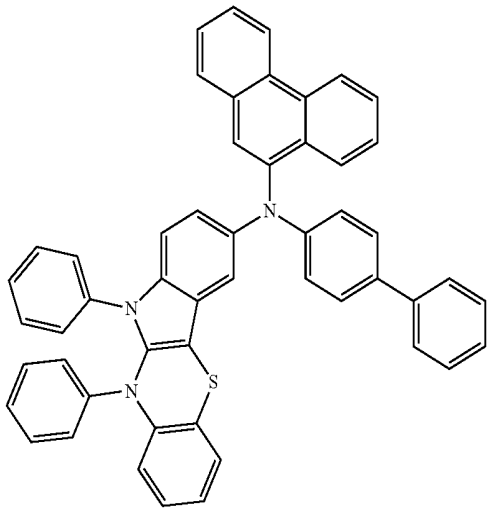


-continued

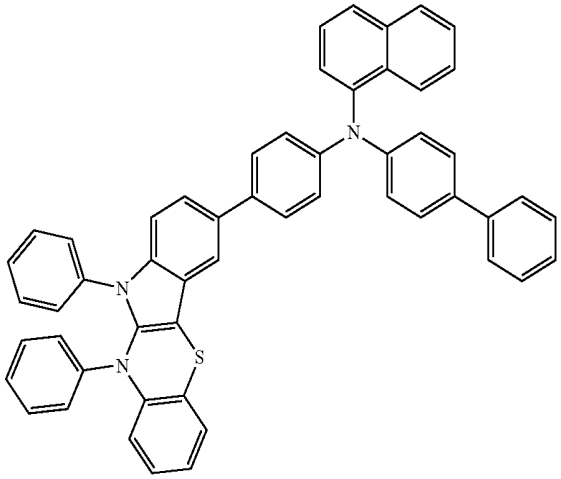
C33



C34

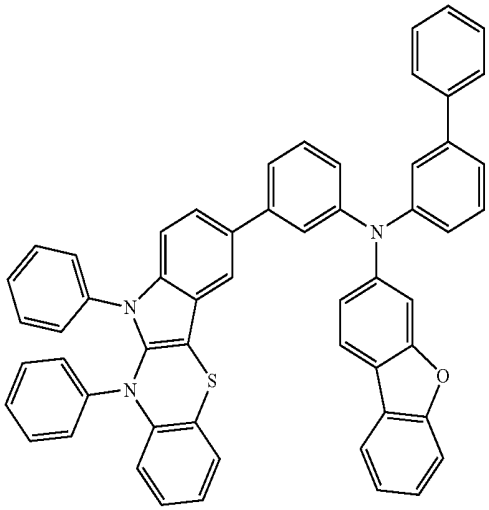


C35

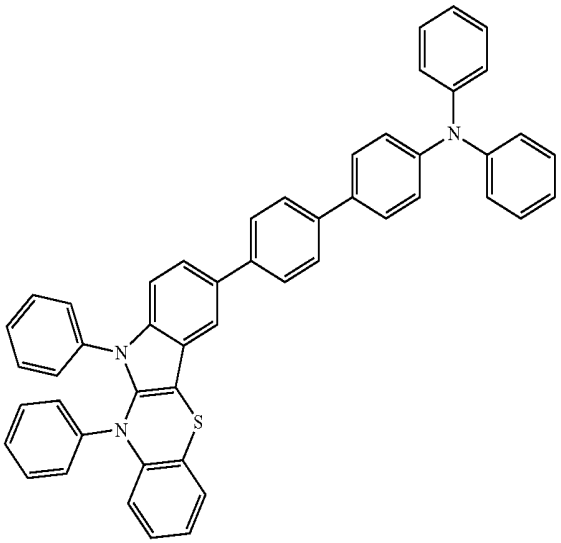


-continued

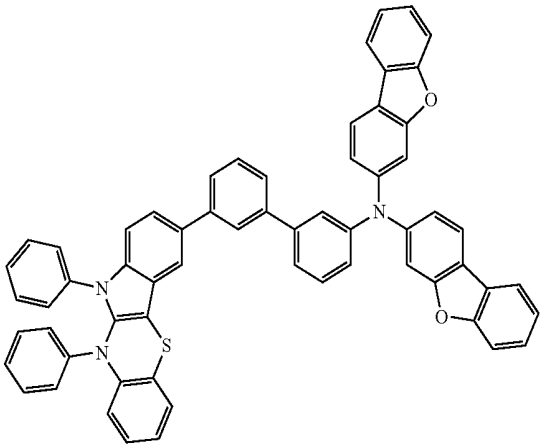
C36



C37

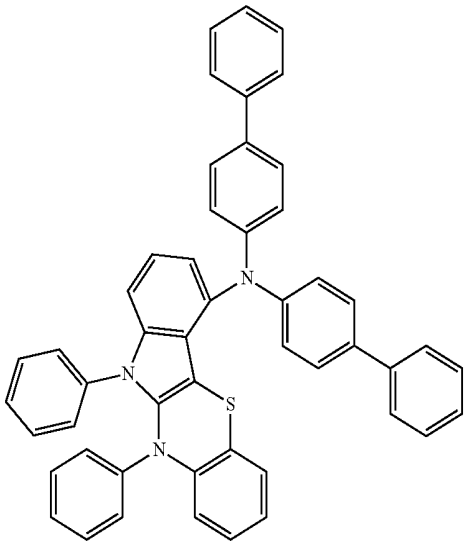


C38

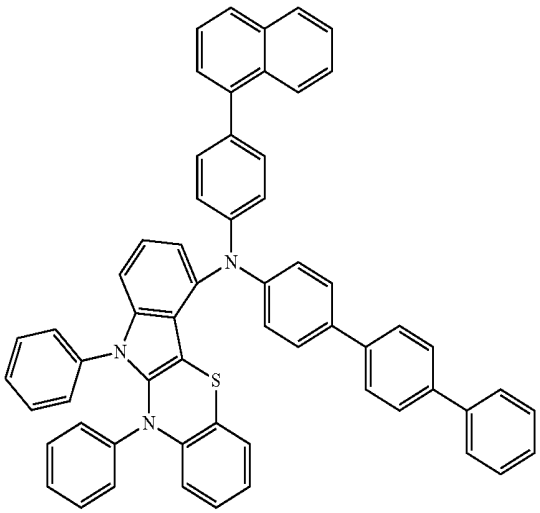


-continued

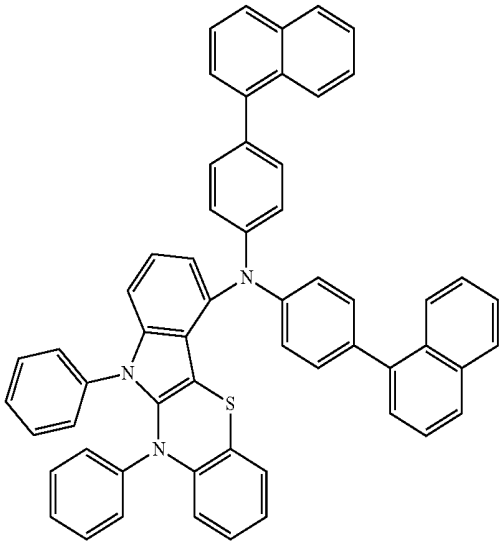
C39



C40

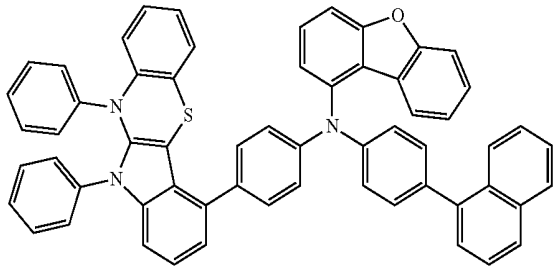


C41

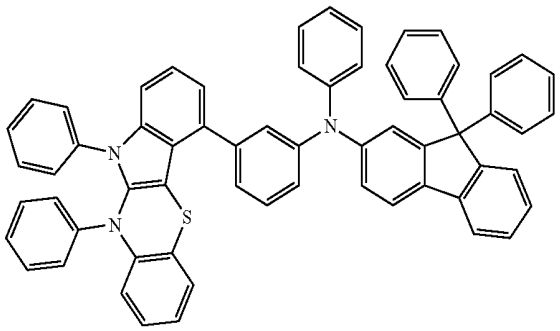


-continued

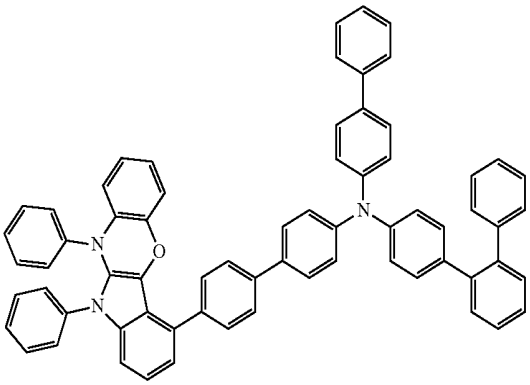
C42



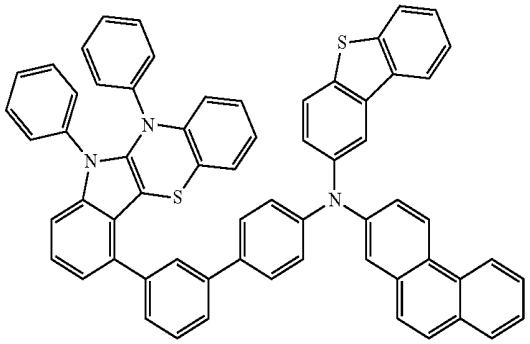
C43



C44

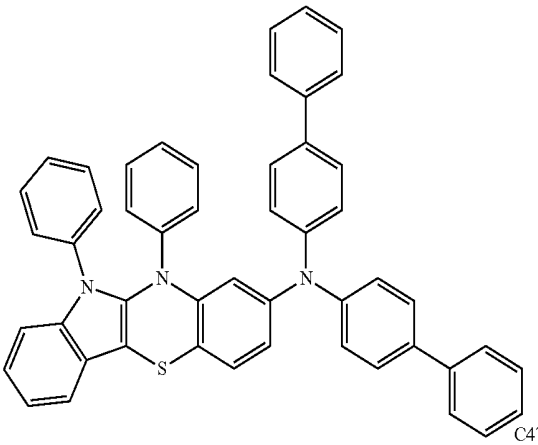


C45

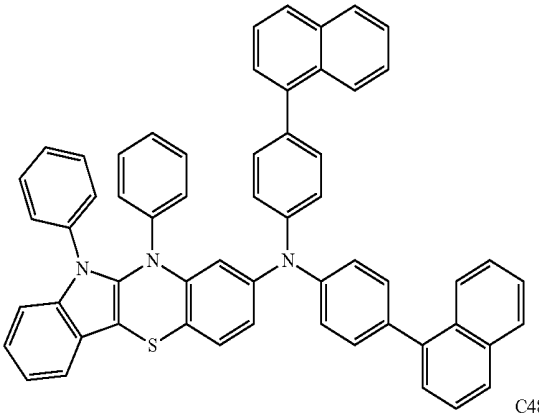


-continued

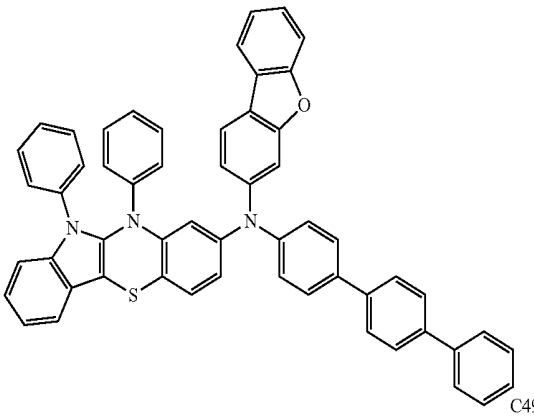
C46



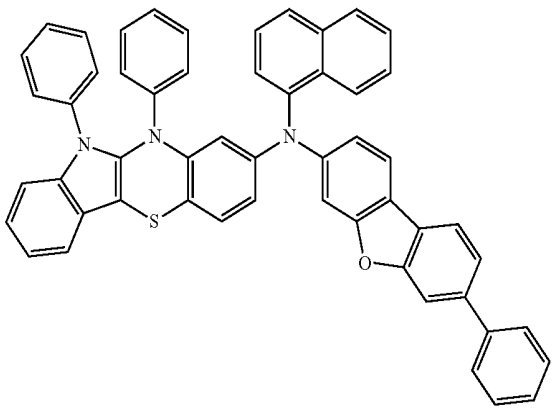
C47



C48

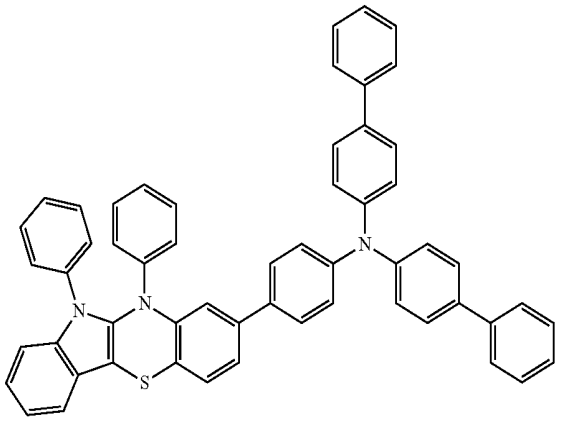


C49

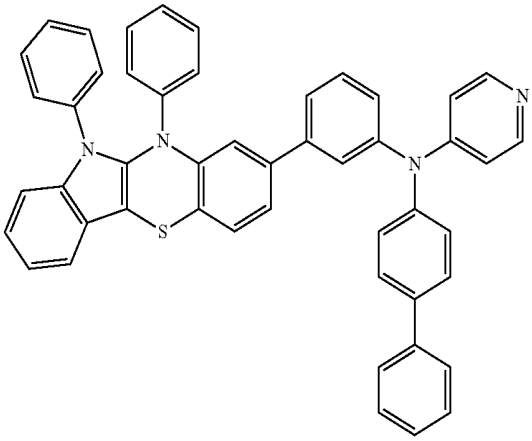


-continued

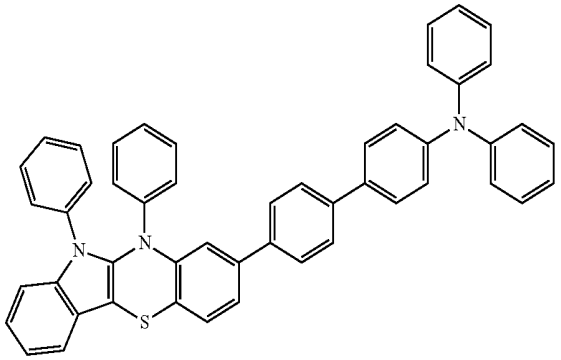
C50



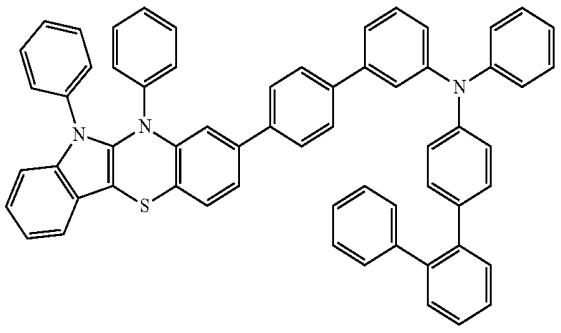
C51



C52

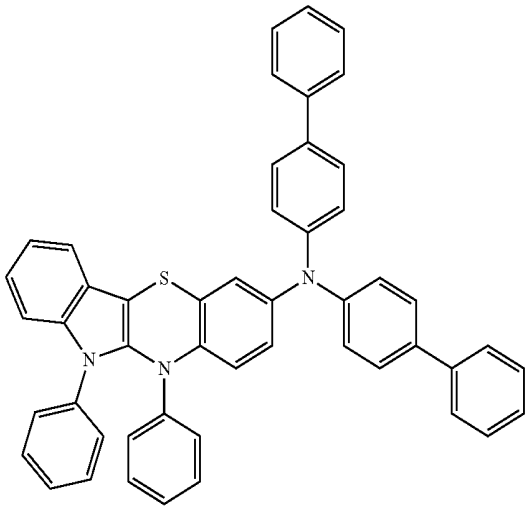


C53

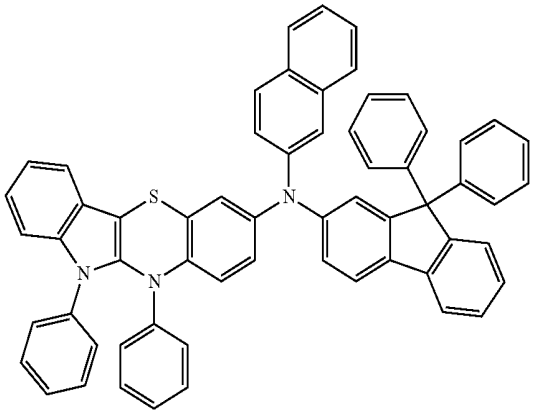


-continued

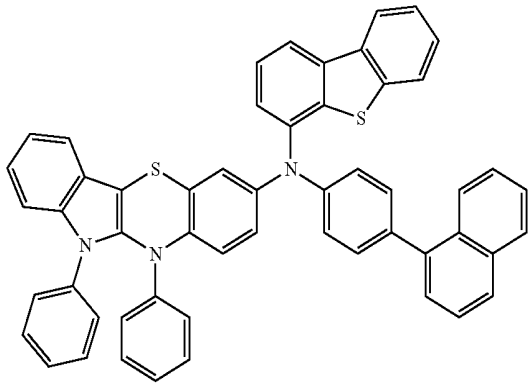
C54



C55

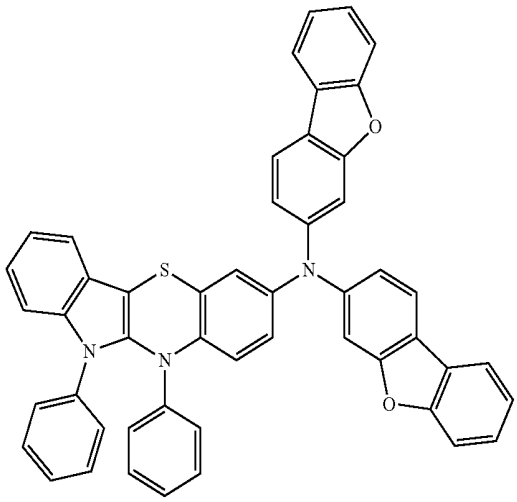


C56

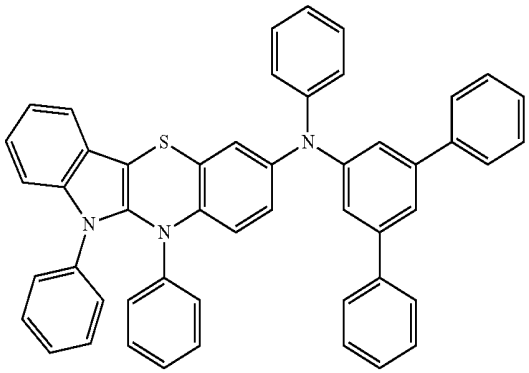


-continued

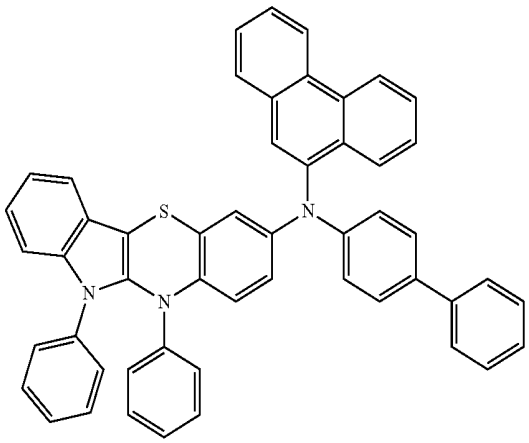
C57



C58

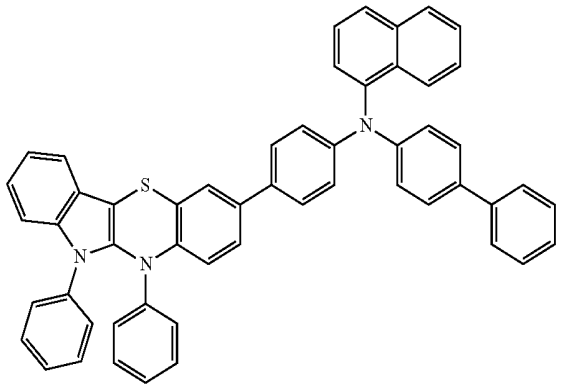


C59

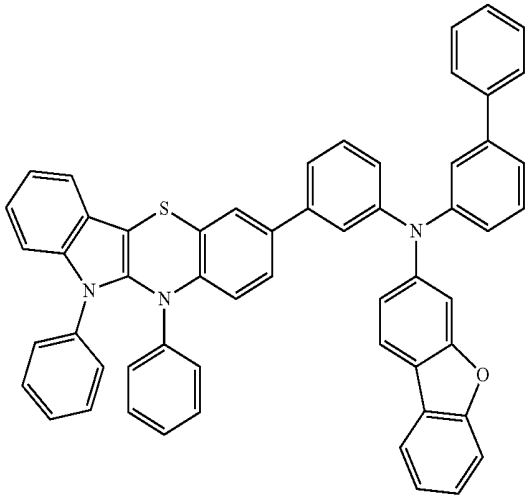


-continued

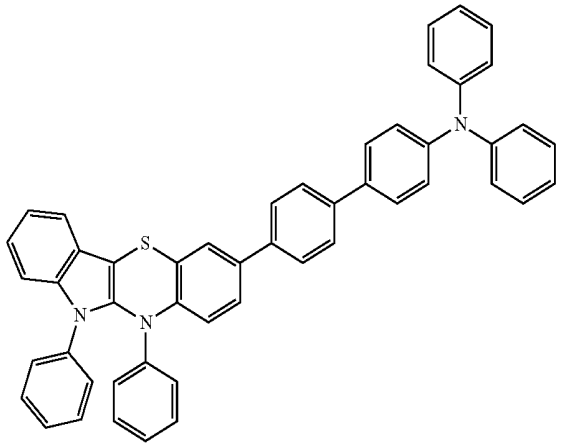
C60



C61

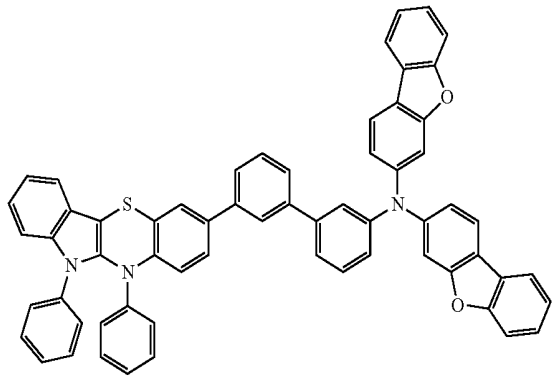


C62

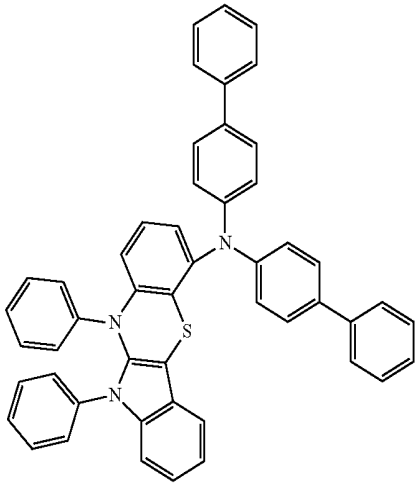


-continued

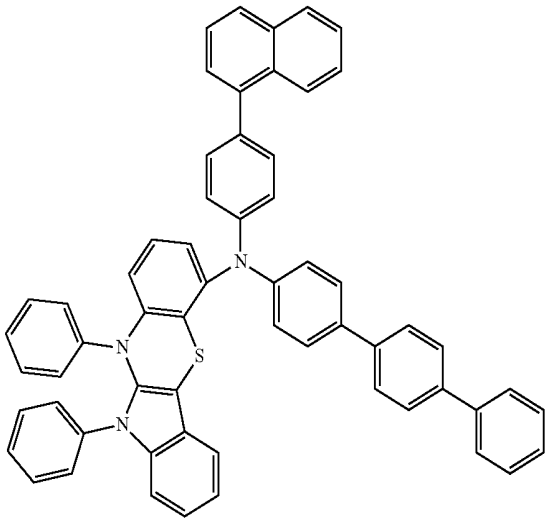
C63



C64

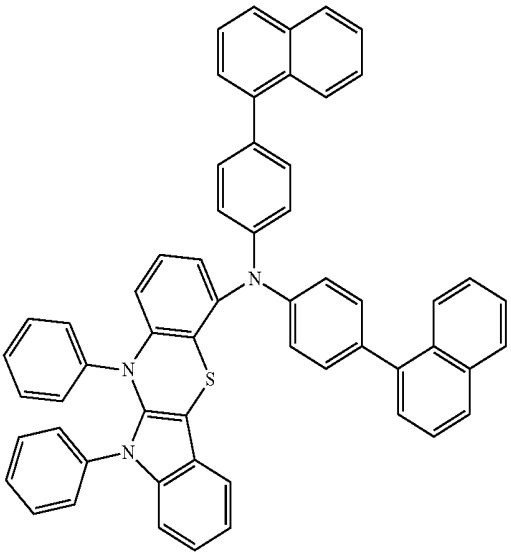


C65

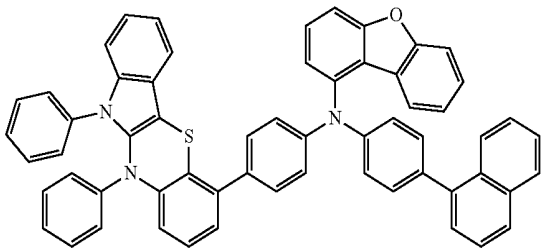


-continued

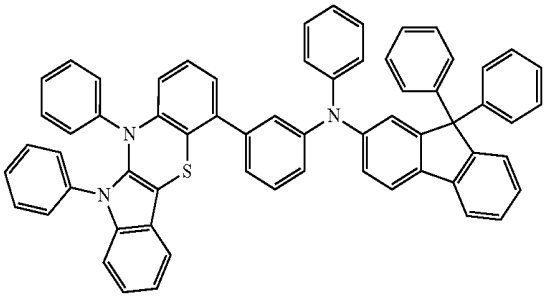
C66



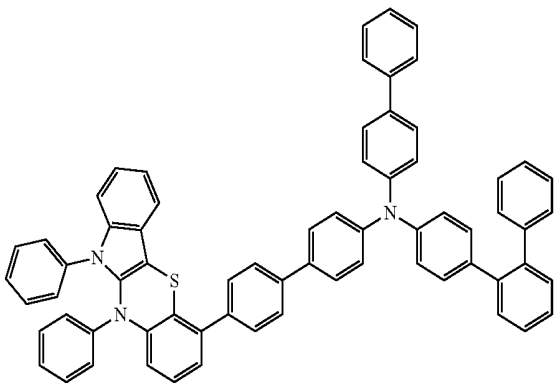
C67



C68

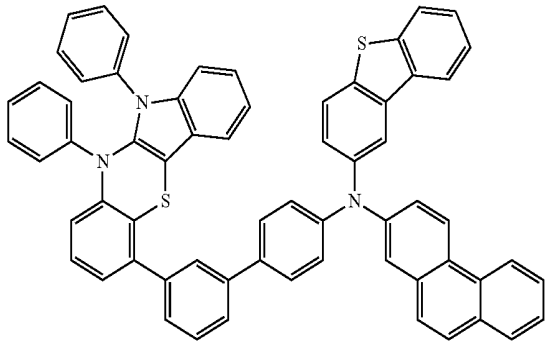


C69



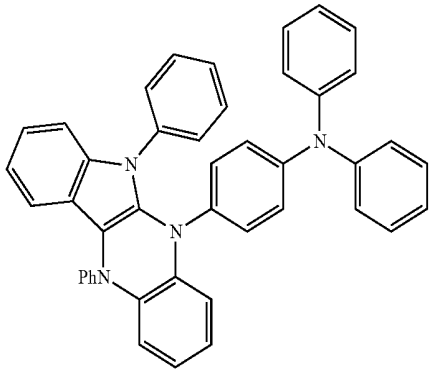
-continued

C70

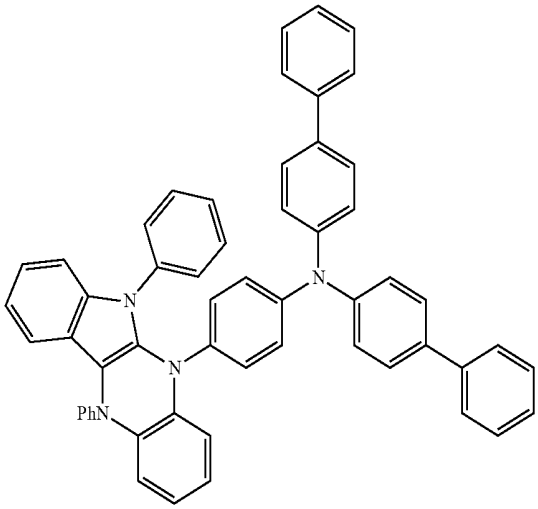


[Compound Group 4]

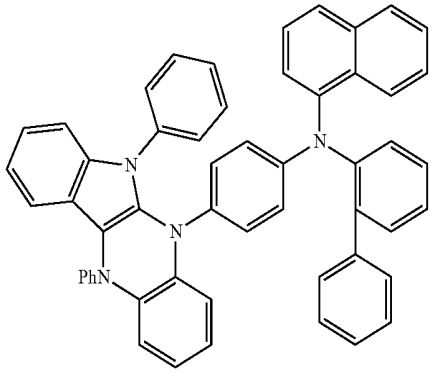
D1



D2

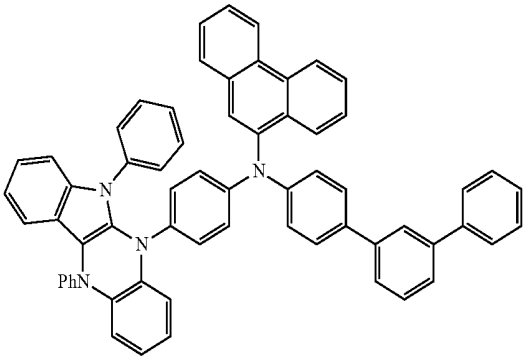


D3

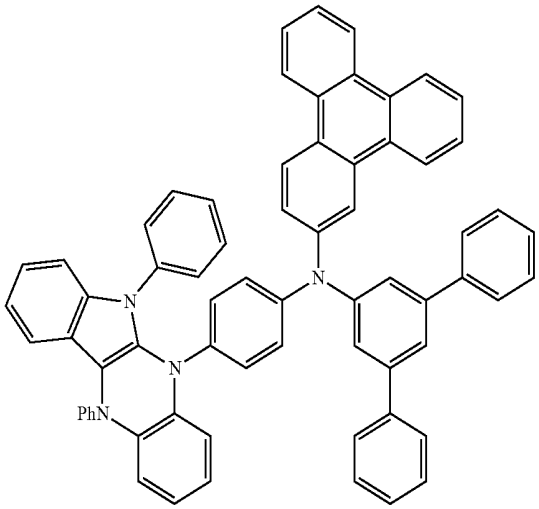


-continued

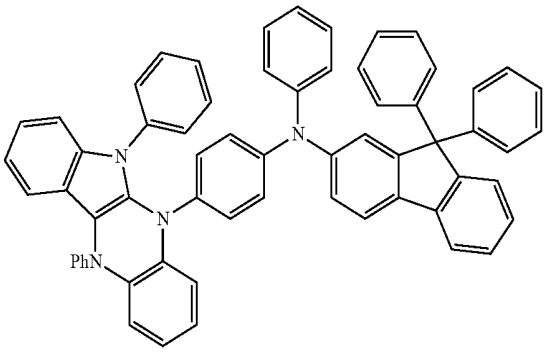
D4



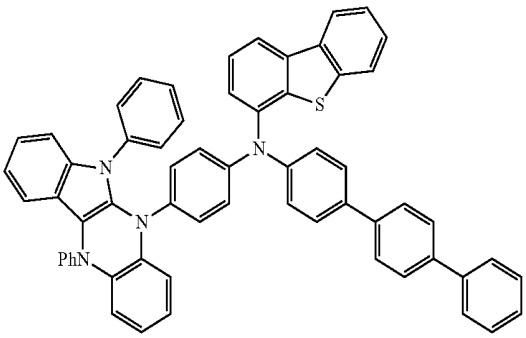
D5



D6

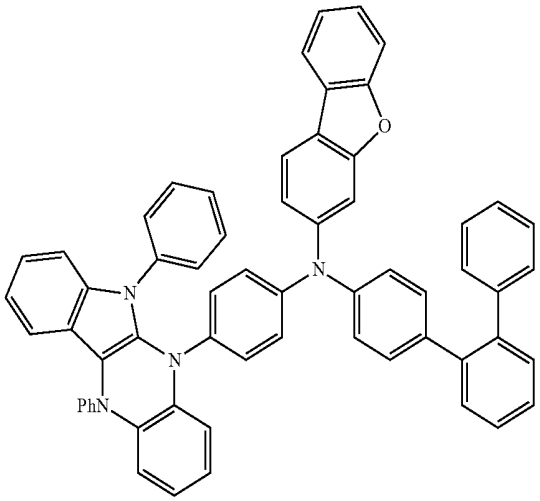


D7

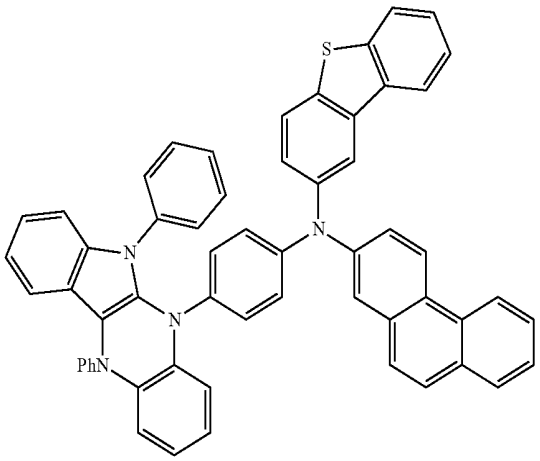


-continued

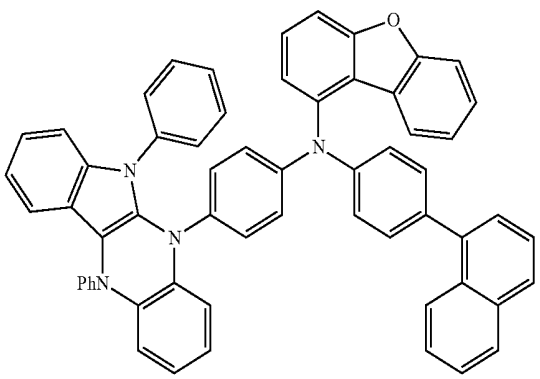
D8



D9

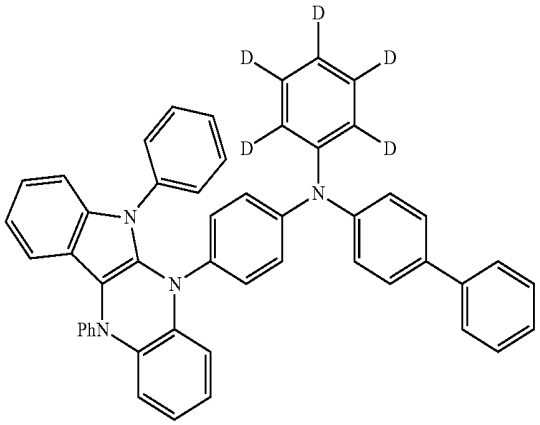


D10

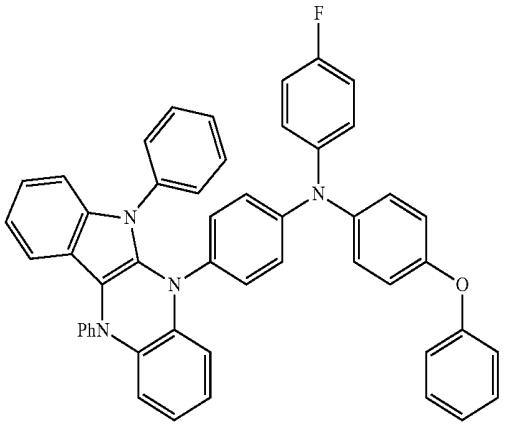


-continued

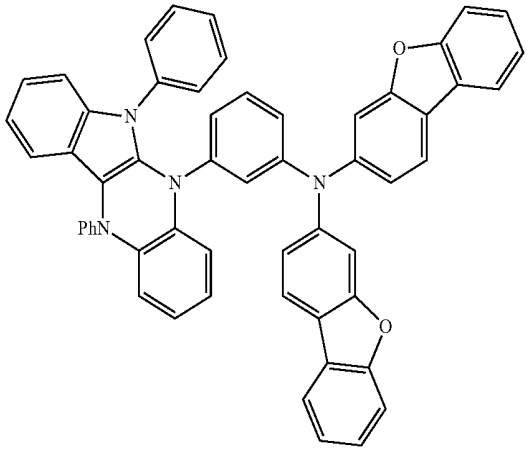
D11



D12

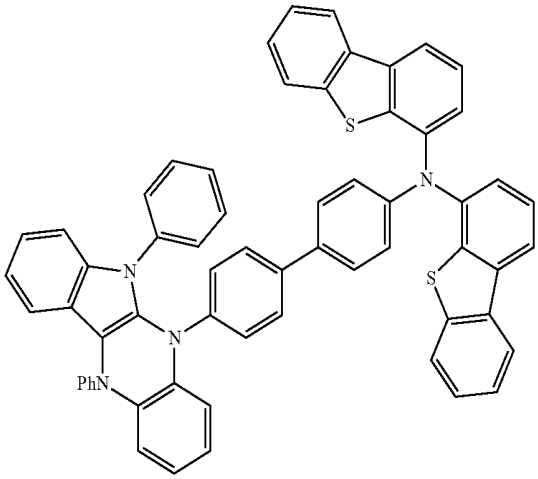


D13

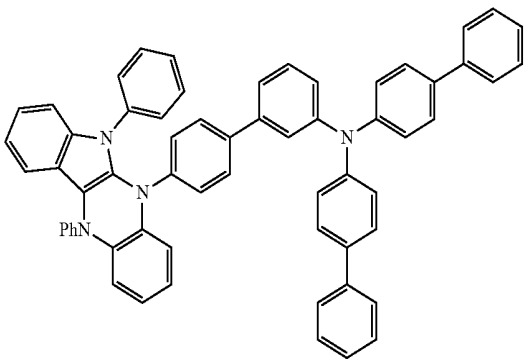


-continued

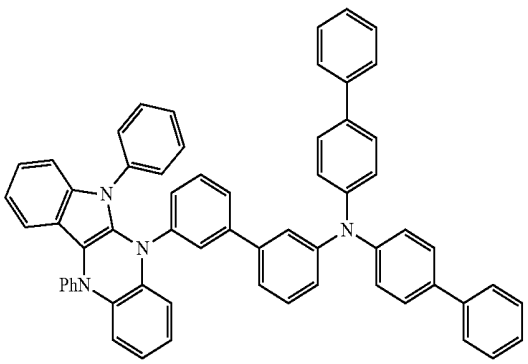
D14



D15

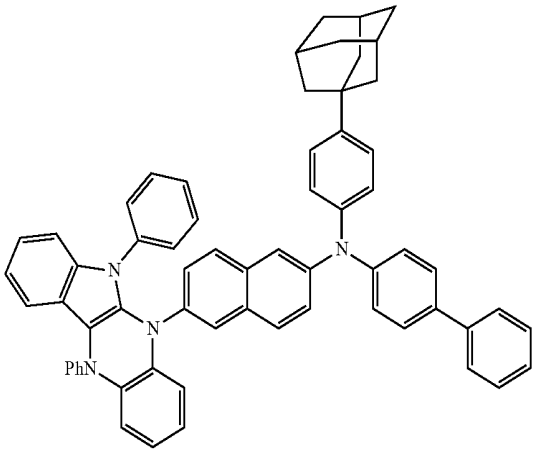


D16

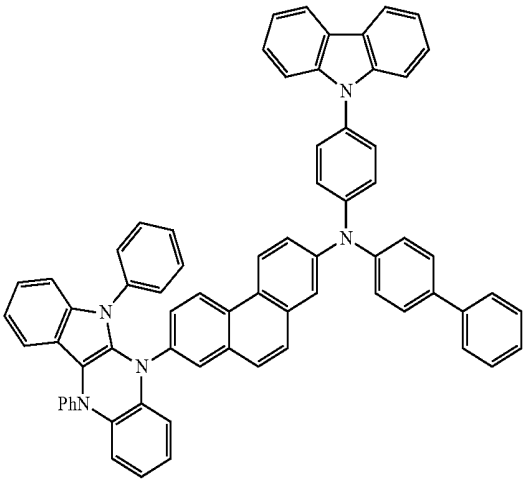


-continued

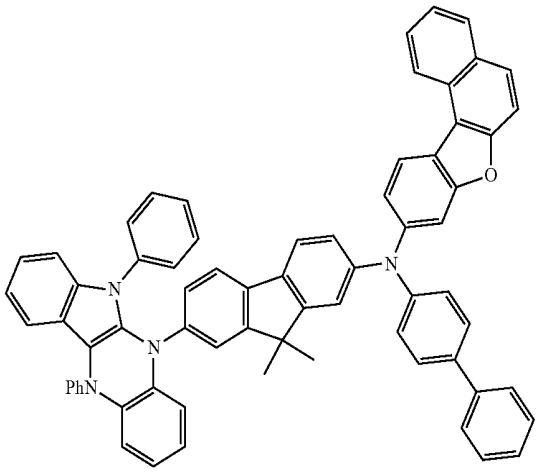
D17



D18

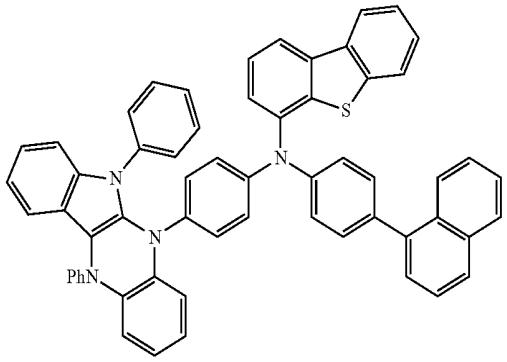


D19

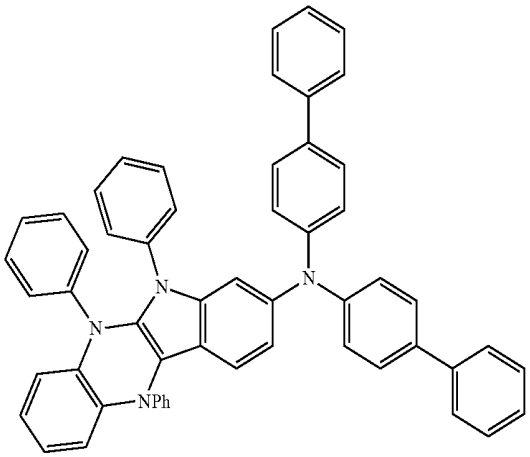


-continued

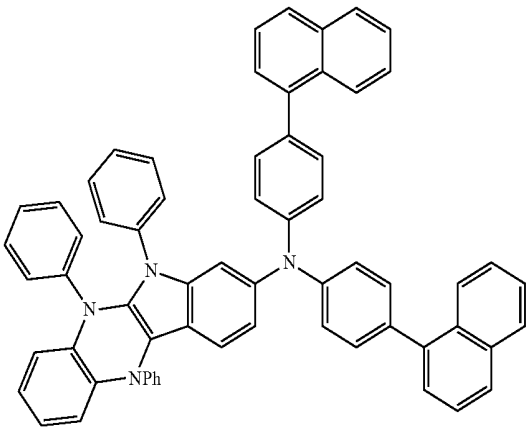
D20



D21

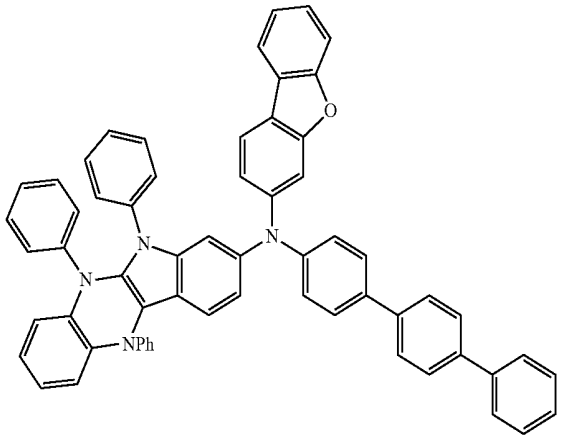


D22

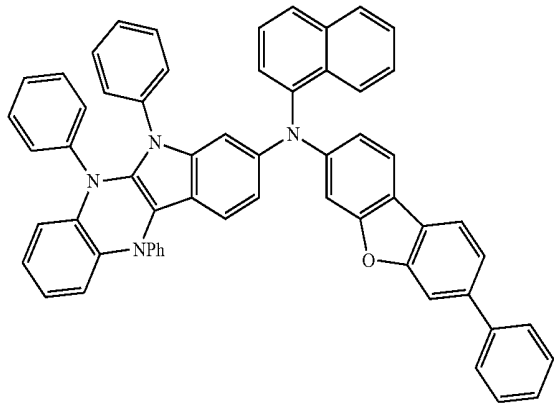


-continued

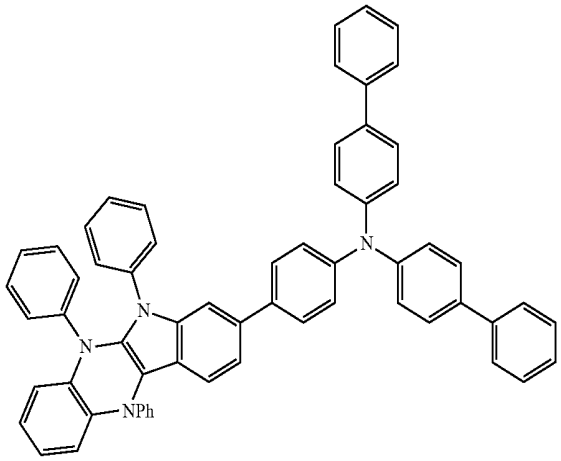
D23



D24

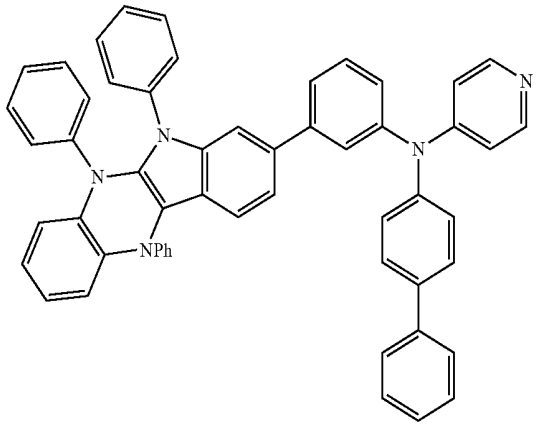


D25

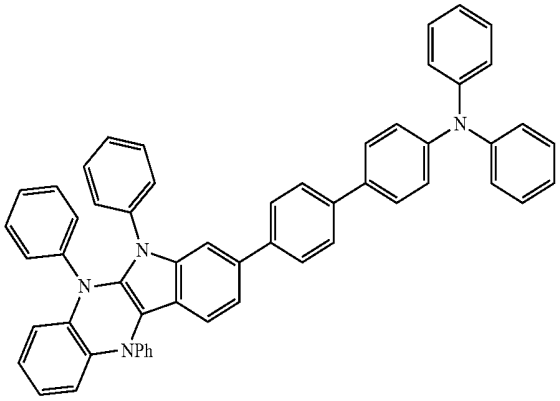


-continued

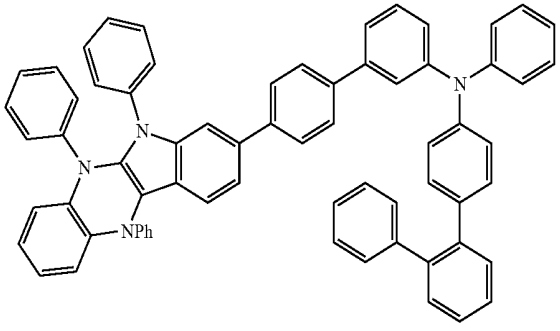
D26



D27

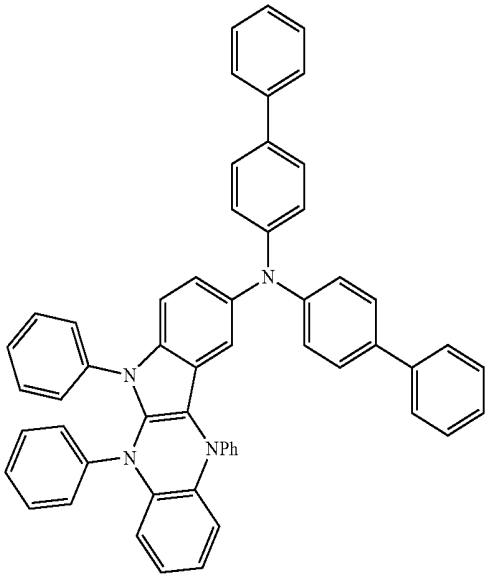


D28

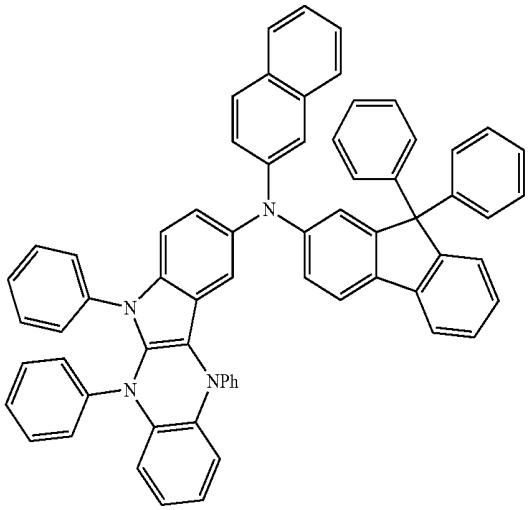


-continued

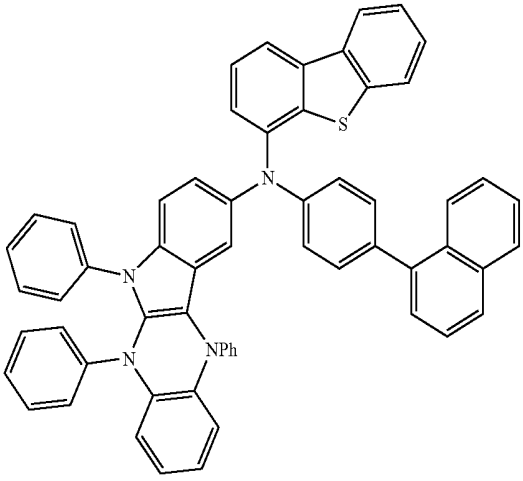
D29



D30

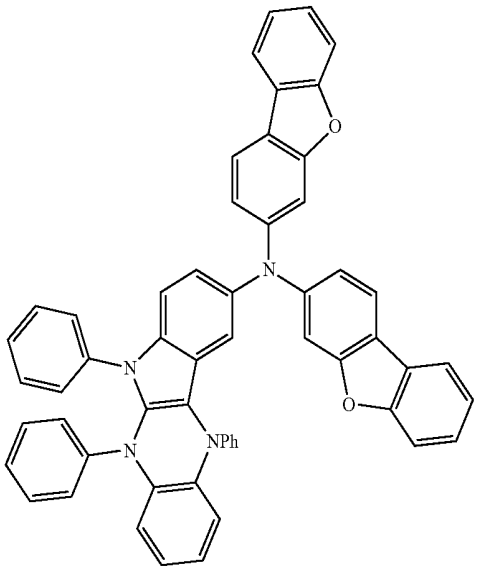


D31

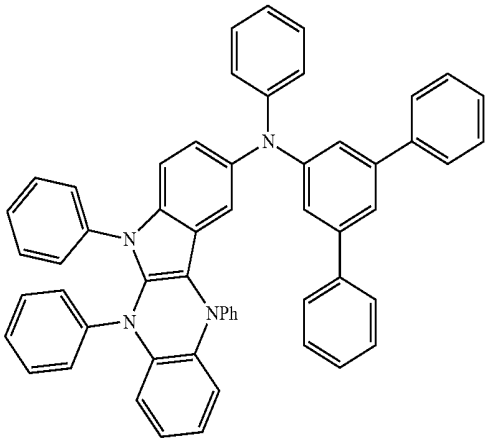


-continued

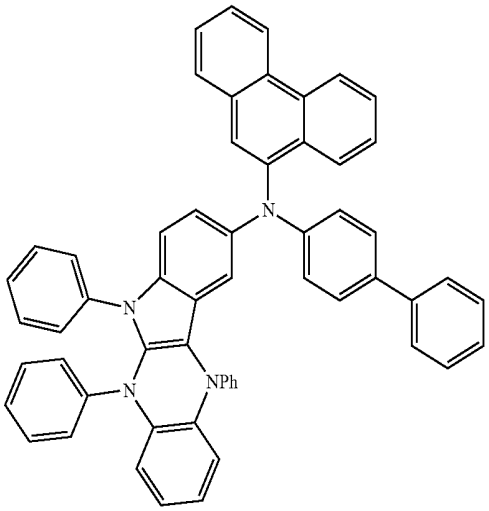
D32



D33

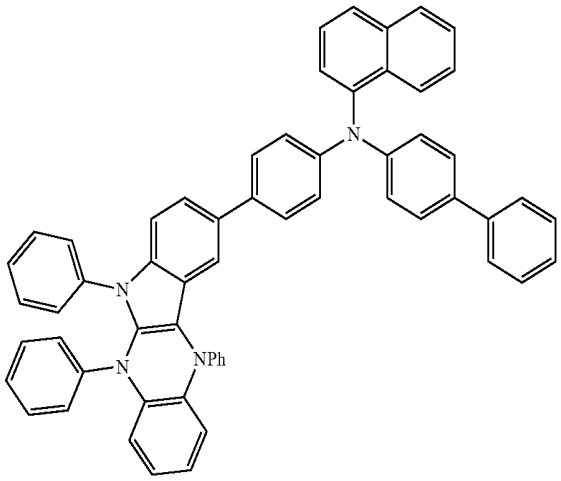


D34

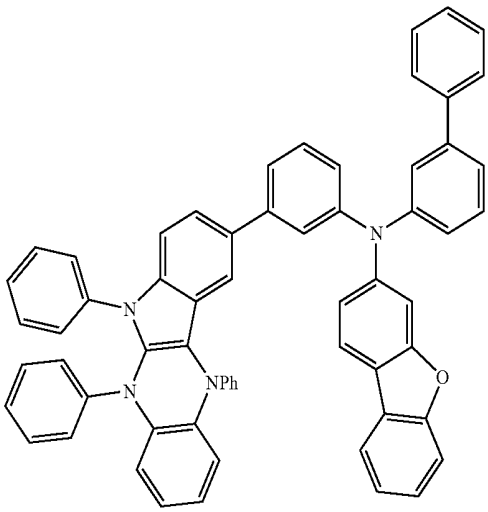


-continued

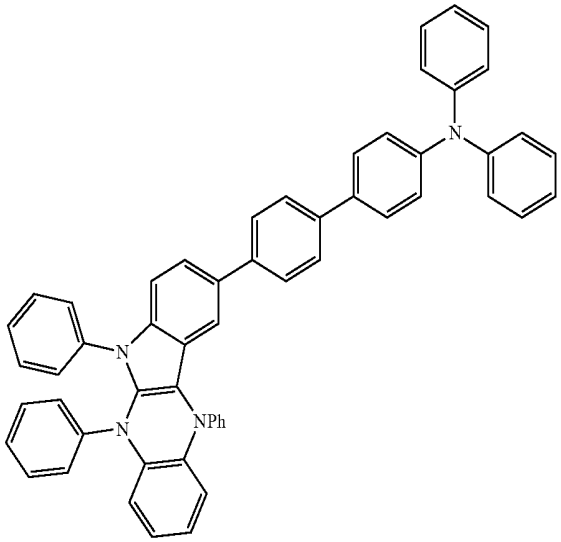
D35



D36

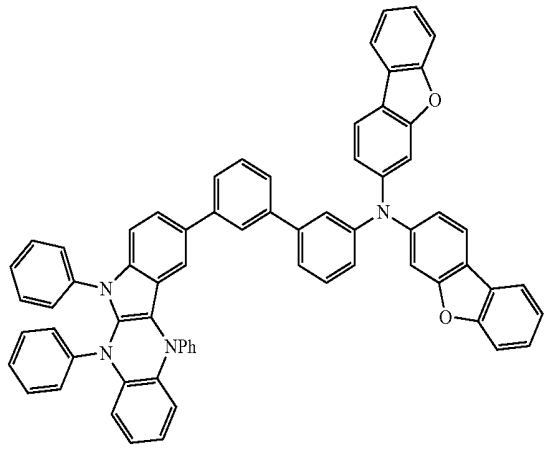


D37

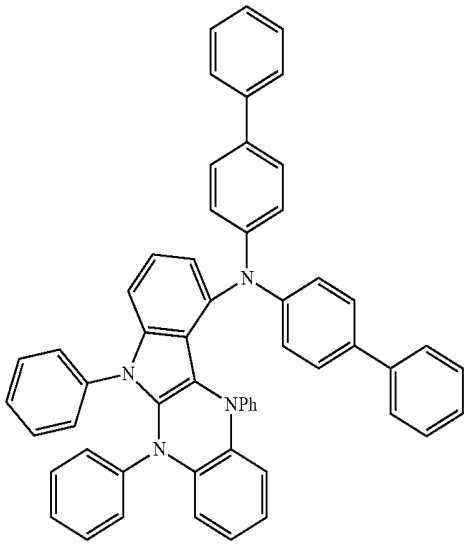


-continued

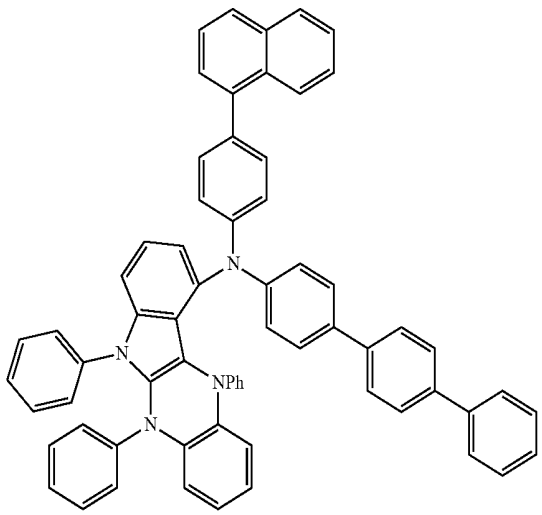
D38



D39

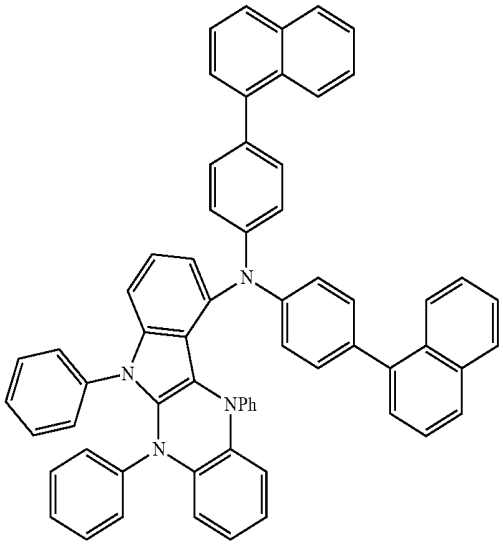


D40

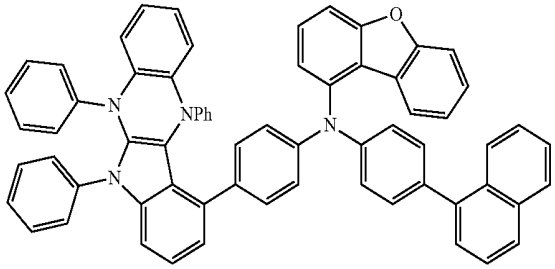


-continued

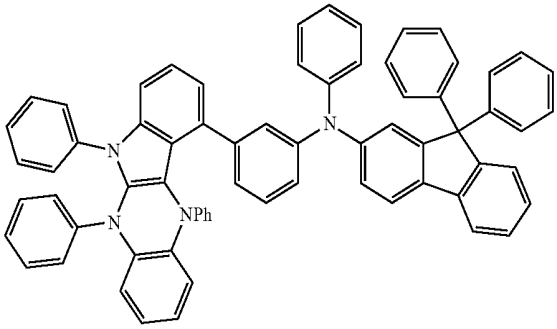
D41



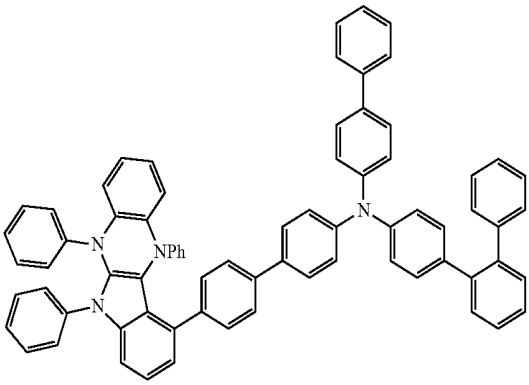
D42



D43

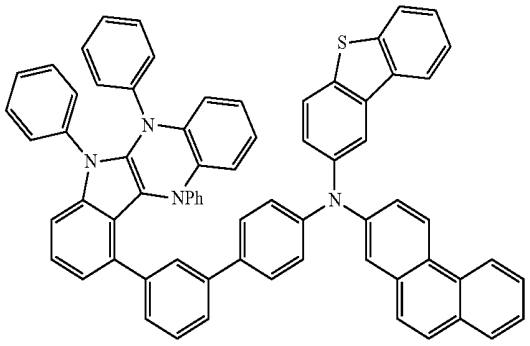


D44

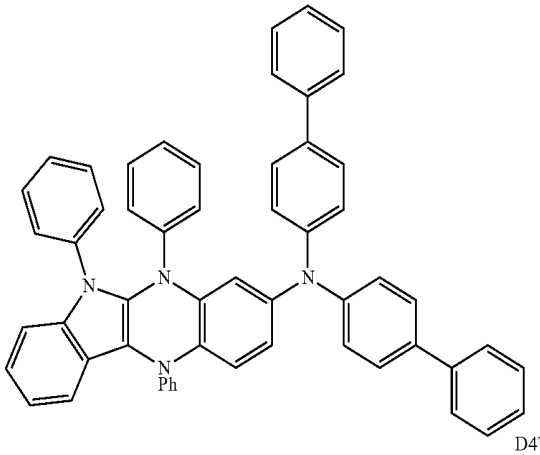


-continued

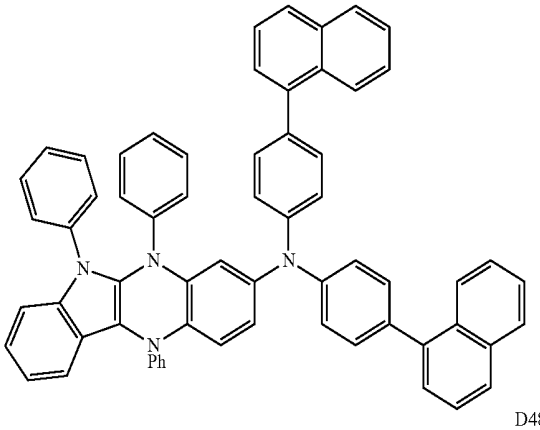
D45



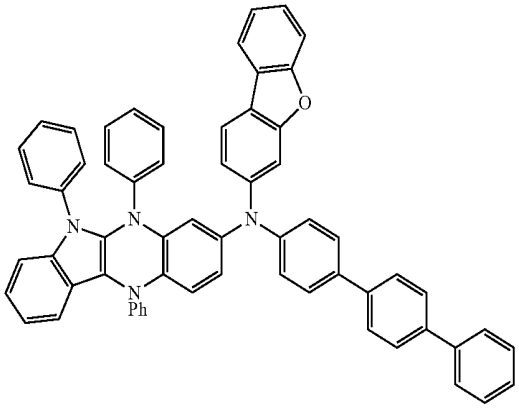
D46



D47

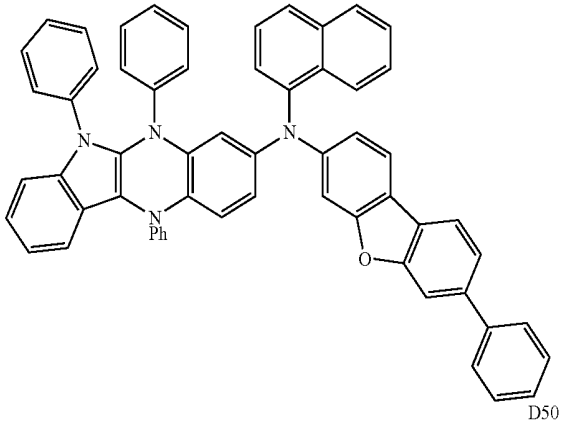


D48

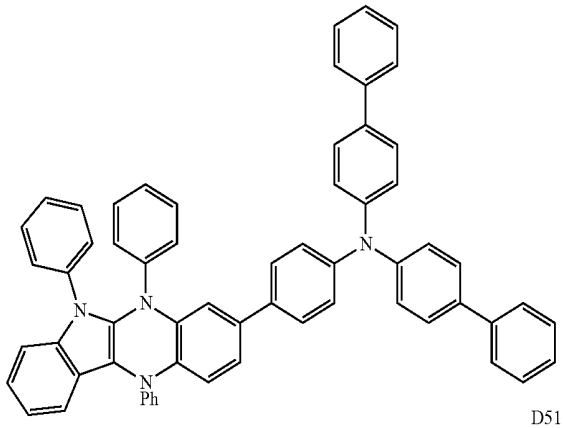


-continued

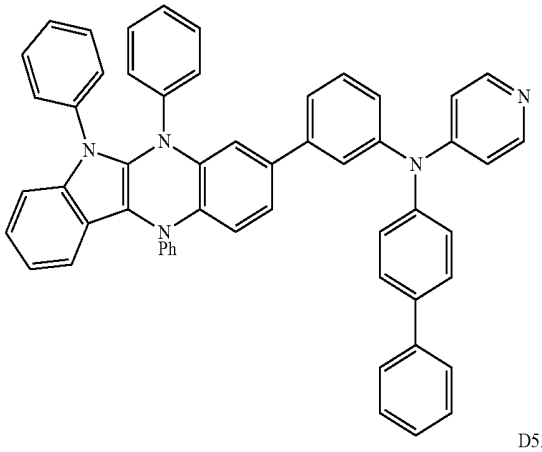
D49



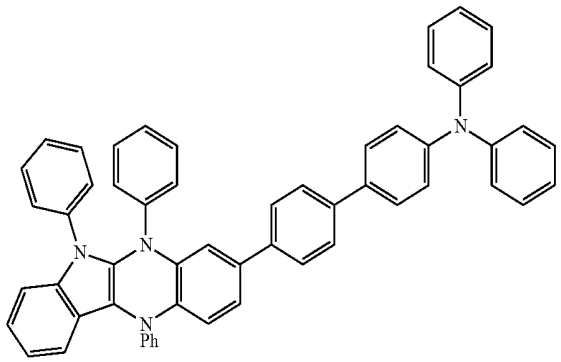
D50



D51

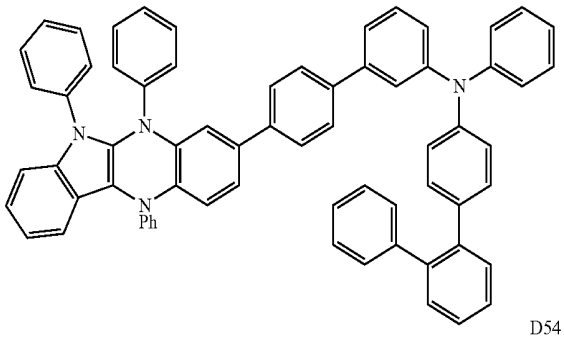


D52

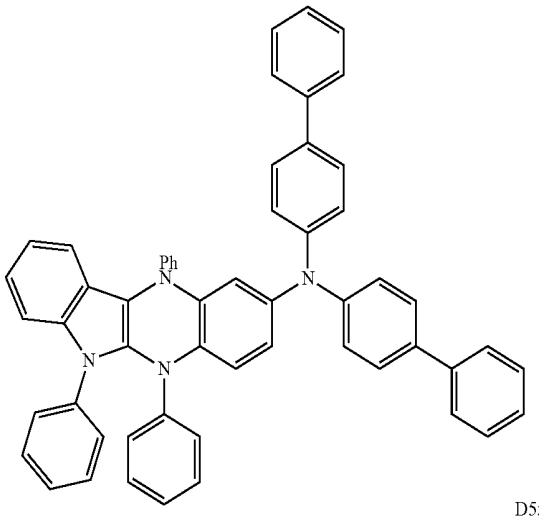


-continued

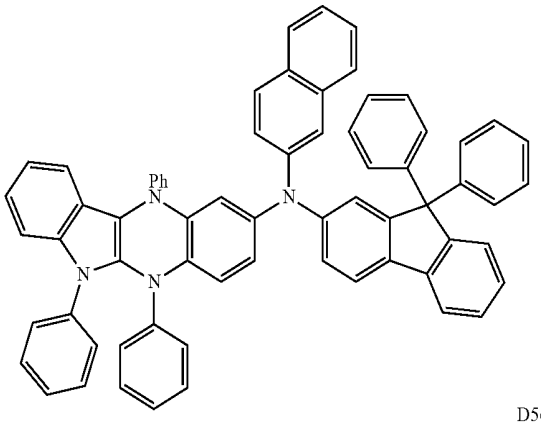
D53



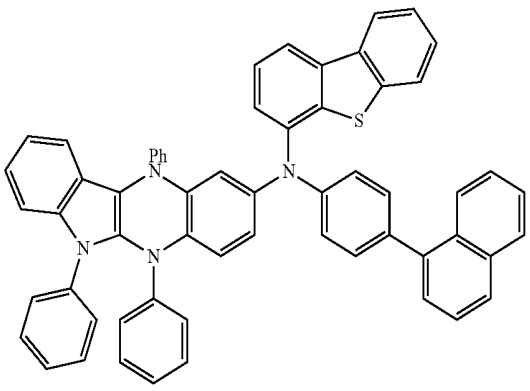
D54



D55

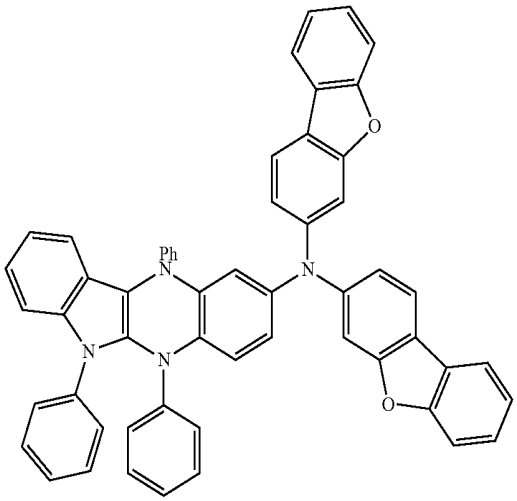


D56

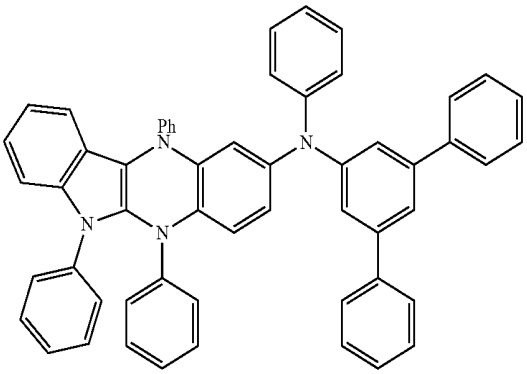


-continued

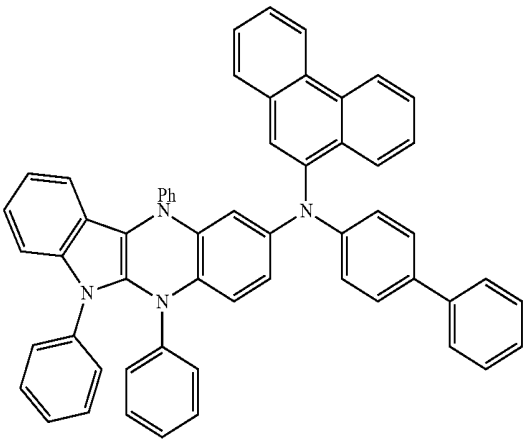
D57



D58

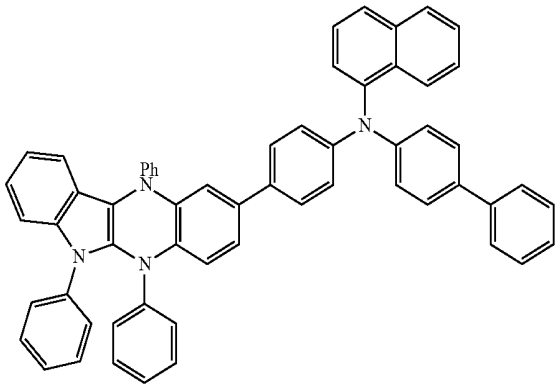


D59



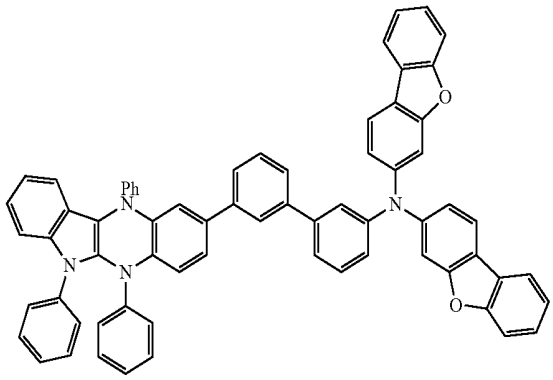
-continued

D60

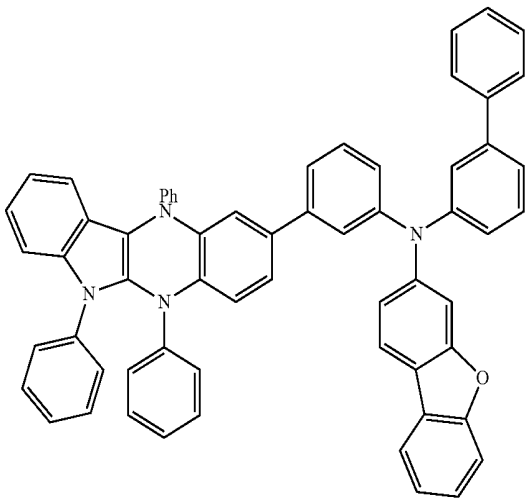


-continued

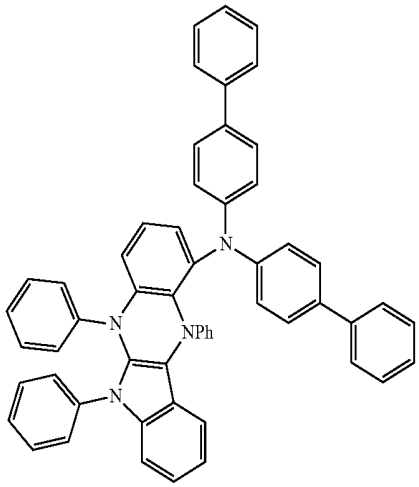
D63



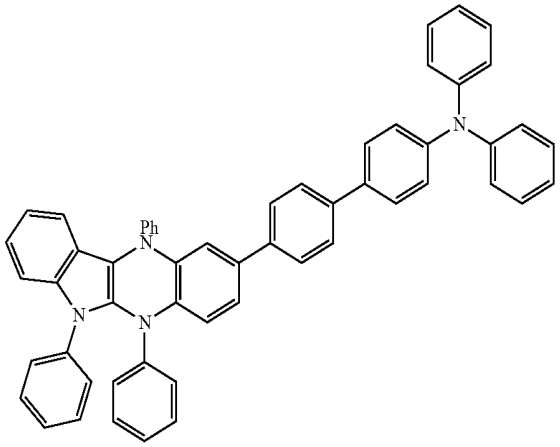
D61



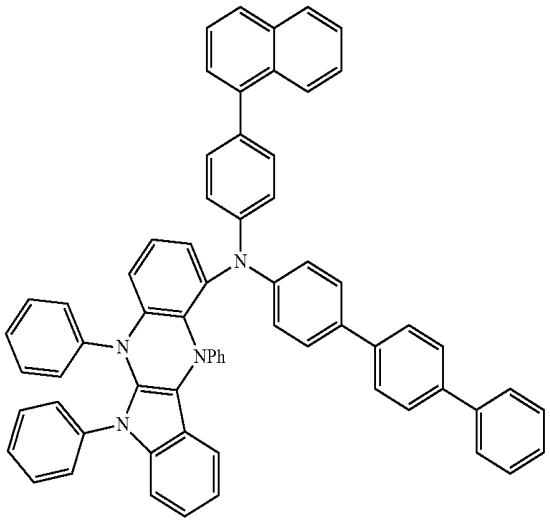
D64



D62

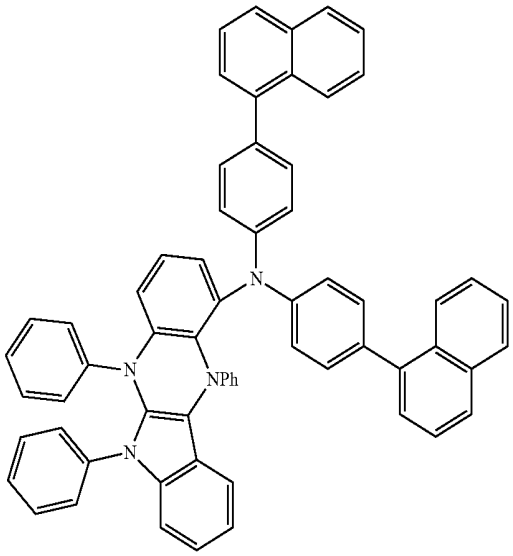


D65

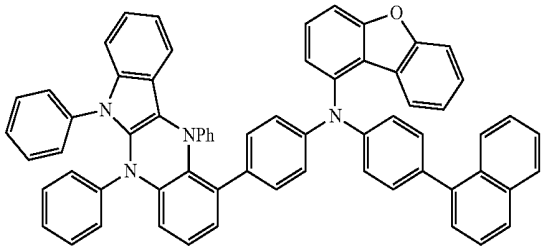


-continued

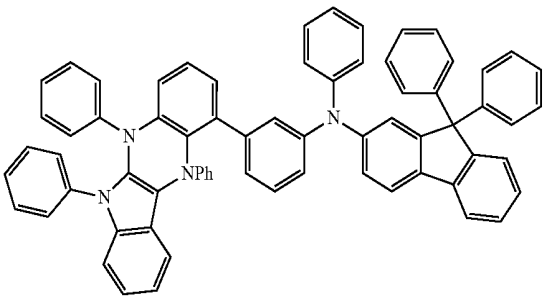
D66



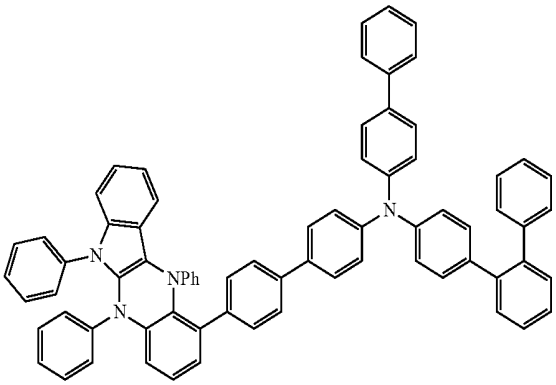
D67



D68

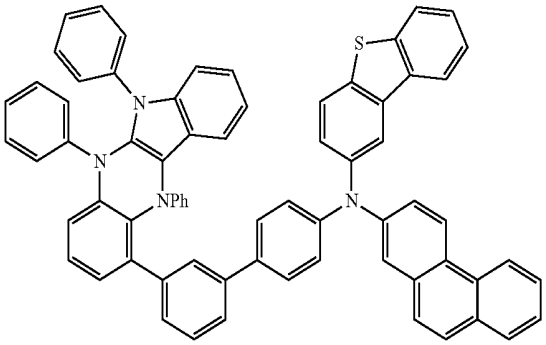


D69



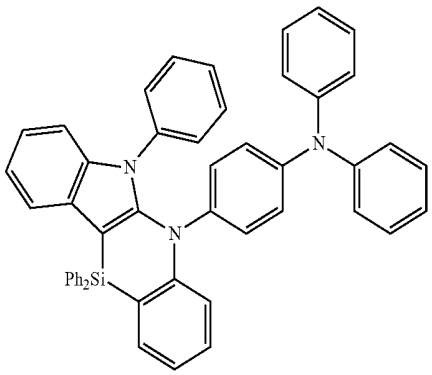
-continued

D70

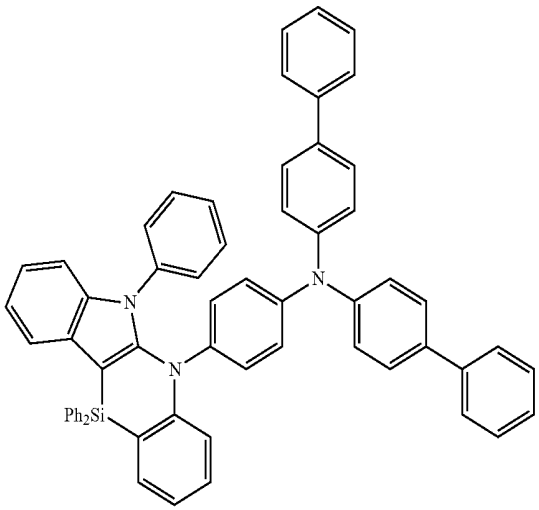


[Compound 5 Group 5]

E1

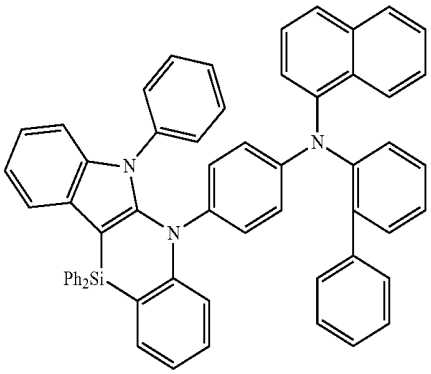


E2

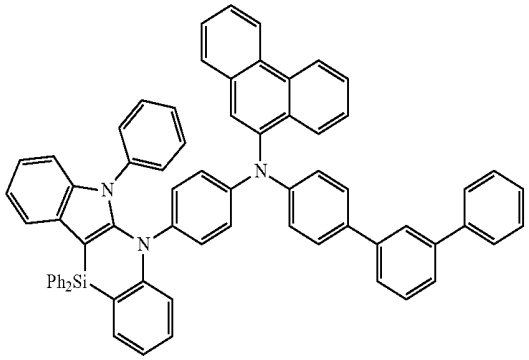


-continued

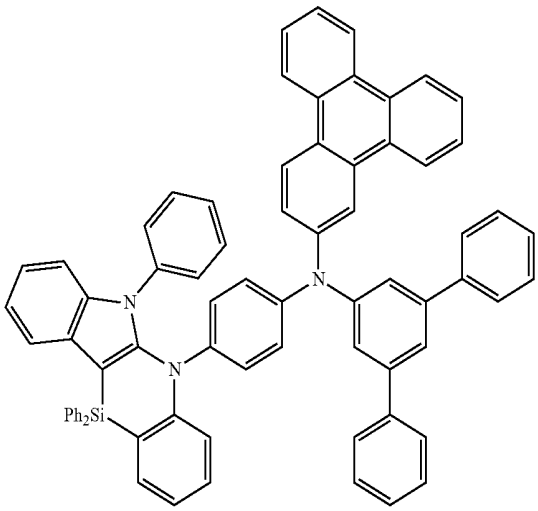
E3



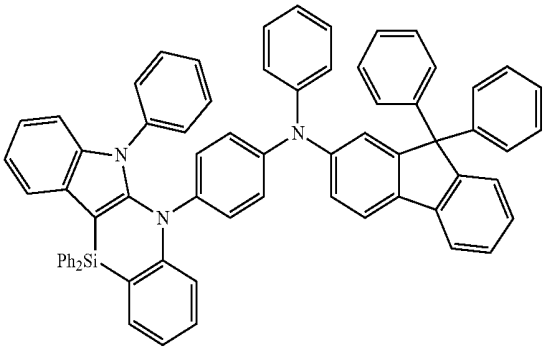
E4



E5

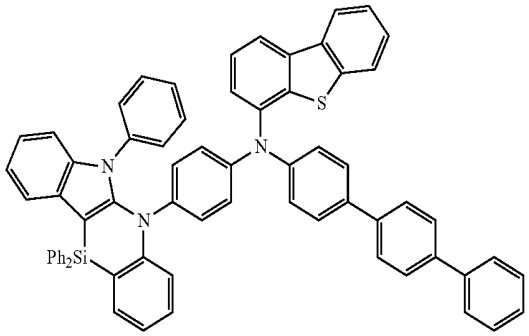


E6

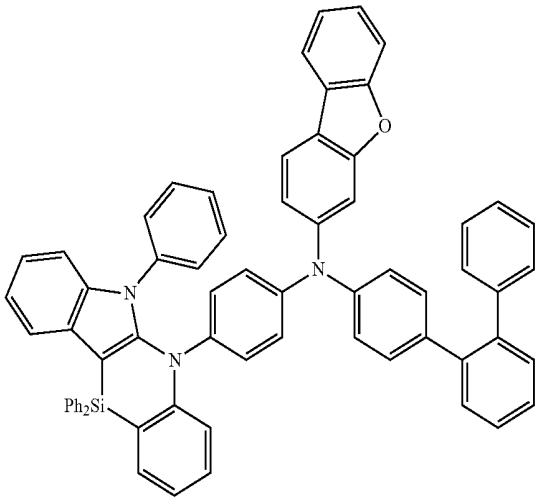


-continued

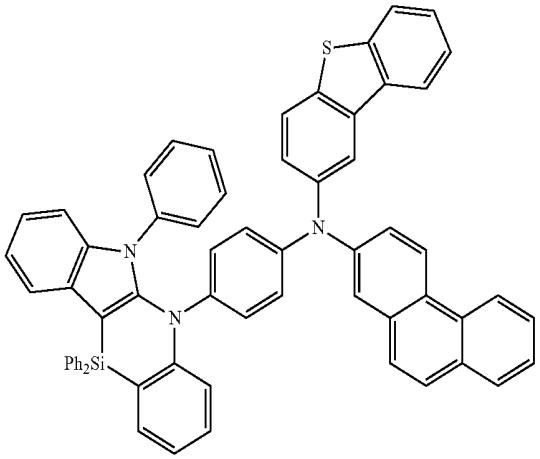
E7



E8

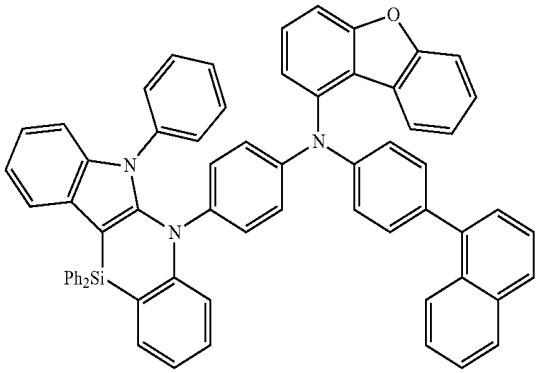


E9

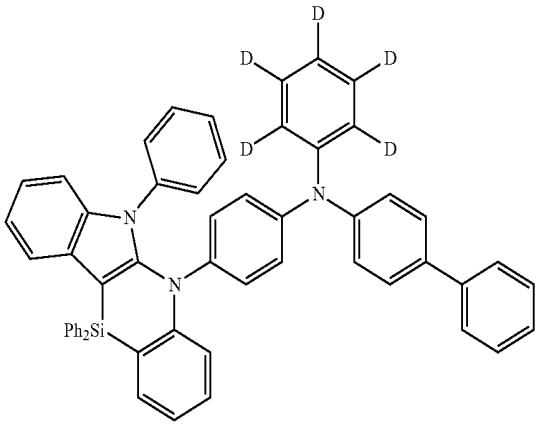


-continued

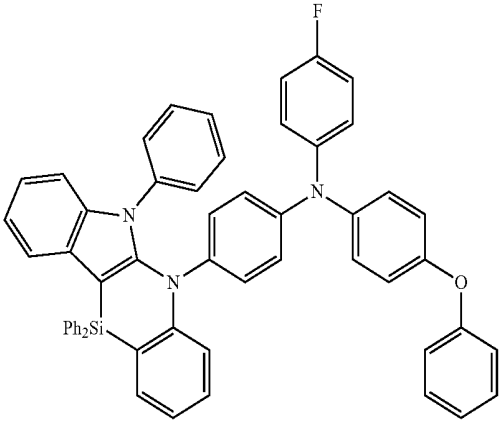
E10



E11

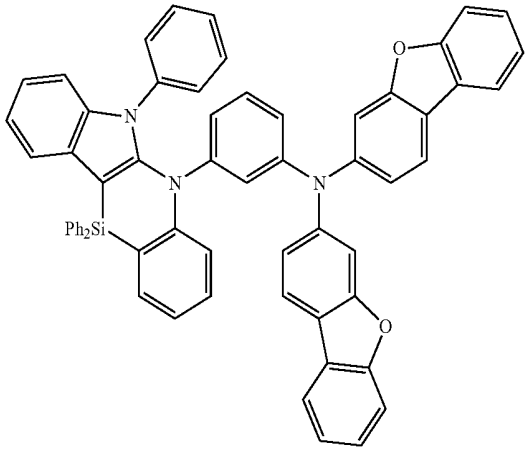


E12

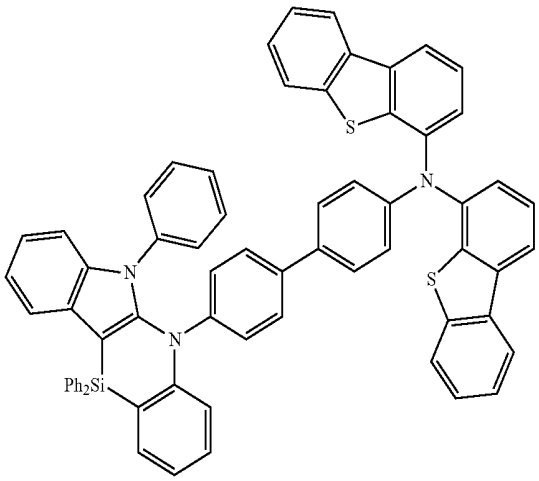


-continued

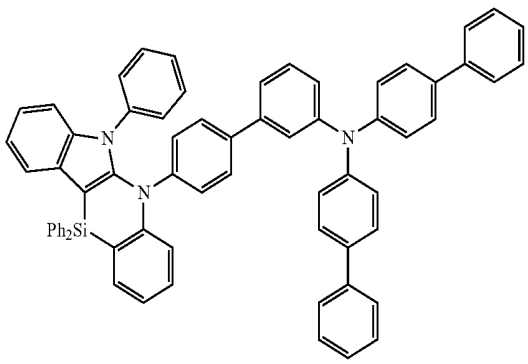
E13



E14

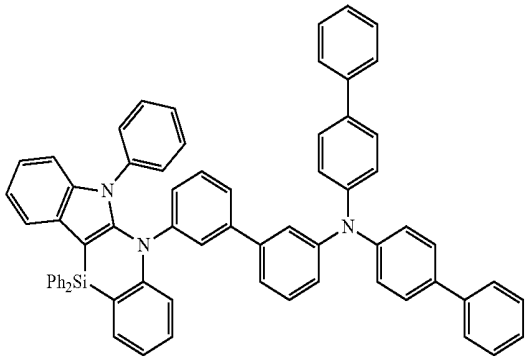


E15

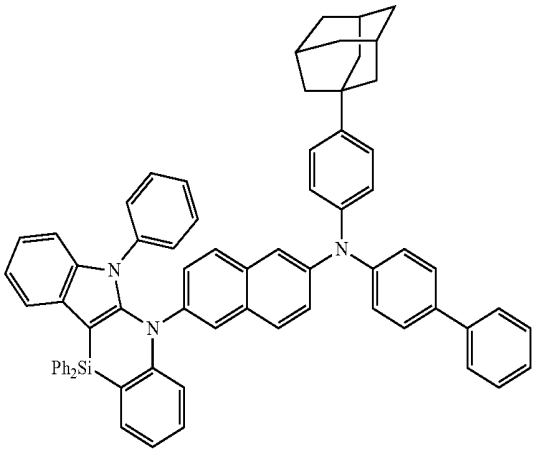


-continued

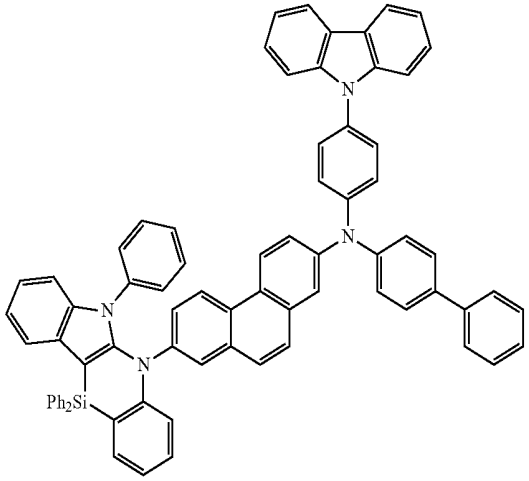
E16



E17

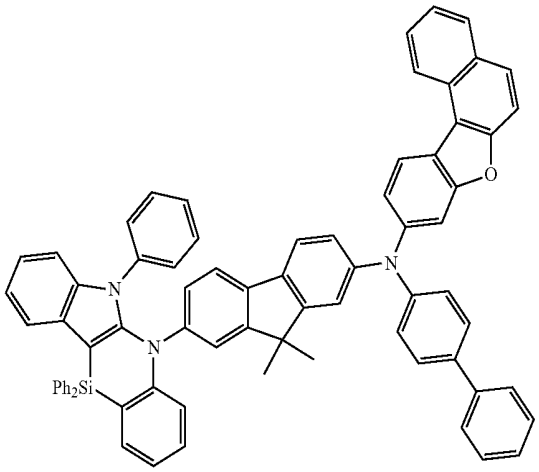


E18

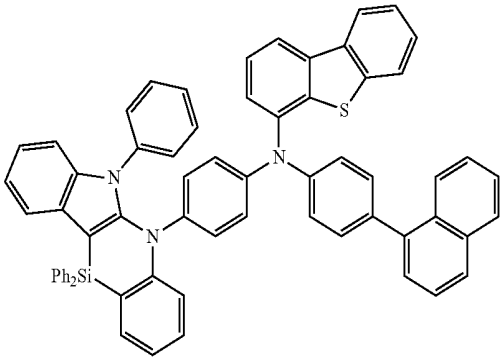


-continued

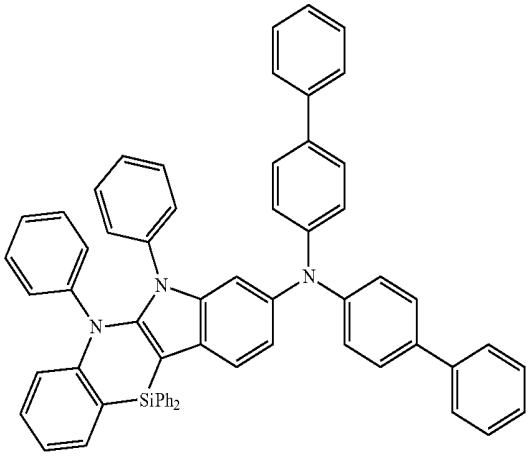
E19



E20

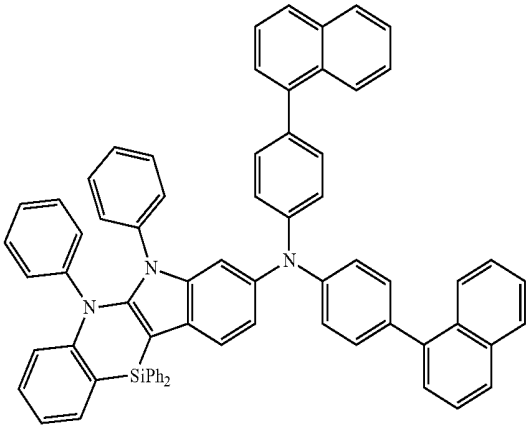


E21

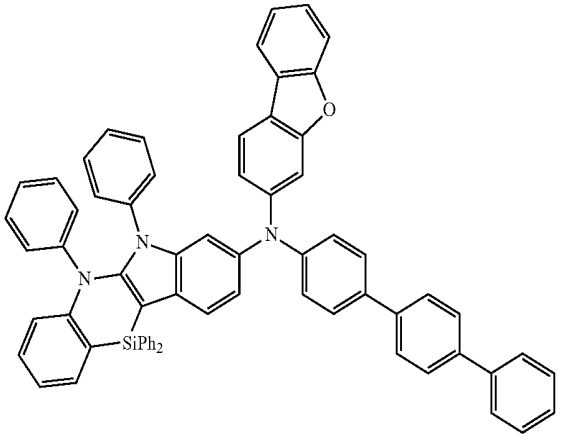


-continued

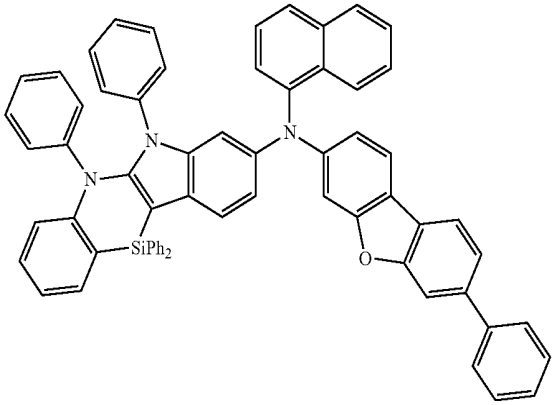
E22



E23

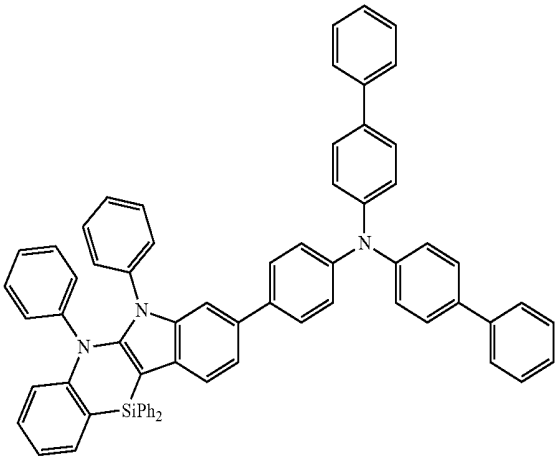


E24

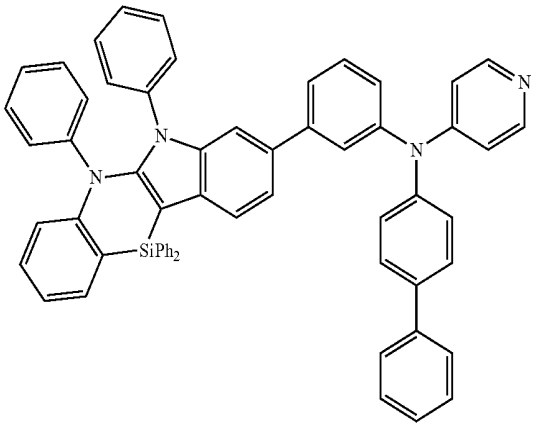


-continued

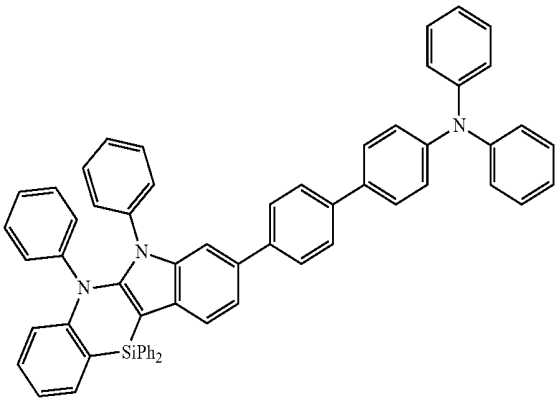
E25



E26

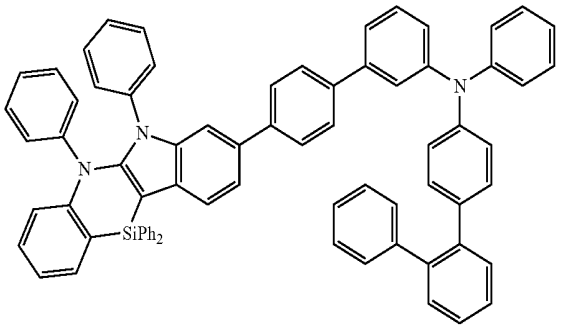


E27

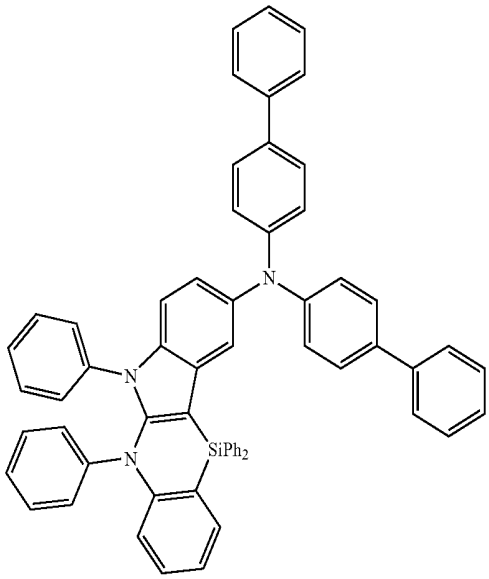


-continued

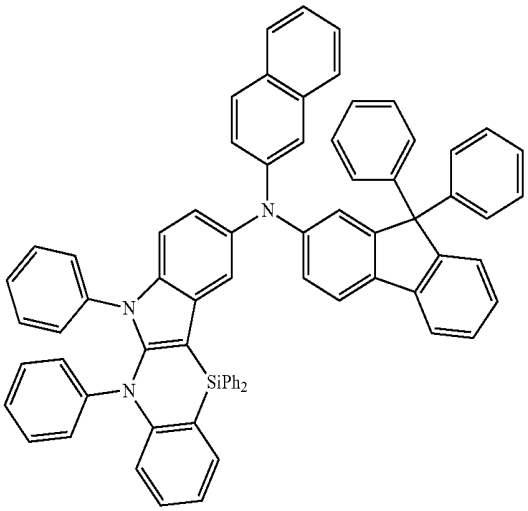
E28



E29

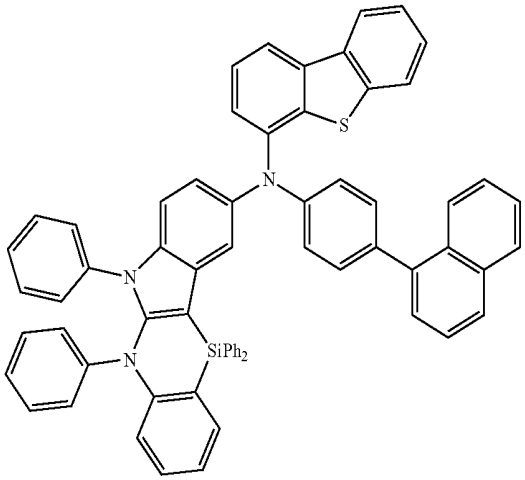


E30

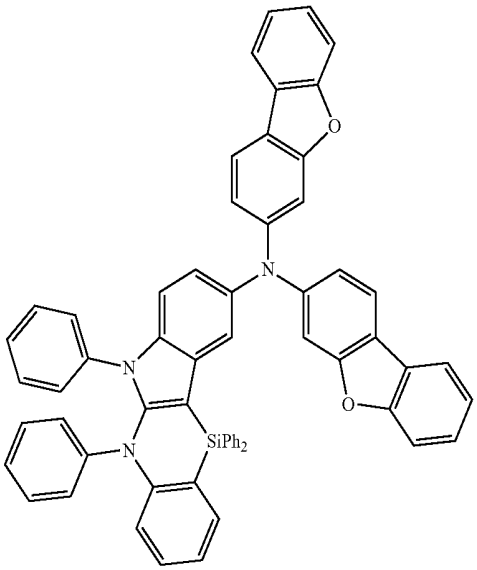


-continued

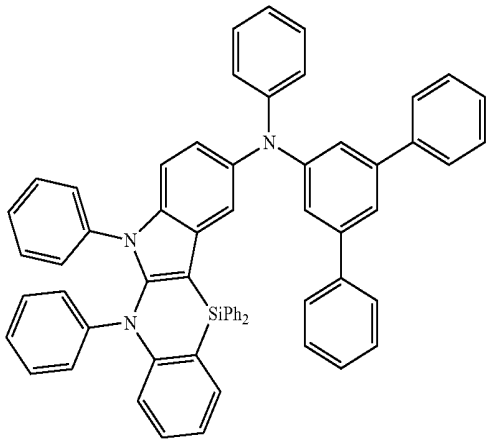
E31



E32

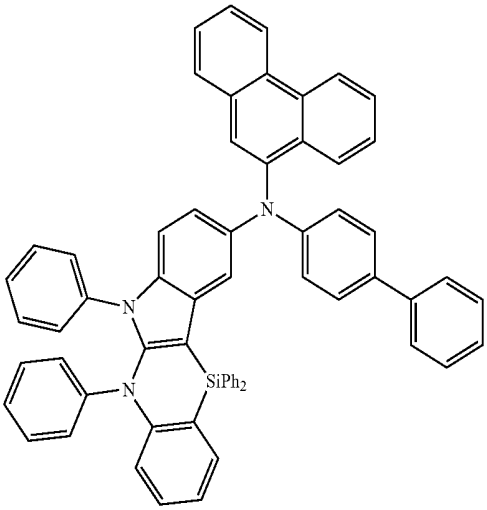


E33

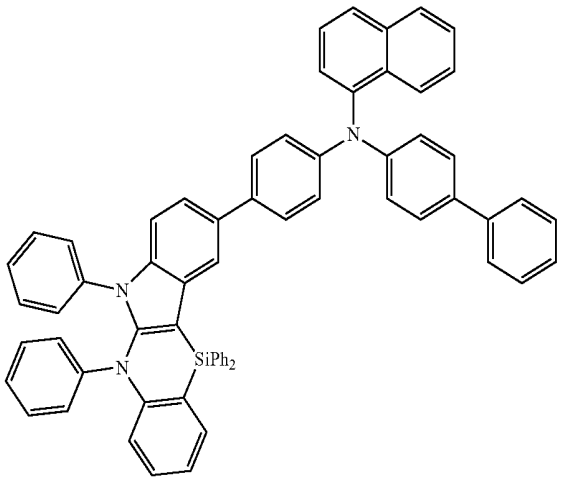


-continued

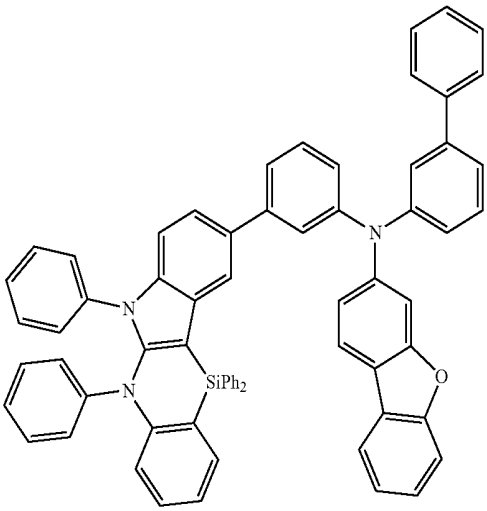
E34



E35

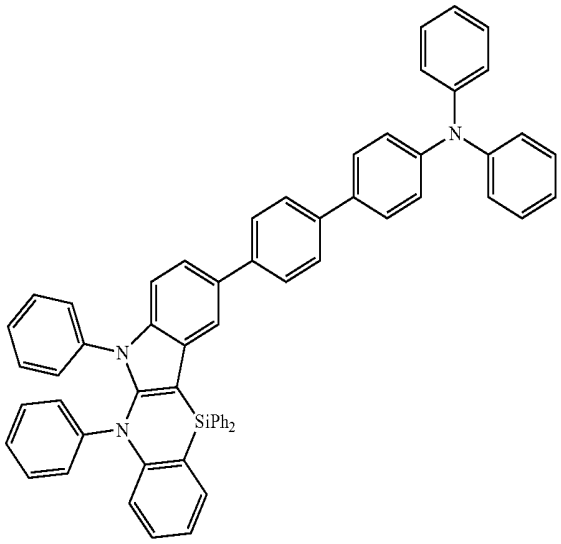


E36

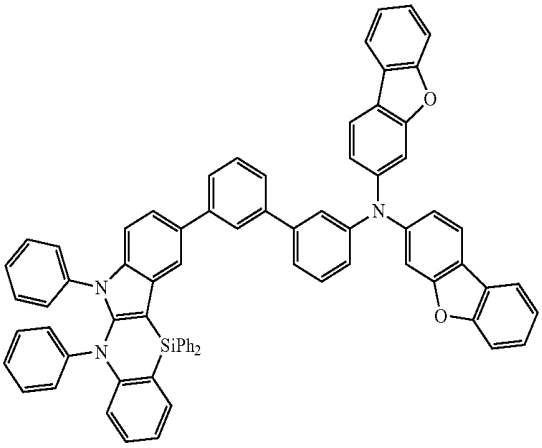


-continued

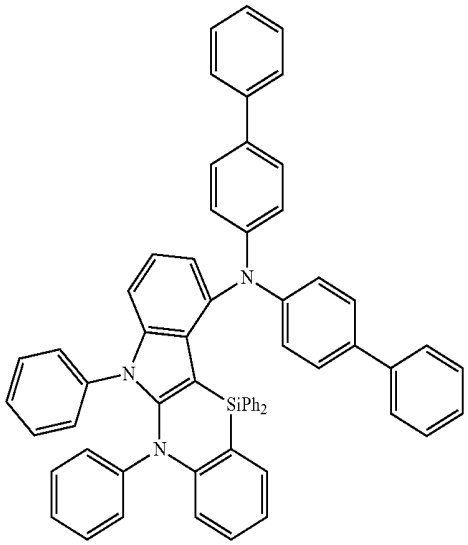
E37



E38

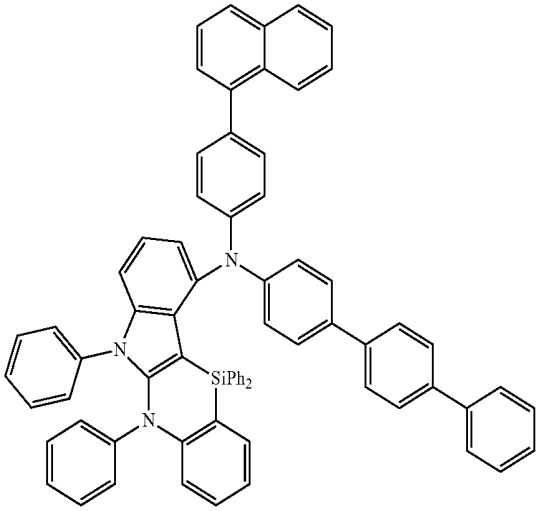


E39

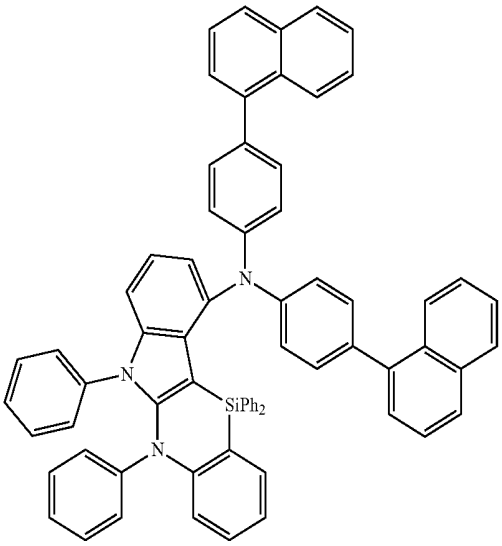


-continued

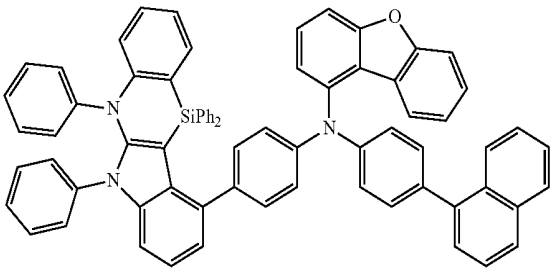
E40



E41

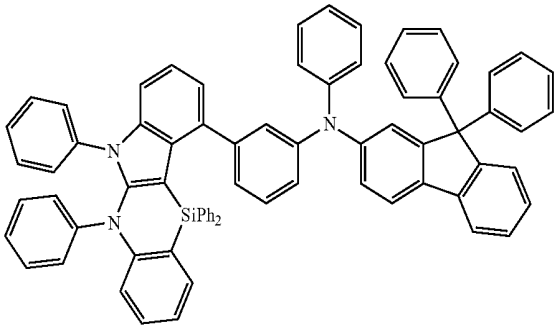


E42

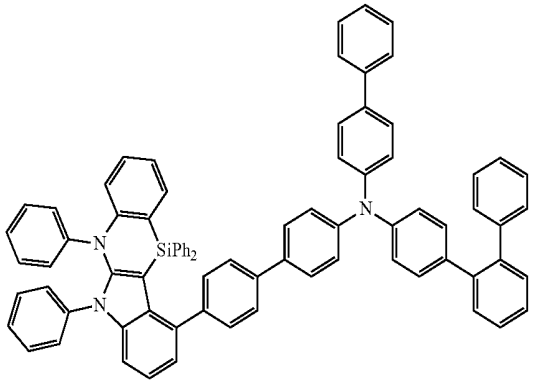


-continued

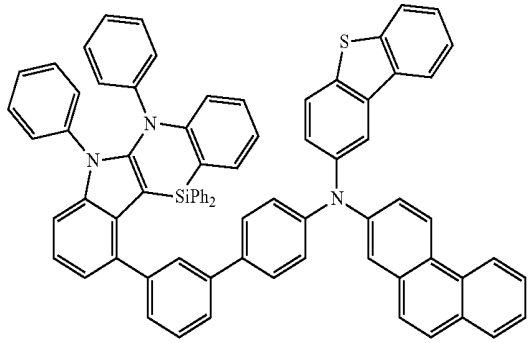
E43



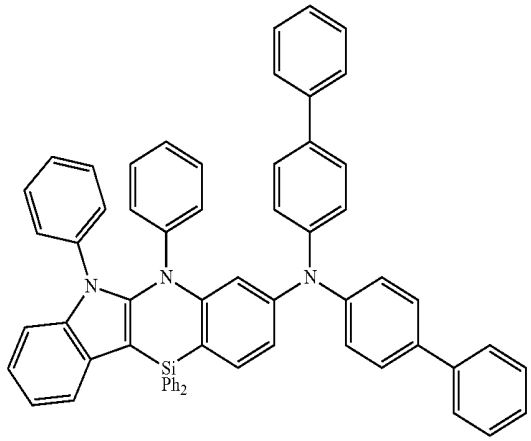
E44



E45

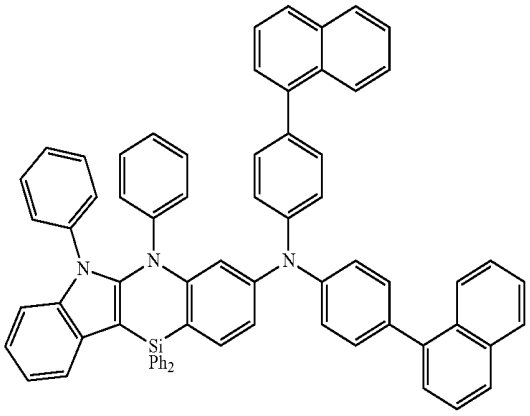


E46

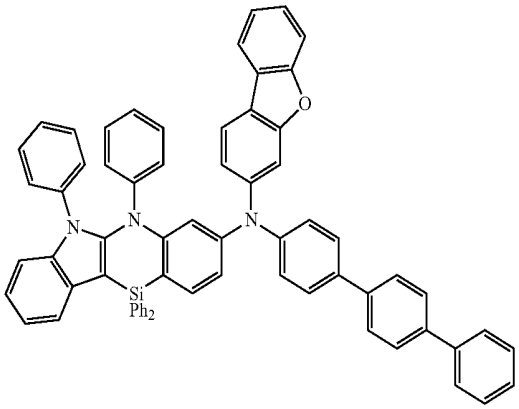


-continued

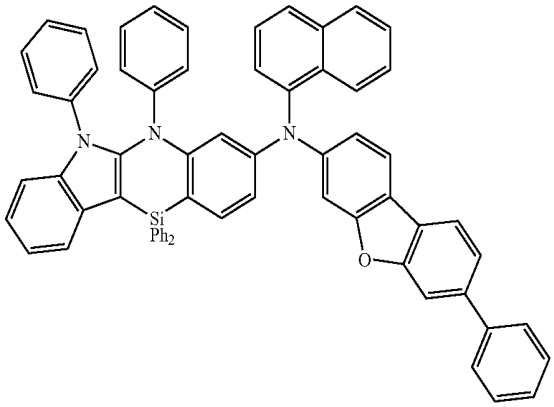
E47



E48

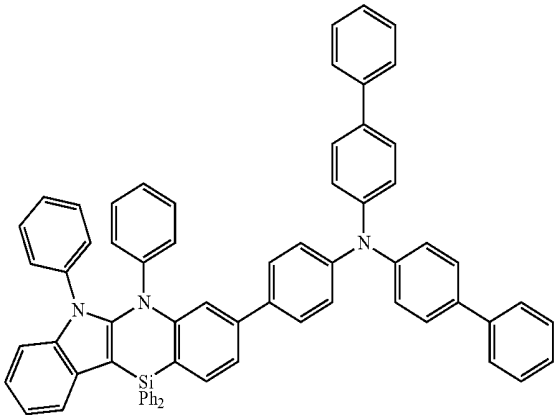


E49

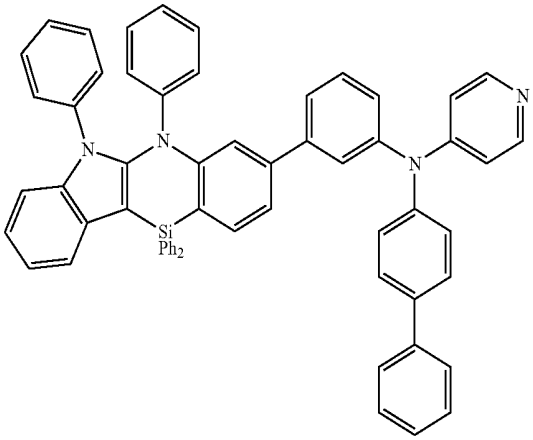


-continued

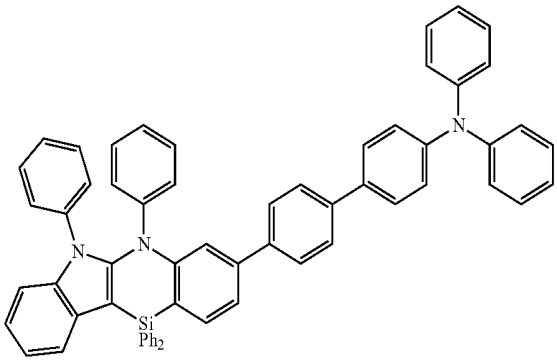
E50



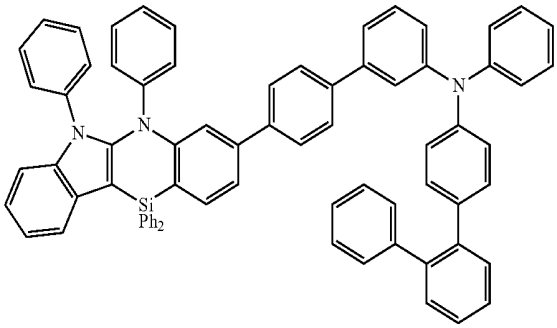
E51



E52

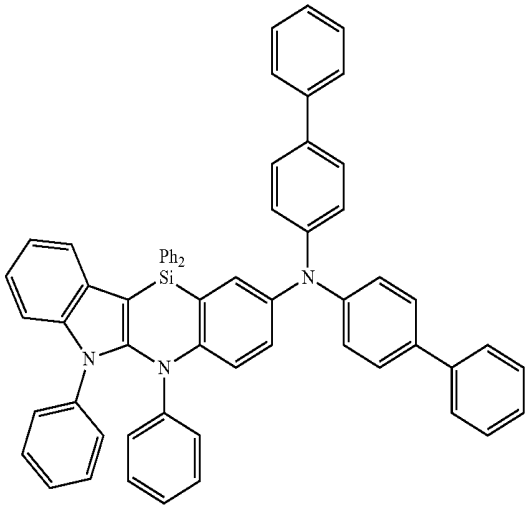


E53

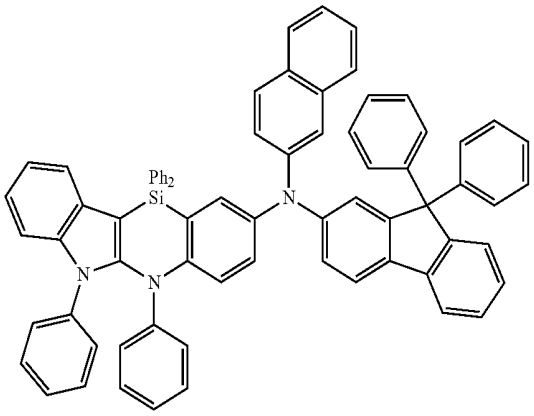


-continued

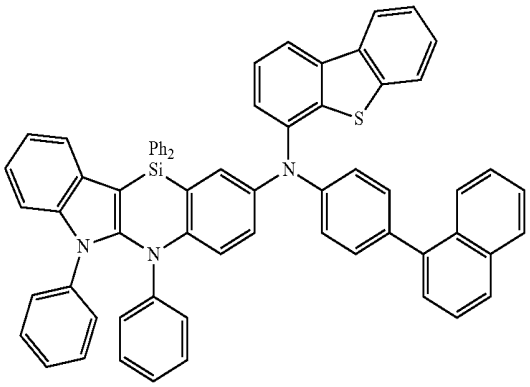
E54



E55

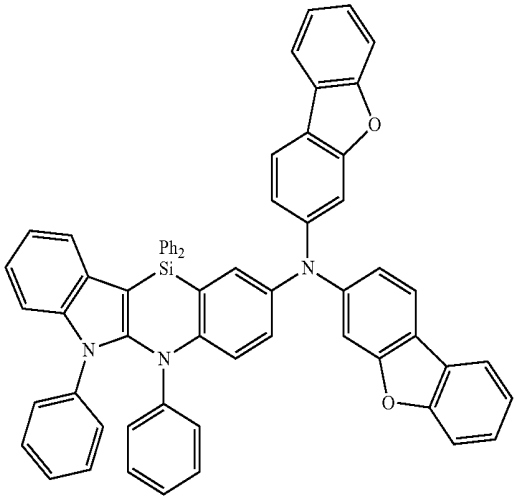


E56

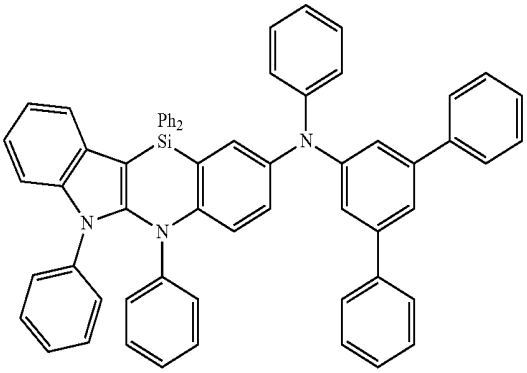


-continued

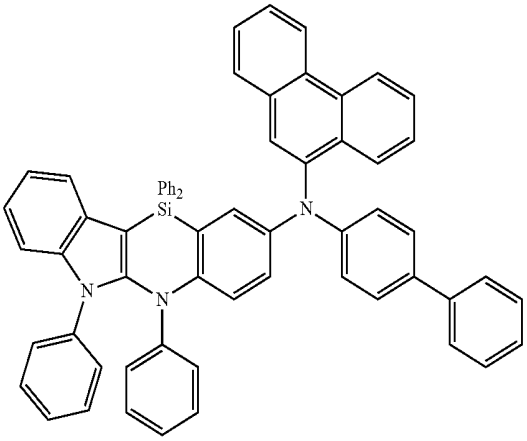
E57



E58

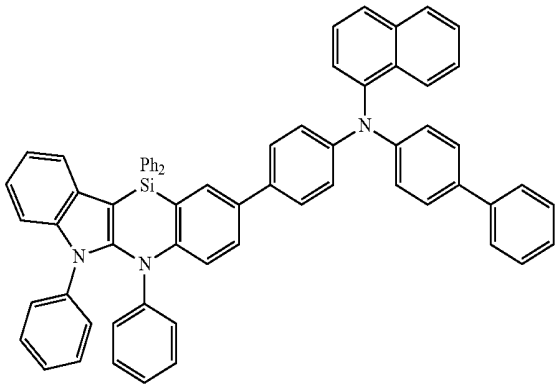


E59

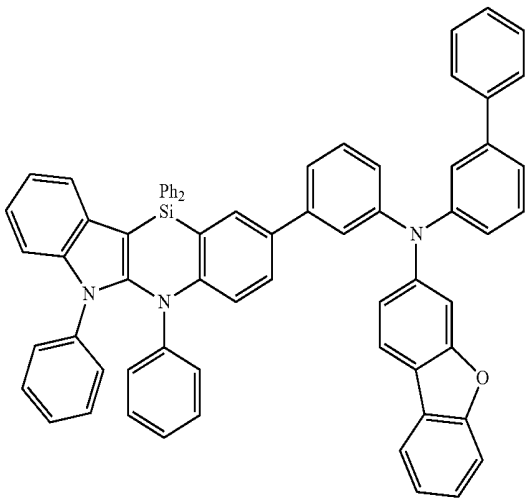


-continued

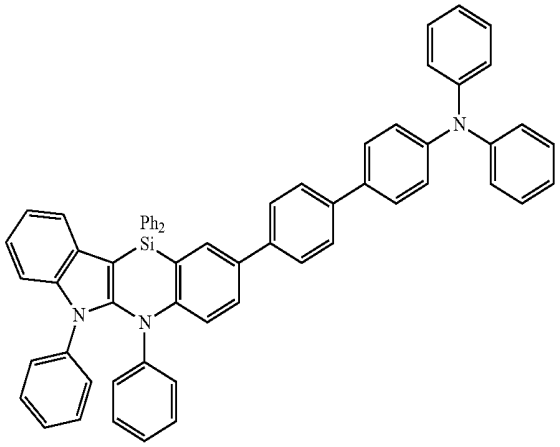
E60



E61

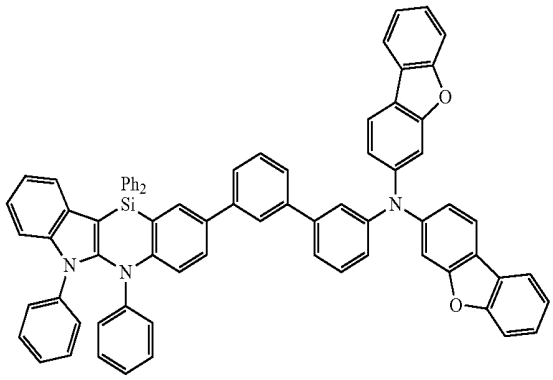


E62

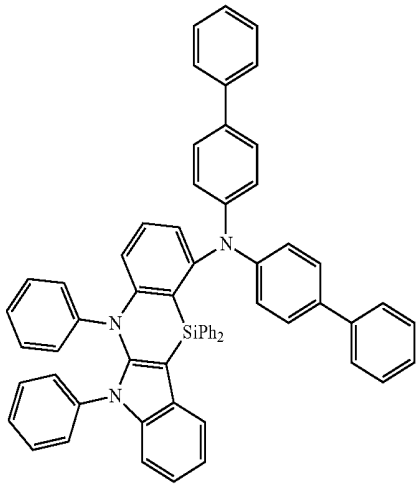


-continued

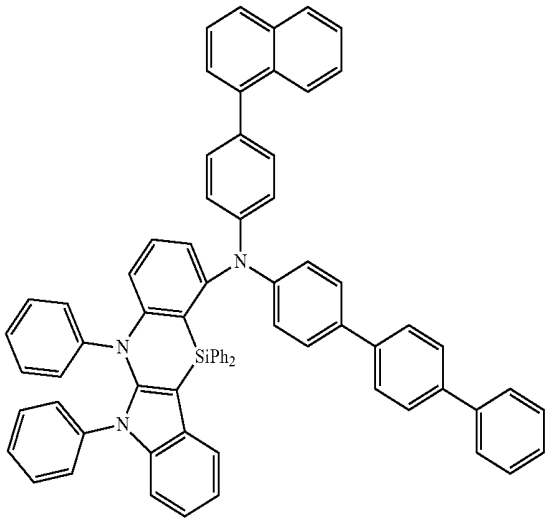
E63



E64

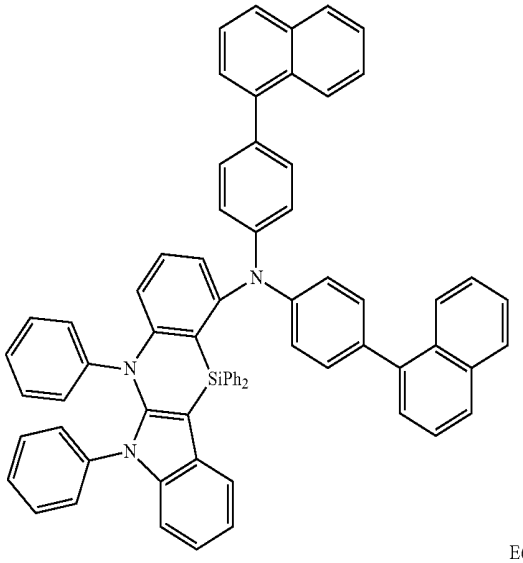


E65

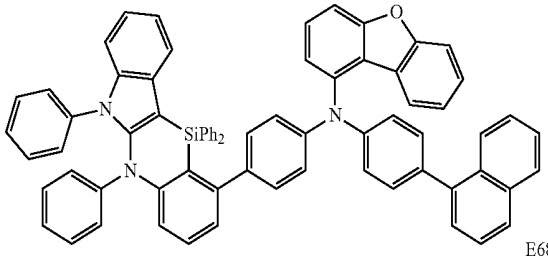


-continued

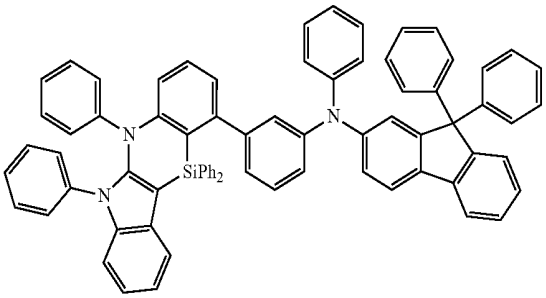
E66



E67

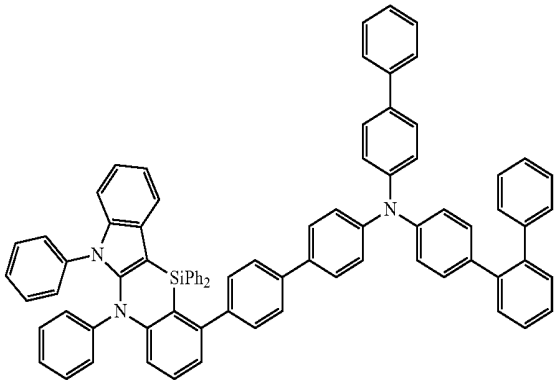


E68

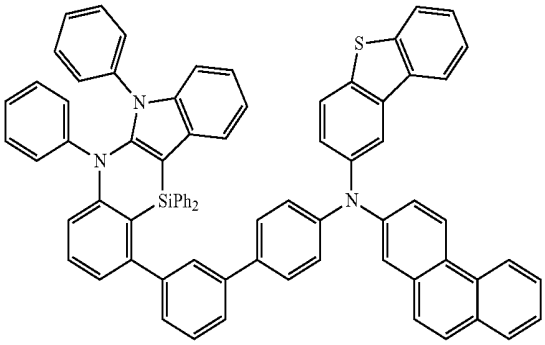


-continued

E69



E70



* * * * *

专利名称(译)	有机电致发光器件和用于有机电致发光器件的稠环化合物		
公开(公告)号	US20200052224A1	公开(公告)日	2020-02-13
申请号	US16/443807	申请日	2019-06-17
[标]申请(专利权)人(译)	三星显示有限公司		
申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
当前申请(专利权)人(译)	三星DISPLAY CO.，LTD.		
[标]发明人	UNO TAKUYA		
发明人	UNO, TAKUYA		
IPC分类号	H01L51/00 C07D487/04 C07D498/04 C07D513/04		
CPC分类号	H01L51/0074 H01L51/5056 H01L51/0067 H01L51/0072 C07D513/04 H01L51/006 H01L51/0054 C07D487/04 H01L51/0073 H01L51/0061 C07D498/04 C07F7/0816 H01L51/0052 H01L51/0058 H01L51/0071 H01L51/0094 H01L51/0059		
优先权	1020180093700 2018-08-10 KR		
外部链接	Espacenet USPTO		

摘要(译)

提供一种有机电致发光器件，其包括第一电极，设置在第一电极上的空穴传输区，设置在空穴传输区上的发射层，设置在发射层上的电子传输区以及设置在电子传输上的第二电极。 空穴传输区域包括稠环化合物的区域，从而确保高发射效率。