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(54) **ORGANIC EMITTING COMPOUND, AND ORGANIC LIGHT EMITTING DIODE AND ORGANIC LIGHT EMITTING DISPLAY DEVICE INCLUDING THE SAME**

(57) The present invention provides an organic emitting compound of following Formula, and an organic light emitting diode and an organic light emitting display device including the organic emitting compound.

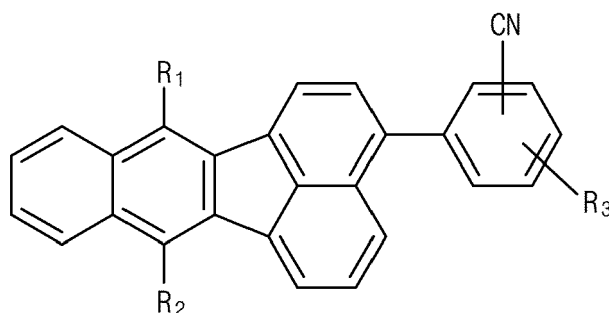
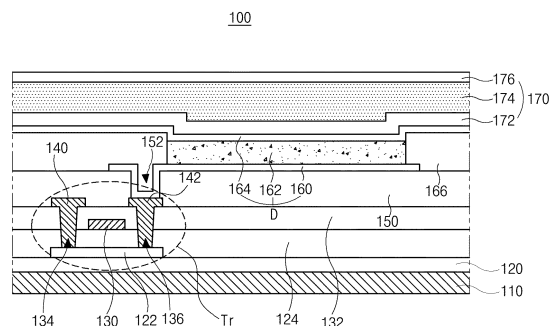


FIG. 1



Description

BACKGROUND

5 FIELD OF TECHNOLOGY

[0001] The present invention relates to an organic emitting compound, and more particularly, to an organic emitting compound including a benzofluoranthene core and an organic light emitting diode and an organic light emitting display device including the same.

10 DISCUSSION OF THE RELATED ART

[0002] Recently, requirement for flat panel display devices having small occupied area is increased. Among the flat panel display devices, a technology of an organic light emitting display device including an organic light emitting diode (OLED) is rapidly developed.

[0003] The OLED emits light by injecting electrons from a cathode as an electron injection electrode and holes from an anode as a hole injection electrode into an emitting layer, combining the electrons with the holes, generating an exciton, and transforming the exciton from an excited state to a ground state. A flexible transparent substrate, for example, a plastic substrate, can be used as a base substrate where elements are formed. In addition, the light emitting diode can be operated at a voltage (e.g., 10V or below) lower than a voltage required to operate other display devices and has low power consumption. Moreover, the light from the light emitting diode has excellent color purity.

[0004] The OLED includes a first electrode as the anode, a second electrode as the cathode being spaced apart from the first electrode and an organic emitting layer therebetween.

[0005] The organic emitting layer may have a single-layered structure of an emitting material layer (EML). Alternatively, to improve the emission efficiency, the organic emitting layer may have a multi-layered structure. For example, the organic emitting layer may include a hole injection layer (HIL), a hole transporting layer (HTL), the EML, an electron transporting layer (ETL) and an electron injection layer (EIL).

[0006] The hole is provided from the first electrode as the anode into the EML through the HIL and the HTL, and the electron is provided from the second electrode as the cathode into the EML through the EIL and the ETL. The hole and the electron are combined in the EML to generate an exciton, and the exciton is transformed from an excited state to a ground state such that the light is emitted from the organic emitting layer.

[0007] The emitting material for the EML may be classified into a fluorescent material and a phosphorescent material.

[0008] In the fluorescent material, since only singlet exciton is involved in emission, the fluorescent material provides low emitting efficiency (quantum efficiency).

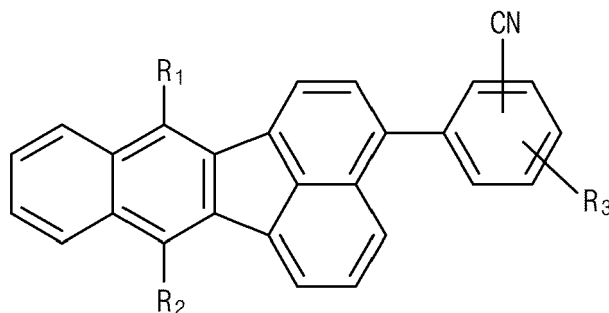
[0009] In the phosphorescent material, since not only singlet exciton but also triplet exciton is involved in emission, the phosphorescent material provides high emitting efficiency. However, since the phosphorescent material requires rare metal atom, e.g., Ir, the phosphorescent material is very expensive. In addition, there is a limitation of blue emission.

SUMMARY

[0010] The present invention is directed to an organic emitting compound and an OLED and an organic light emitting display device including the same that substantially obviate one or more of the problems associated with the limitations and disadvantages of the related conventional art.

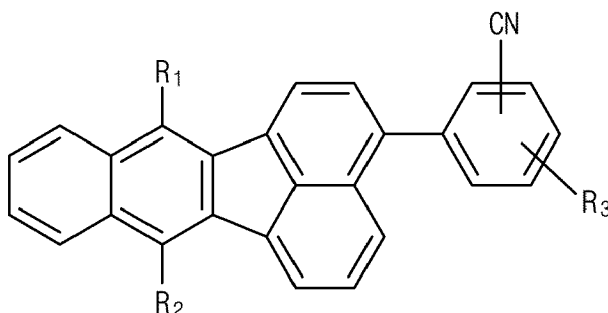
[0011] Additional features and advantages of the present invention are set forth in the description which follows, and will be apparent from the description, or evident by practice of the present invention. The objectives and other advantages of the present invention are realized and attained by the features described herein as well as in the appended drawings.

[0012] To achieve these and other advantages in accordance with the purpose of the embodiments of the present invention, as described herein, in our aspect an organic emitting compound of Formula:



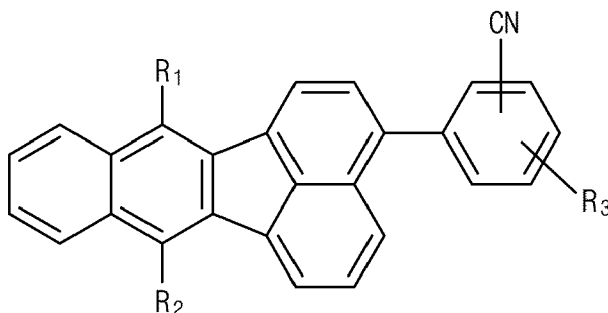
is provided, wherein each of R_1 , R_2 and R_3 is independently selected from the group consisting of hydrogen, C1 to C20 alkyl group, C1 to C20 alkoxy group, C1 to C20 silyl group, C6 to C30 aryl group, C5 to C30 heteroaryl group and amine group.

[0013] Another aspect of the present invention is an organic light emitting diode comprising: a first electrode; a second electrode facing the first electrode; and a first emitting material layer positioned between the first and second electrodes and including a first host and an organic emitting compound, wherein the organic emitting compound is represent by Formula:



wherein each of R_1 , R_2 and R_3 is independently selected from the group consisting of hydrogen, C1 to C20 alkyl group, C1 to C20 alkoxy group, C1 to C20 silyl group, C6 to C30 aryl group, C5 to C30 heteroaryl group and amine group.

[0014] Another aspect of the present invention is an organic light emitting display device comprising: a substrate; an organic light emitting diode on the substrate, the organic light emitting diode including: a first electrode; a second electrode facing the first electrode; and a first emitting material layer positioned between the first and second electrodes and including a first host and an organic emitting compound; and an encapsulation film covering the organic light emitting diode, wherein the organic emitting compound is represent by Formula:



wherein each of R_1 , R_2 and R_3 is independently selected from the group consisting of hydrogen, C1 to C20 alkyl group, C1 to C20 alkoxy group, C1 to C20 silyl group, C6 to C30 aryl group, C5 to C30 heteroaryl group and amine group.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying drawings, which are included to provide a further understanding of the present invention

and are incorporated in and constitute a part of this specification, illustrate embodiments of the present invention and together with the description serve to explain the principles of the present invention.

FIG. 1 is a schematic cross-sectional view of an organic light emitting display device of the present invention.

FIG. 2 is a schematic cross sectional view of an OLED according to a first embodiment of the present invention.

FIG. 3 is a view explaining a light emission mechanism in an OLED.

FIGs. 4A and 4B are views explaining an energy band diagram in an organic emitting layer of an OLED.

FIG. 5 is a schematic cross sectional view of an OLED according to a second embodiment of the present invention.

FIG. 6 is a schematic cross sectional view of an OLED according to a third embodiment of the present invention.

DETAILED DESCRIPTION

[0016] Reference will now be made in detail to some of the examples and preferred embodiments, which are illustrated in the accompanying drawings.

[0017] FIG. 1 is a schematic cross-sectional view of an organic light emitting display device of the present invention.

[0018] As shown in FIG. 1, the organic light emitting display device 100 may include a substrate 110, a TFT Tr and an OLED D connected to the TFT Tr.

[0019] The substrate 110 may be a glass substrate or a plastic substrate. For example, the substrate 110 may be a polyimide substrate.

[0020] A buffer layer 120 may be formed on the substrate 110, and the TFT Tr may be formed on the buffer layer 120. The buffer layer 120 may be omitted.

[0021] A semiconductor layer 122 may be formed on the buffer layer 120. The semiconductor layer 122 may include an oxide semiconductor material or polycrystalline silicon.

[0022] When the semiconductor layer 122 includes the oxide semiconductor material, a light-shielding pattern (not shown) may be formed under the semiconductor layer 122. The light to the semiconductor layer 122 may be shielded or blocked by the light-shielding pattern such that thermal degradation of the semiconductor layer 122 can be prevented. On the other hand, when the semiconductor layer 122 includes polycrystalline silicon, impurities may be doped into both sides of the semiconductor layer 122.

[0023] A gate insulating layer 124 may be formed on the semiconductor layer 122. The gate insulating layer 124 may be formed of an inorganic insulating material such as silicon oxide or silicon nitride.

[0024] A gate electrode 130, which is formed of a conductive material, e.g., metal, may be formed on the gate insulating layer 124 to correspond to a center of the semiconductor layer 122.

[0025] In FIG. 1, the gate insulating layer 124 may be formed on an entire surface of the substrate 110. Alternatively, the gate insulating layer 124 may be patterned to have the same shape as the gate electrode 130.

[0026] An interlayer insulating layer 132, which is formed of an insulating material, may be formed on the gate electrode 130. The interlayer insulating layer 132 may be formed of an inorganic insulating material, e.g., silicon oxide or silicon nitride, or an organic insulating material, e.g., benzocyclobutene or photo-acryl.

[0027] The interlayer insulating layer 132 may include first and second contact holes 134 and 136 exposing both sides of the semiconductor layer 122. The first and second contact holes 134 and 136 may be positioned at both sides of the gate electrode 130 to be spaced apart from the gate electrode 130.

[0028] The first and second contact holes 134 and 136 may be formed through the gate insulating layer 124. Alternatively, when the gate insulating layer 124 is patterned to have the same shape as the gate electrode 130, the first and second contact holes 134 and 136 may be formed only through the interlayer insulating layer 132.

[0029] A source electrode 140 and a drain electrode 142, which are formed of a conductive material, e.g., metal, may be formed on the interlayer insulating layer 132.

[0030] The source electrode 140 and the drain electrode 142 may be spaced apart from each other with respect to the gate electrode 130 and respectively contact both sides of the semiconductor layer 122 through the first and second contact holes 134 and 136.

[0031] The semiconductor layer 122, the gate electrode 130, the source electrode 140 and the drain electrode 142 constitute the TFT Tr. The TFT Tr serves as a driving element.

[0032] In the TFT Tr, the gate electrode 130, the source electrode 140, and the drain electrode 142 may be positioned over the semiconductor layer 122. Namely, the TFT Tr has a coplanar structure.

[0033] Alternatively, in the TFT Tr, the gate electrode may be positioned under the semiconductor layer, and the source and drain electrodes may be positioned over the semiconductor layer such that the TFT Tr may have an inverted staggered structure. In this instance, the semiconductor layer may include amorphous silicon.

[0034] Although not shown, the gate line and the data line cross each other to define the pixel region, and the switching TFT is formed to be connected to the gate and data lines. The switching TFT is connected to the TFT Tr as the driving element.

[0035] In addition, the power line, which may be formed to be parallel to and spaced apart from one of the gate and data lines, and the storage capacitor for maintaining the voltage of the gate electrode of the TFT Tr in one frame may be further formed.

[0036] A passivation layer 150, which includes a drain contact hole 152 exposing the drain electrode 142 of the TFT Tr, may be formed to cover the TFT Tr.

[0037] A first electrode 160, which is connected to the drain electrode 142 of the TFT Tr through the drain contact hole 152, is separately formed in each pixel region. The first electrode 160 may be an anode and may be formed of a conductive material having a relatively high work function. For example, the first electrode 160 may be formed of a transparent conductive material such as indium-tin-oxide (ITO) or indium-zinc-oxide (IZO).

[0038] When the OLED device 100 is operated in a top-emission type, a reflection electrode or a reflection layer may be formed under the first electrode 160. For example, the reflection electrode or the reflection layer may be formed of aluminum-palladium-copper (APC) alloy.

[0039] A bank layer 166 may be formed on the passivation layer 150 to cover an edge of the first electrode 160. Namely, the bank layer 166 is positioned at a boundary of the pixel region and exposes a center of the first electrode 160 in the pixel region.

[0040] An organic emitting layer 162 may be formed on the first electrode 160. The organic emitting layer 162 includes an organic emitting compound of the present invention. The organic emitting compound may be used as a dopant, and the organic emitting layer 162 may further include a host. For example, the dopant may be doped with a ratio of approximately 1 to 30 wt% with respect to the host. In addition, the organic emitting layer 162 may further include a delayed fluorescent compound as another dopant. In this instance, a summation of the organic emitting compound and the delayed fluorescent compound may have a range of approximately 1 to 50 wt% with respect to the host. The organic emitting layer 162 emits blue light.

[0041] The organic emitting layer 162 may have a single-layered structure of an emitting material layer including the organic emitting compound. To increase an emitting efficiency of the OLED device, the organic emitting layer 162 may have a multi-layered structure.

[0042] A second electrode 164 may be formed over the substrate 110 where the organic emitting layer 162 is formed. The second electrode 164 may cover an entire surface of the display area and may be formed of a conductive material having a relatively low work function to serve as a cathode. For example, the second electrode 164 may be formed of aluminum (Al), magnesium (Mg) or Al-Mg alloy.

[0043] The first electrode 160, the organic emitting layer 162 and the second electrode 164 constitute the OLED D.

[0044] An encapsulation film 170 may be formed on the second electrode 164 to prevent penetration of moisture into the OLED D. The encapsulation film 170 may include a first inorganic insulating layer 172, an organic insulating layer 174 and a second inorganic insulating layer 176 sequentially stacked, but it is not limited thereto.

[0045] A polarization plate (not shown) for reducing an ambient light reflection may be disposed over the top-emission type OLED D. For example, the polarization plate may be a circular polarization plate.

[0046] In addition, a cover window (not shown) may be attached to the encapsulation film 170 or the polarization plate. In this instance, the substrate 110 and the cover window have a flexible property such that a flexible display device may be provided.

[0047] FIG. 2 is a schematic-cross sectional view of an OLED according to a first embodiment of the present invention.

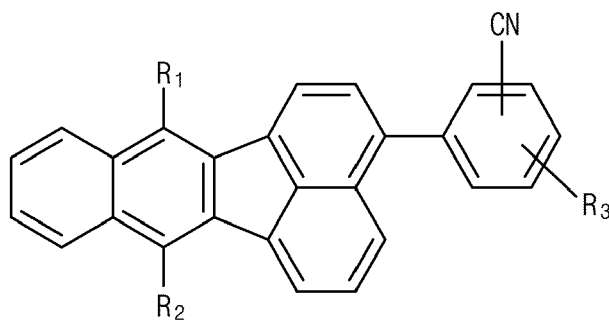
[0048] As shown in FIG. 2, the OLED D includes the first and second electrodes 160 and 164, which face each other, and the organic emitting layer 162 therebetween. The organic emitting layer 162 may include an emitting material layer (EML) 240 between the first and second electrodes 160 and 164, a hole transporting layer (HTL) 220 between the first electrode 160 and the EML 240 and an electron transporting layer (ETL) 260 between the second electrode 164 and the EML 240.

[0049] In addition, the organic emitting layer 162 may further include a hole injection layer (HIL) 210 between the first electrode 160 and the HTL 220 and an electron injection layer (EIL) 270 between the second electrode 164 and the ETL 260.

[0050] Moreover, the organic emitting layer 162 may further include an electron blocking layer (EBL) 230 between the HTL 220 and the EML 240 and a hole blocking layer (HBL) 250 between the EML 240 and the ETL 260.

[0051] The organic emitting layer 162, preferably the EML 240, includes an organic emitting compound of Formula 1 as a dopant.

[Formula 1]



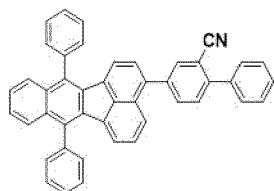
[0052] In Formula 1, each of R_1 , R_2 and R_3 is independently selected from the group consisting of hydrogen, C1 to C20 alkyl group, C1 to C20 alkoxy group, C1 to C20 silyl group, C6 to C30 aryl group, C5 to C30 heteroaryl group and amine group.

[0053] Namely, the organic emitting compound of the present invention includes a benzofluoranthene core and a cyanophenylene moiety directly connected with each other, i.e. no linker groups are present between the benzofluoranthene core and the cyanophenylene moiety.

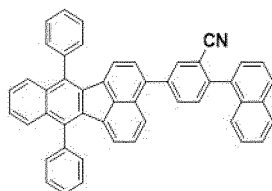
[0054] The organic emitting compound has a fluorescent emission property and narrow full width at half maximum (FWHM). In addition, since the cyanophenylene moiety is directly bonded to the benzofluoranthene core, the organic emitting compound has a deep HOMO level.

[0055] Preferably, in the compound of Formula 1, R_1 and R_2 is independently selected from the group consisting of hydrogen and C6 to C30 aryl group, and R_3 is a C6 to C30 aryl group. Additionally, the R_3 group is preferably in para or meta position of the benzofluoranthene. For example, each of R_1 , R_2 and R_3 may be independently selected from the group consisting of phenyl, naphthyl and anthracenyl.

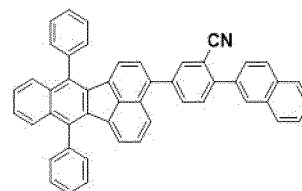
[0056] For example, the organic emitting compound may be selected from the group consisting of the following compounds:



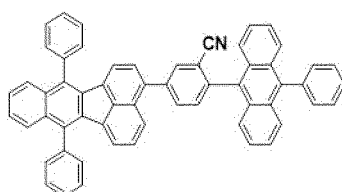
compound 1



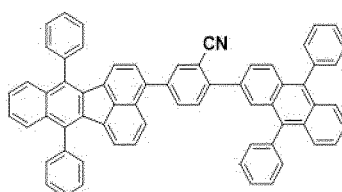
compound 2



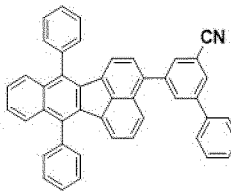
compound 3



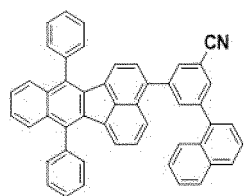
compound 4



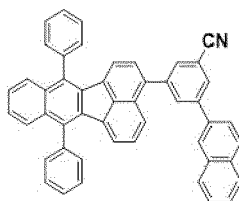
compound 5



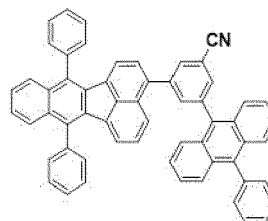
compound 6



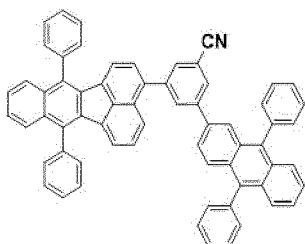
compound 7



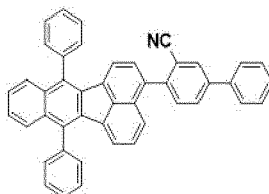
compound 8



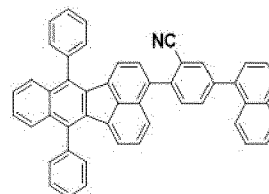
compound 9



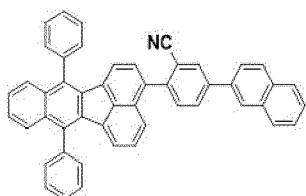
compound 10



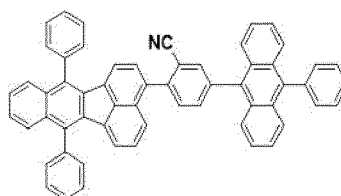
compound 11



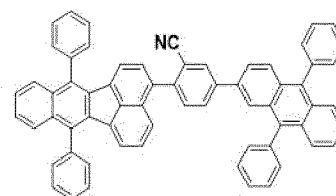
compound 12



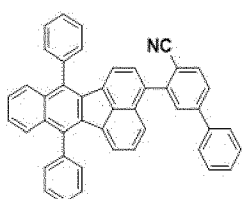
compound 13



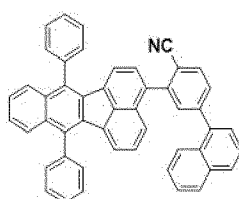
compound 14



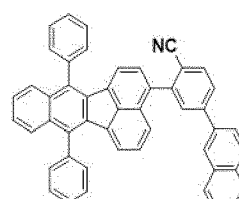
compound 15



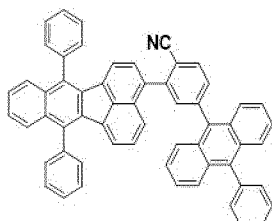
compound 16



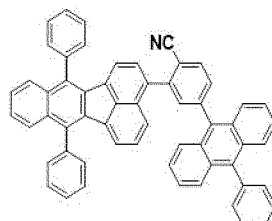
compound 17



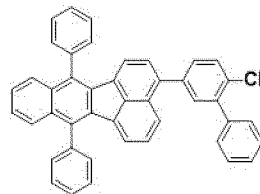
compound 18



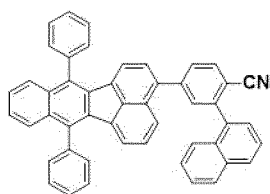
compound 19



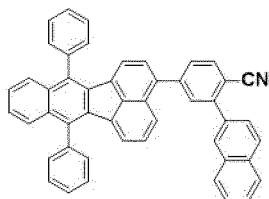
compound 20



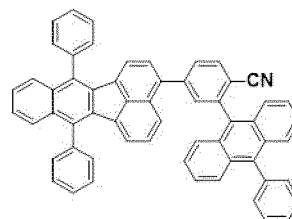
compound 21



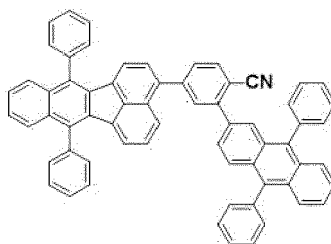
compound 22



compound 23



compound 24



compound 25

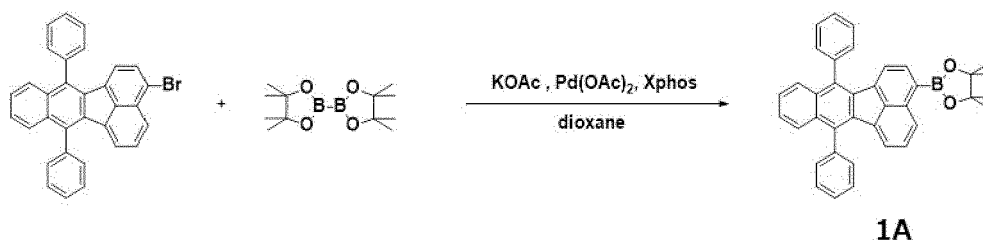
[Synthesis of organic emitting compounds]

1. Synthesis of compound 1

(1) compound 1A [2-(7,12-diphenylbenzo[k]fluoranthene-3-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane]

[0057]

[Reaction Formula 1-1]

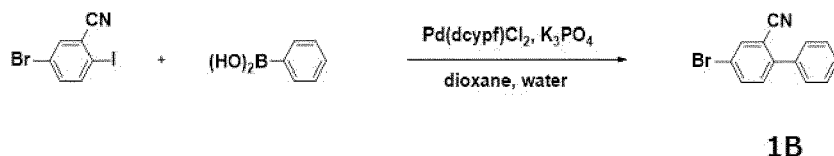


[0058] After 3-bromo-7,12-diphenylbenzo[k]fluoranthene (20.0 g, 41.4 mmol), bis(pinacolato)diboron (21.0 g, 82.8 mmol), potassium acetate(KOAc) (12.2 g, 124.1 mmol), palladium(II) acetate(Pd(OAc)₂) (0.37 g, 1.7 mmol), Xphos (3.2 g, 6.6 mmol) and dioxane (600 ml) were put into the rounded-bottom flask (1000 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 110 °C for 10 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 1A was obtained. (15.3g, yield: 70%)

(2) compound 1B [4-bromo-[1,1'-biphenyl]-2-carbonitrile]

[0059]

[Reaction Formula 1-2]

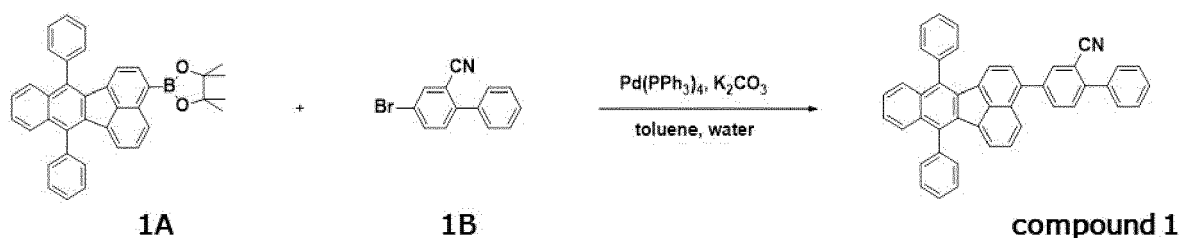


[0060] After 5-bromo-2-iodobenzonitrile (8.0 g, 26.0 mmol), phenylboronic acid (3.5 g, 28.6 mmol), potassium phosphate (13.8 g, 65.0 mmol), [1,1'-bis(di-cyclohexylphosphino)ferrocene]dichloropalladium(II) (0.4 g, 0.5 mmol), dioxane (50ml) and water (15ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90 °C for 5 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 1B was obtained. (3.5g, yield: 52%)

(3) compound 1 [4-(7,12-diphenylbenzo[k]fluoranthen-3-yl)-[1,1'-biphenyl]-2-carbonitrile]

[0061]

[Reaction Formula 1-3]



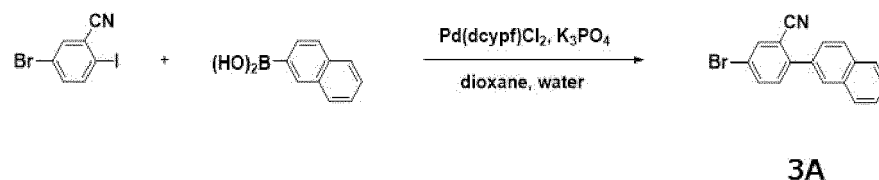
[0062] After compound 1A (3.0 g, 5.7 mmol), compound 1B (1.6 g, 6.2 mmol), potassium carbonate (3.1 g, 22.6 mmol), tetrakis(triphenylphosphine)palladium(0.3g, 0.3 mmol), toluene (30ml), water (10ml) and tetrahydrofuran(THF) (5ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90 °C for 10 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 1 was obtained. (2.5g, yield: 76%)

2. Synthesis of compound 3

(1) compound 3A [5-bromo-2-(naphthalen-2-yl)benzonitrile]

[0063]

[Reaction Formula 2-1]



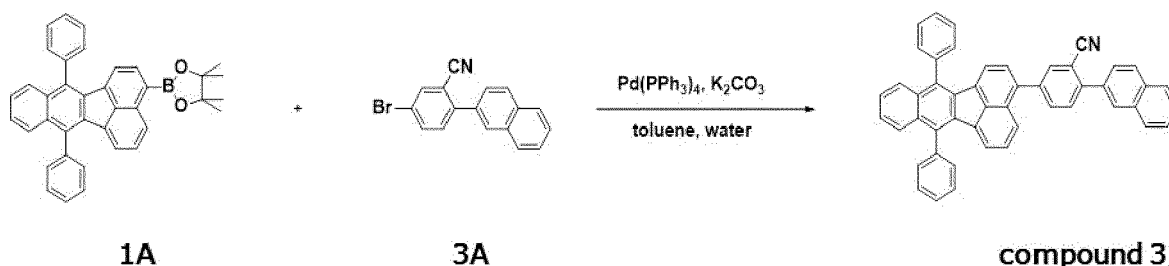
[0064] After 5-bromo-2-iodobenzonitrile (5.0 g, 16.2 mmol), naphthalen-2-ylboronic acid (3.1 g, 17.9 mmol), potassium phosphate (8.6 g, 40.6 mmol), [1,1'-bis(di-cyclohexylphosphino)ferrocene]dichloropalladium(II) (0.3 g, 0.3 mmol), dioxane (50ml) and water (15ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90 °C for 5 hrs. After completion of reaction, the organic layer is extracted using

dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 3A was obtained. (3.3g, yield: 66%)

(2) compound 3 [5-(7,12-diphenylbenzo[k]fluoranthren-3-yl)-2-(naphthalen-2-yl)benzonitrile]

[0065]

[Reaction Formula 2-2]



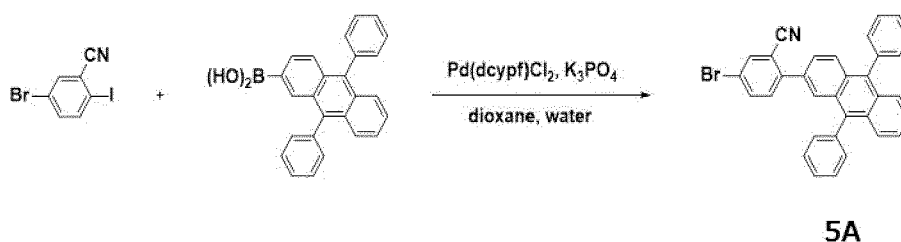
[0066] After compound 1A (3.0 g, 5.7 mmol), compound 3A (1.9 g, 6.2 mmol), potassium carbonate (3.1 g, 22.6 mmol), tetrakis(triphenylphosphine)palladium (0.3 g, 0.3 mmol), toluene (30 ml), water (10 ml) and THF (5 ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90°C for 10 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 3 was obtained. (2.7 g, yield: 75%)

3. Synthesis of compound 5

(1) compound 5A [5-bromo-2-(9,10-diphenylanthracen-2-yl)benzonitrile]

[0067]

[Reaction Formula 3-1]

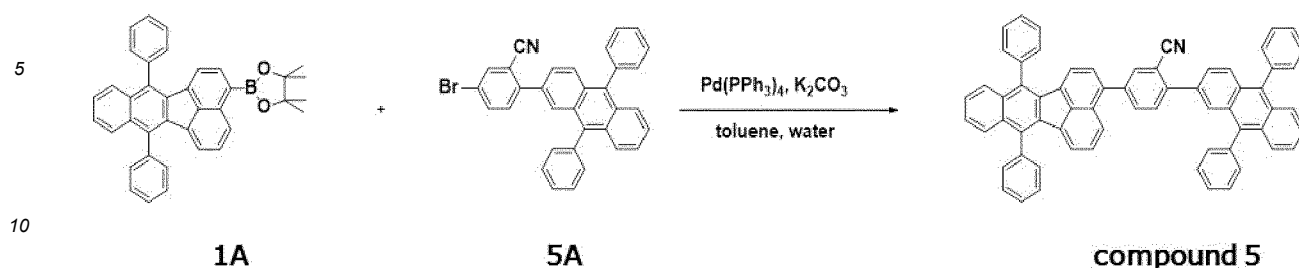


[0068] After 5-bromo-2-iodobenzonitrile (5.0 g, 16.2 mmol), (9,10-diphenylanthracen-2-yl)boronic acid (6.7 g, 17.9 mmol), potassium phosphate (8.6 g, 40.6 mmol), [1,1'-bis(di-cyclohexylphosphino)ferrocene]dichloropalladium(II) (0.3 g, 0.3 mmol), dioxane (50 ml) and water (15 ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90 °C for 5 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 5A was obtained. (5.2 g, yield: 63%)

(2) compound 5 [2-(9,10-diphenylanthracen-2-yl)-5-(7,12-diphenylbenzo[k]fluoranthren-3-yl)benzonitrile]

[0069]

[Reaction Formula 3-2]



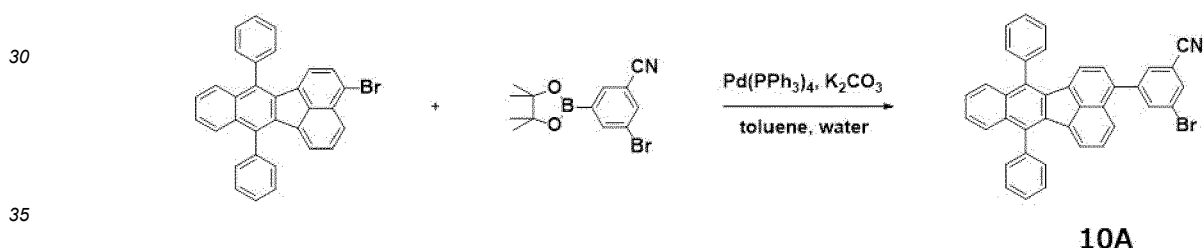
[0070] After compound 1A (3.0 g, 5.7 mmol), compound 5A (3.2 g, 6.2 mmol), potassium carbonate (3.1 g, 22.6 mmol), tetrakis(triphenylphosphine)palladium (0.3 g, 0.3 mmol), toluene (30 ml), water (10 ml) and THF (5 ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90 °C for 10 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 5 was obtained. (3.0 g, yield: 64%)

4. Synthesis of compound 10

(1) compound 10A [3-bromo-5-(7,12-diphenylbenzo[k]fluoranthen-3-yl)benzonitrile]

[0071]

[Reaction Formula 4-1]

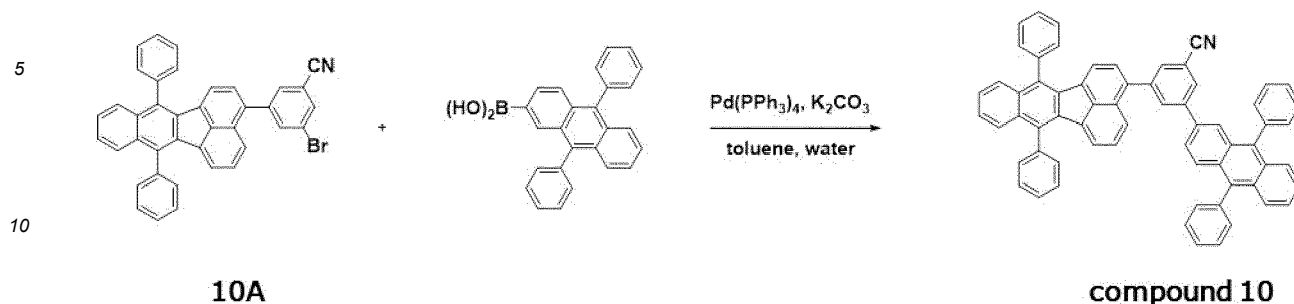


[0072] After 3-bromo-7,12-diphenylbenzo[k]fluoranthene (8.0 g, 16.6 mmol), 3-bromo-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzonitrile (5.6 g, 18.2 mmol), potassium carbonate (9.1 g, 66.2 mmol), tetrakis(triphenylphosphine)palladium (1.0 g, 0.8 mmol), toluene (90 ml), water (30 ml) and THF (15 ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90 °C for 10 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 10A was obtained. (5.1 g, yield: 53%)

(2) compound 10 [3-(9,10-diphenylanthracen-2-yl)-5-(7,12-diphenylbenzo[k]fluoranthen-3-yl)benzonitrile]

[0073]

[Reaction Formula 4-2]



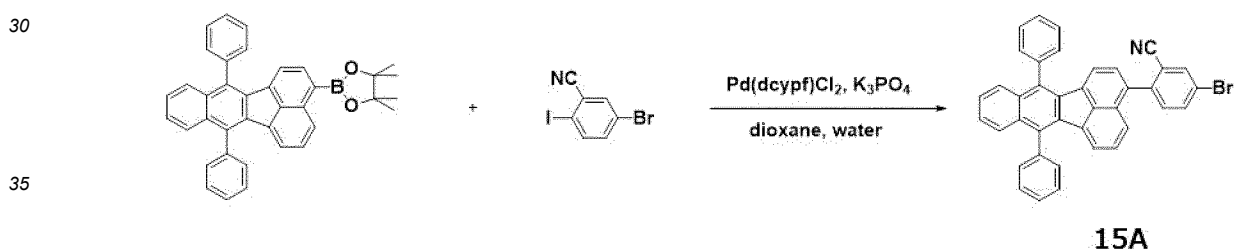
15 **[0074]** After compound 10A (4.5 g, 7.7 mmol), (9,10-diphenylanthracen-2-yl)boronic acid (3.2 g, 8.5 mmol), potassium carbonate (4.3 g, 30.1 mmol), tetrakis(triphenylphosphine)palladium(0.4 g, 0.4 mmol), toluene (45ml), water (15ml) and THF (5ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90 °C for 10 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 10 was obtained. (3.6g, yield: 56%)

5. Synthesis of compound 15

(1) compound 15A [5-bromo-2-(7,12-diphenylbenzo[k]fluoranthren-3-yl)benzonitrile]

[0075]

[Reaction Formula 5-1]

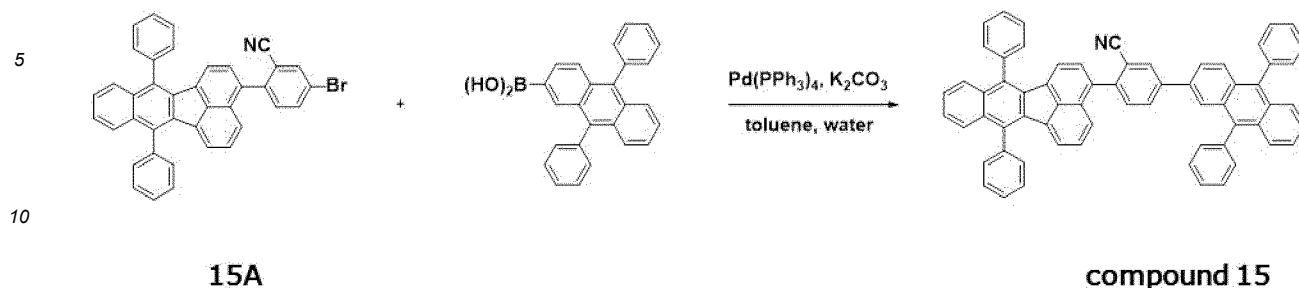


40 **[0076]** After compound 1A (8.0 g, 15.1 mmol), 5-bromo-2-iodobenzonitrile (5.1 g, 16.6 mmol), potassium phosphate (8.0 g, 37.7 mmol), 1,1'-bis(di-cyclohexylphosphino)ferrocene]dichloropalladium(II) (0.3 g, 0.3 mmol), dioxane (90ml) and water (15ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90 °C for 5 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 15A was obtained. (6.3g, yield: 71 %)

(2) compound 15 [5-(9,10-diphenylanthracen-2-yl)-2-(7,12-diphenylbenzo[k]fluoranthren-3-yl)benzonitrile]

[0077]

[Reaction Formula 5-2]



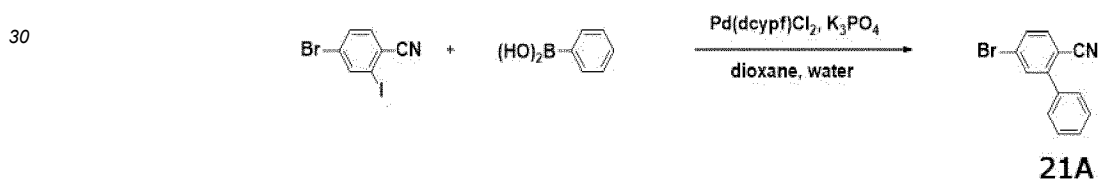
15 **[0078]** After compound 15A (3.5 g, 6.0 mmol), (9,10-diphenylanthracen-2-yl)boronic acid (2.5 g, 6.6 mmol), potassium carbonate (3.3 g, 23.9 mmol), tetrakis(triphenylphosphine)palladium(0.3 g, 0.3 mmol), toluene (45ml), water (15ml) and THF (5ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90°C for 10 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 15 was obtained. (3.1g, yield: 62%)

6. Synthesis of compound 21

(1) compound 21A [5-bromo-[1,1'-biphenyl]-2-carbonitrile]

25 **[0079]**

[Reaction Formula 6-1]

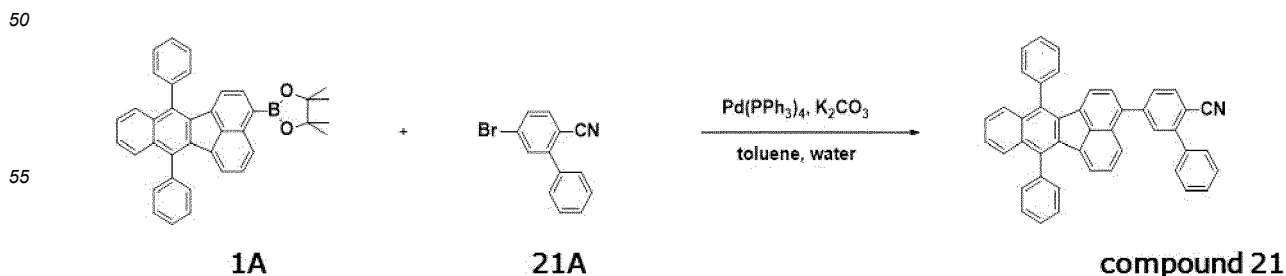


40 **[0080]** After 4-bromo-2-iodobenzonitrile (6.0 g, 19.5 mmol), phenylboronic acid (2.6 g, 21.4 mmol), potassium phosphate (10.3 g, 48.7 mmol), [1,1'-bis(di-cyclohexylphosphino)ferrocene]dichloropalladium(II) (0.3 g, 0.4 mmol), dioxane (50ml) and water (15ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90°C for 6 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 21A was obtained. (3.3g, yield: 65%)

45 (2) compound 21 [5-(7,12-diphenylbenzo[k]fluoranthen-3-yl)-[1,1'-biphenyl]-2-carbonitrile]

[0081]

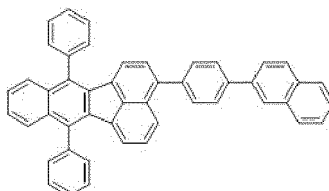
[Reaction Formula 6-2]



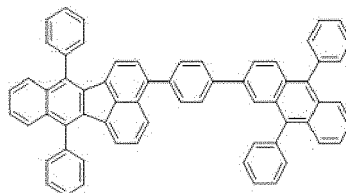
[0082] After compound 1A (3.0 g, 5.7 mmol), compound 21 A (1.6 g, 6.2 mmol), potassium carbonate (3.1 g, 22.6 mmol), tetrakis(triphenylphosphine)palladium (0.3g, 0.3 mmol), toluene (30ml), water (10ml) and THF (5ml) were put into the rounded-bottom flask (500 ml), and nitrogen gas is purged. The mixture was stirred under the temperature of 90°C for 10 hrs. After completion of reaction, the organic layer is extracted using dichloromethane and distilled water, and the solvent was removed by the reduced-pressure distillation. The column chromatography using hexane and dichloromethane was performed to the crude product such that compound 21 was obtained. (2.3g, yield: 70%)

[0083] The maximum emission wavelength (λ_{max}) and the FWHM of compounds 1, 3, 5, 10 and 15 and compounds of Formulas 2 to 5 are measured and listed in Table 1.

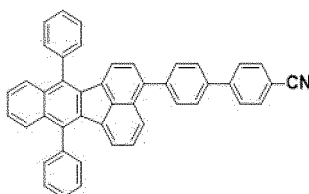
[Formula 2]



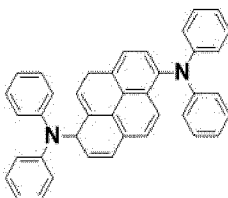
[Formula 3]



[Formula 4]



[Formula 5]



[0084] The compounds in Formulas 2 to 4 also includes a benzofluoranthene core without a cyanophenylene moiety directly bonded to the benzofluoranthene core. The compound in Formula 5 is the related art blue fluorescent dopant.

Table 1

	λ_{max} [nm]	FWHM [nm]
compound 1	443	50

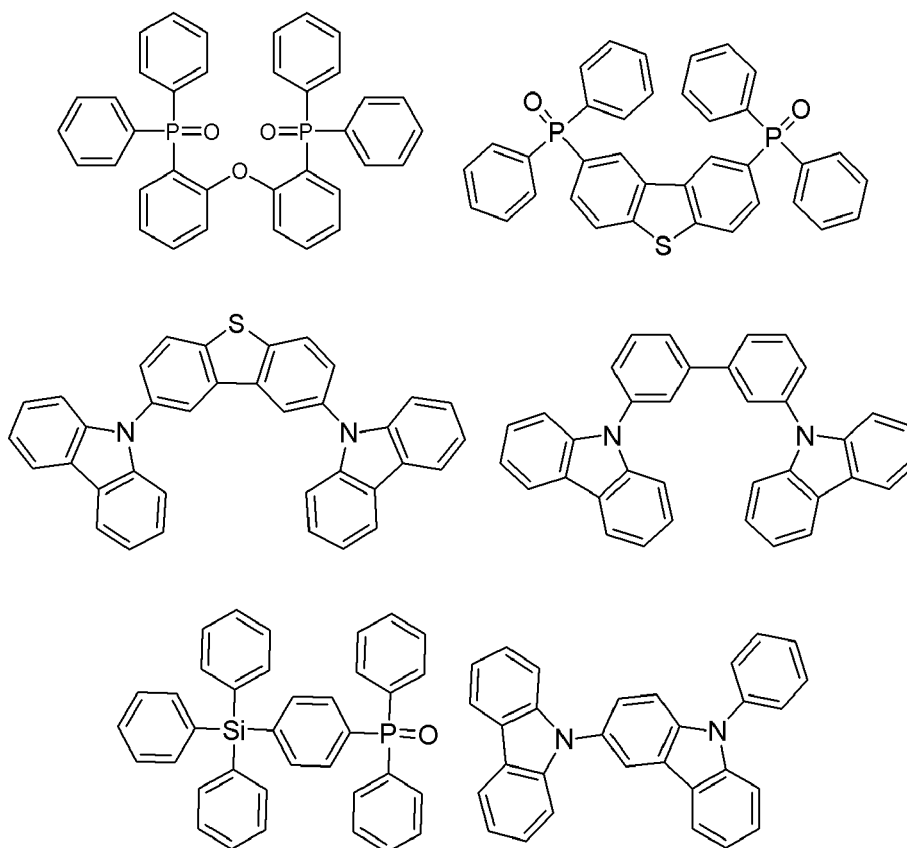
(continued)

	λ_{max} [nm]	FWHM [nm]
compound 3	443	48
compound 5	450	46
compound 10	448	48
compound 15	449	45
Formula 2	445	50
Formula 3	451	52
Formula 4	444	48
Formula 5	461	51

[0085] As shown in Table 1, the organic emitting compound of the present invention has blue emission property and narrow FWHM. Namely, the organic emitting compound of the present invention includes the benzofluoranthene core and the cyanophenylene moiety, which is directly bonded to the benzofluoranthene core, such that blue emission with high color purity is provided.

[0086] The EML may further include a host. Namely, the organic emitting compound of the present invention is used as the dopant in the EML and is doped by approximately 1 to 30 wt% with respect to the host.

[0087] For example, one of the following materials, namely Bis[2-(diphenylphosphino)phenyl] ether oxide (DPEPO), 2,8-bis(diphenylphosphoryl)dibenzothiophene (PPT), 2,8-di(9H-carbazol-9-yl)dibenzothiophene (DCzDBT), m-bis(carbazol-9-yl)biphenyl (m-CBP), Diphenyl-4-triphenylsilylphenyl-phosphine oxide (TPSO1), 9-(9-phenyl-9H-carbazol-6-yl)-9H-carbazole (CCP) in order, may be used as the host.



[0088] The EML 240 may further include a delayed fluorescent compound. Namely, in the EML 240, the organic emitting compound of the present invention is used as a first dopant (fluorescent dopant), and the delayed fluorescent

compound is used as a second dopant (delayed fluorescent dopant). A summation of the organic emitting compound of the present invention and the delayed fluorescent compound may have a range of approximately 1 to 50 wt% with respect to the host.

[0089] The percentage by weight of the delayed fluorescent dopant may be greater than that of the fluorescent dopant. As a result, the energy transfer from the delayed fluorescent dopant into the fluorescent dopant is sufficiently generated.

[0090] In the delayed fluorescent compound, a difference between the energy level of singlet state of the dopant and the energy level of triplet state of the dopant is equal to less than 0.3eV. As a result, the energy level of triplet state of the delayed fluorescent dopant is converted into the energy level of singlet state of the delayed fluorescent dopant by the reverse intersystem crossing (RISC) effect.

[0091] Namely, the delayed fluorescent compound is configured such that a triplet exciton is activated by an electric field and is thus up-converted into a singlet exciton, and accordingly, both of the triplet exciton and the singlet exciton are involved in light emission.

[0092] Since the EML 240 includes both the organic emitting compound of the present invention as the fluorescent dopant and the delayed fluorescent dopant, the singlet energy and the triplet energy of the delayed fluorescent dopant are transferred into the organic emitting compound of the present invention as the fluorescent dopant and the emission is provided from the organic emitting compound of the present invention as the fluorescent dopant. As result, the quantum efficiency of the OLED D is increased, and the FWHM of the OLED D is narrowed.

[0093] Referring to FIG. 3, which is a view explaining a light emission mechanism in an OLED, the energy level of the triplet state ($E_{T1}(TD)$) of the delayed fluorescent dopant is converted into the energy level of the singlet state ($E_{S1}(TD)$) by the effect of the reverse intersystem crossing (RISC), and the energy level of the singlet state ($E_{S1}(TD)$) of the delayed fluorescent dopant is transferred into the energy level of the singlet state ($E_{S1}(FD)$) of the fluorescent dopant by an effect of Foster resonance energy transfer. As a result, the light is emitted from the fluorescent dopant.

[0094] The energy level of the singlet state ($E_{S1}(H)$) of the host is greater than the energy level of the singlet state ($E_{S1}(TD)$) of the delayed fluorescent dopant. In addition, the energy level of the triplet state ($E_{T1}(TD)$) of the delayed fluorescent dopant is smaller than the energy level of the triplet state ($E_{T1}(H)$) of the host and greater than the energy level of the triplet state ($E_{T1}(FD)$) of fluorescent dopant. Moreover, the energy level of the singlet state ($E_{S1}(H)$) of the host is greater than the energy level of the singlet state ($E_{S1}(FD)$) of the fluorescent dopant.

[0095] When not satisfying this condition, a quenching happens at the delayed fluorescent dopant and/or the fluorescent dopant or an energy transfer from the host to the delayed fluorescent dopant does not happen, and thus the quantum efficiency of the OLED D is reduced.

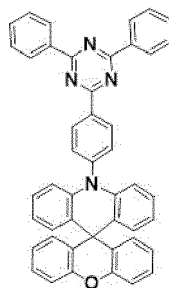
[0096] A difference between the energy level of the HOMO of the delayed fluorescent dopant and the energy level of the HOMO of the organic emitting compound as the fluorescent dopant is equal to or less than 0.3eV. The difference is greater than 0.3eV, the hole is trapped in the HOMO level of the fluorescent dopant such that high quantum efficiency of the delayed fluorescent dopant cannot be provided.

[0097] As shown in FIG. 4A, when the difference (ΔH) between the energy level of the HOMO of the fluorescent dopant (FD) and the energy level of the HOMO of the delayed fluorescent dopant (TD) is too big (e.g., $\Delta H > 0.3\text{eV}$), the hole (h^+) from the anode is transferred into the fluorescent dopant (FD) such that the emission directly happens from the fluorescent dopant. In this instance, the narrow FWHM by the fluorescent dopant is provided, but high quantum efficiency by the delayed fluorescent dopant cannot be provided.

[0098] However, as shown in FIG. 4B, when the difference (ΔH) between the energy level of the HOMO of the fluorescent dopant (FD) and the energy level of the HOMO of the delayed fluorescent dopant (TD) is equal to or less than approximately 0.3eV ($\Delta H \leq 0.3\text{eV}$), the hole (h^+) is transferred into the delayed fluorescent dopant (TD) such that the exciton is generated in the delayed fluorescent dopant. Accordingly, the emission happens from the fluorescent dopant (FD) by the above energy transfer, and high quantum efficiency by the delayed fluorescent dopant (TD) and narrow FWHM by the fluorescent dopant (FD) are provided.

[0099] The energy level of the HOMO of the compound of Formula 6 (TD), which may be used as the delayed fluorescent dopant, the compounds 1, 3, 5, 10 and 15, and the compounds of Formulas 2 to 5 are measured and listed in Table 2.

[Formula 6]



[0100] The energy level of the HOMO are measured by the cyclic voltammetry.

Table 2

	HOMO (eV)
TD	5.50
compound 1	5.32
compound 3	5.30
compound 5	5.29
compound 10	5.26
compound 15	5.25
Formula 2	5.08
Formula 3	5.07
Formula 4	5.11
Formula 5	5.04

[0101] As shown in Table 2, the organic emitting compound of the present invention has deep HOMO level. Namely, since the organic emitting compound of the present invention includes the benzofluoranthene core and the cyanophenylene moiety, which is directly bonded to the benzofluoranthene core, the organic emitting compound has deep HOMO level. Accordingly, the difference between the energy level of the HOMO of the delayed fluorescent dopant and the energy level of the HOMO of the organic emitting compound as the fluorescent dopant is equal to or less than 0.3eV.

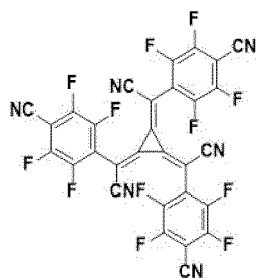
[0102] When the EML of the OLED includes the organic emitting compound as a first dopant and the delayed fluorescent compound as a second dopant, the quantum efficiency and the color purity are improved.

[OLED]

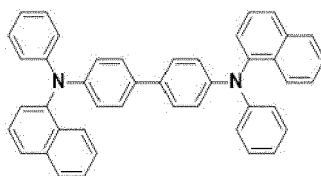
[0103] Following layers are sequentially deposited on an ITO layer (anode).

[0104] (a) HIL (50 Å, compound of Formula 7-1 (HATCN)), (b) HTL (500 Å, compound of Formula 7-2 (NPB)), (c) EBL (100 Å, compound of Formula 7-3), (d) EML (300 Å, Host (DPEPO: TD (compound of Formula 6, 27wt%): FD (3wt%)), (e) HBL (100 Å, DPEP)), (f) ETL (250 Å, compound of Formula 7-4 (TPBi)), (g) EIL (8 Å, LiF), and (h) Cathode (1000 Å, Al)

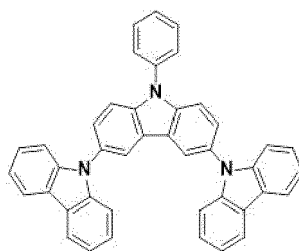
[Formula 7-1]



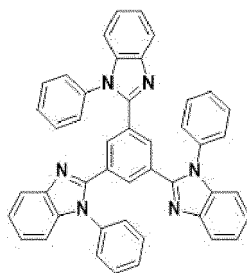
[Formula 7-2]



[Formula 7-3]



[Formula 7-4]



(1) Example 1 (Ex1)

[0105] The compound 1 is used as the fluorescent dopant (FD) in the EML.

(2) Example 2 (Ex2)

[0106] The compound 3 is used as the fluorescent dopant (FD) in the EML.

(3) Example 3 (Ex3)

[0107] The compound 5 is used as the fluorescent dopant (FD) in the EML.

(4) Example 4 (Ex4)

[0108] The compound 10 is used as the fluorescent dopant (FD) in the EML.

(5) Example 5 (Ex5)

[0109] The compound 15 is used as the fluorescent dopant (FD) in the EML.

(6) Comparative Example 2 (Ref1)

[0110] The compound of Formula 2 is used as the fluorescent dopant (FD) in the EML.

(7) Comparative Example 3 (Ref2)

[0111] The compound of Formula 3 is used as the fluorescent dopant (FD) in the EML.

(8) Comparative Example 3 (Ref3)

[0112] The compound of Formula 4 is used as the fluorescent dopant (FD) in the EML.

(9) Comparative Example 4 (Ref4)

[0113] The compound of Formula 5 is used as the fluorescent dopant (FD) in the EML.

[0114] The properties, i.e., the driving voltage ([V]), the current efficiency ([cd/A]), the power efficiency ([lm/W]), the CIE color coordinate, the maximum EL (ELmax) and the external quantum efficiency (EQE), of the organic light emitting diodes of Examples 1 to 5 and Comparative Examples 1 to 4 are measured and listed in Table 3.

Table 3

	V	cd/A	lm/W	CIE _x	CIE _y	ELmax (nm)	EQE (%)
Ex1	4.2	15.0	11.2	0.140	0.153	448	12.2
Ex2	4.3	15.7	11.5	0.146	0.154	448	12.3
Ex3	4.3	18.3	13.3	0.151	0.161	451	13.0
Ex4	4.5	14.3	10.0	0.148	0.161	450	11.1
Ex5	4.3	12.5	9.2	0.150	0.163	452	10.2
Ref1	5.6	10.5	5.9	0.140	0.150	447	5.6
Ref2	5.5	10.3	5.8	0.149	0.164	453	6.8
Ref3	5.1	11.0	6.8	0.142	0.148	445	7.0
Ref4	5.8	11.7	6.3	0.147	0.171	462	6.1

[0115] As shown in Table 3, in comparison to the OLED in Comparative Examples 1 to 4, the OLED of Examples 1 to 5 including the organic emitting compound of the present invention, which includes the benzofluoranthene core and the cyanophenylene moiety, which is directly bonded to the benzofluoranthene core, in the EML and the delayed fluorescent dopant has improved emitting efficiency and reduced power consumption.

[0116] FIG. 5 is a schematic-cross sectional view of an OLED according to a second embodiment of the present invention.

[0117] As shown in FIG. 5, an OLED D includes the first and second electrodes 160 and 164, which face each other, and the organic emitting layer 162 therebetween. The organic emitting layer 162 includes an EML 340, which includes first and second layers 342 and 344 and is positioned between the first and second electrodes 160 and 164, an HTL 320 between the first electrode 160 and the EML 340 and an ETL 360 between the second electrode 164 and the EML 340.

[0118] In addition, the organic emitting layer 162 may further include a HIL 310 between the first electrode 160 and the HTL 320 and an EIL 370 between the second electrode 164 and the ETL 360.

[0119] Moreover, the organic emitting layer 162 may further include an EBL 330 between the HTL 320 and the EML 340 and a HBL 350 between the EML 340 and the ETL 360.

[0120] For example, in the EML 340, one of the first layer 342 (e.g., a first emitting material layer) and the second layer 344 (e.g., a second emitting material layer) may include the organic emitting compound of the present invention as a first dopant (a fluorescent dopant) and a delayed fluorescent compound as a second dopant (a first delayed fluorescent dopant), and a host (a first host). The other one of the first and second layers 342 and 344 may include a

[0121] The first host may be selected from the materials of Formula 7, and the second host may be same as or different from the first host. The first and second delayed fluorescent dopants may be same.

[0122] The organic light emitting diode, where the first layer 342 includes the fluorescent dopant, the first delayed fluorescent dopant and the first host, will be explained.

[0123] In the first layer 342, a summation of the fluorescent dopant and the first delayed fluorescent dopant may be 1 to 50 wt% with respect to the first host. In the second layer 344, the second delayed fluorescent dopant may have 1 to 30 wt% with respect to the second host.

[0124] In the OLED D, since the first layer 342 of the EML 340 includes the organic emitting compound of the present invention as the fluorescent dopant and the first delayed fluorescent dopant, the singlet energy and the triplet energy of the first delayed fluorescent dopant are transferred into the fluorescent dopant, i.e., the organic emitting compound of the present invention, such that the emission is generated from the fluorescent dopant. Accordingly, the quantum efficiency of the OLED D is increased, and the FWHM of the OLED D is narrowed.

[0125] On the other hand, when the amount, i.e., percentage by weight, of the first delayed fluorescent dopant is increased to increase the energy efficiency in the first layer 342, the quenching may happen in the first delayed fluorescent dopant such that the emitting efficiency may be decreased.

[0126] However, in the OLED of the present invention, since the OLED D includes the second layer 344, which is adjacent to the first layer 342 and includes the second delayed fluorescent dopant, without increasing the amount of the first delayed fluorescent dopant in the first layer 342, the energy efficiency is increased without the quenching problem.

[0127] Namely, the singlet energy of the first delayed fluorescent dopant in the first layer 342 and the singlet energy of the second delayed fluorescent dopant in the second layer 344 are transferred into the fluorescent dopant in the first layer 342 such that the emission happens from the fluorescent dopant.

[0128] The percentage by weight of the first delayed fluorescent dopant in the first layer 342 may be smaller than that of the fluorescent dopant in the first layer 342 and/or that of the second delayed fluorescent dopant in the second layer 344.

[0129] For example, the second host, which is included in the second layer 344 with the second delayed fluorescent dopant, may be same as a material of the HBL 350. In this instance, the second layer 344 may have a hole blocking function with an emission function. Namely, the second layer 344 may serve as a buffer layer for blocking the hole. When the HBL 350 is omitted, the second layer 344 serves as an emitting layer and a hole blocking layer.

[0130] When the first layer 342 includes the second delayed fluorescent dopant and the second layer 344 includes the fluorescent dopant, i.e., the organic emitting compound of the present invention, the first delayed fluorescent dopant, the host of the first layer 342 may be same as a material of the EBL 330. In this instance, the first layer 342 may have an electron blocking function with an emission function. Namely, the first layer 342 may serve as a buffer layer for blocking the electron. When the EBL 330 is omitted, the first layer 342 serves as an emitting layer and an electron blocking layer.

[0131] Alternatively, in the EML 340, one of the first layer 342 and the second layer 344 may include the organic emitting compound of the present invention as a first dopant (a first fluorescent dopant) and a delayed fluorescent compound as a second dopant (a delayed fluorescent dopant), and a host (a first host), and the other one of the first and second layers 342 and 344 may include a fluorescent compound as a third dopant (a second fluorescent dopant) and a second host.

[0132] The first host may be selected from the materials described above, namely Bis[2-(diphenylphosphino)phenyl] ether oxide (DPEPO), 2,8-bis(diphenylphosphoryl)dibenzothiophene (PPT), 2,8-di(9H-carbazol-9-yl)dibenzothiophene (DCzDBT), m-bis(carbazol-9-yl)biphenyl (m-CBP), Diphenyl-4-triphenylsilylphenyl-phosphine oxide (TPSO1), 9-(9-phenyl-9H-carbazol-6-yl)-9H-carbazole (CCP), and the second host may be same as or different from the first host. The first and second fluorescent dopants may be same.

[0133] When the amount, i.e., percentage by weight, of the first fluorescent dopant is increased to increase the brightness by the first fluorescent dopant in the first layer 342, the quenching may happen in the first fluorescent dopant such that the emitting efficiency may be decreased.

[0134] However, in the OLED of the present invention, since the OLED D includes the second layer 344, which is adjacent to the first layer 342 and includes the second fluorescent dopant, without increasing the amount of the first fluorescent dopant in the first layer 342, the brightness is increased without the quenching problem.

[0135] Namely, the singlet energy of the delayed fluorescent dopant in the first layer 342 is transferred into the first fluorescent dopant in the first layer 342 and the second fluorescent dopant in the second layer 344 such that the emission happens from the first and second fluorescent dopants. Accordingly, the brightness of the OLED D is improved without the quenching problem in the fluorescent dopant.

[0136] In this instance, the percentage by weight of the delayed fluorescent dopant in the first layer 342 may be greater than that of the first fluorescent dopant in the first layer 342 and smaller than that of the second fluorescent dopant in the second layer 344. In addition, the percentage by weight of the first fluorescent dopant in the first layer 342 may be smaller than that of the second fluorescent dopant in the second layer 344.

[0137] For example, the second host, which is included in the second layer 344 with the second fluorescent dopant, may be same as a material of the HBL 350. In this instance, the second layer 344 may have a hole blocking function with an emission function. Namely, the second layer 344 may serve as a buffer layer for blocking the hole. When the HBL 350 is omitted, the second layer 344 serves as an emitting layer and a hole blocking layer.

[0138] When the first layer 342 includes the second fluorescent dopant and the second layer 344 includes the first fluorescent dopant and the delayed fluorescent dopant, the host of the first layer 342 may be same as a material of the EBL 330. In this instance, the first layer 342 may have an electron blocking function with an emission function. Namely, the first layer 342 may serve as a buffer layer for blocking the electron. When the EBL 330 is omitted, the first layer 342 serves as an emitting layer and an electron blocking layer.

[0139] FIG. 6 is a schematic-cross sectional view of an OLED according to a third embodiment of the present invention.

[0140] As shown in FIG. 6, an organic light emitting diode D includes the first and second electrodes 160 and 164, which face each other, and the organic emitting layer 162 therebetween. The organic emitting layer 162 includes an EML 440, which includes first to third layers 442, 444 and 446 and is positioned between the first and second electrodes 160 and 164, a HTL 420 between the first electrode 160 and the EML 440 and an ETL 460 between the second electrode 164 and the EML 440.

[0141] In addition, the organic emitting layer 162 may further include a HIL 410 between the first electrode 160 and the HTL 420 and an EIL 470 between the second electrode 164 and the ETL 460.

[0142] Moreover, the organic emitting layer 162 may further include an EBL 430 between the HTL 420 and the EML 440 and a HBL 450 between the EML 440 and the ETL 460.

[0143] In the EML 440, the first layer 442 is positioned between the second layer 444 and the third layer 446. Namely, the second layer 444 is positioned between the EBL 430 and the first layer 442, and the third layer 446 is positioned between the first layer 442 and the HBL 450.

[0144] The first layer 442 (e.g., a first emitting material layer) may include a fluorescent compound as a first dopant (a first fluorescent dopant), and each of the second and third layers 444 and 446 includes the organic emitting compound of the present invention as a second dopant (a second fluorescent dopant) and a delayed fluorescent compound as a third dopant (delayed fluorescent dopant). The delayed fluorescent dopant in the second layer 444 and the delayed fluorescent dopant in the third layer 446 may be same or different.

[0145] In the OLED D, since the second layer 444 and the third layer 446 of the EML 440 includes the organic emitting compound of the present invention as the fluorescent dopant and the delayed fluorescent dopant, the singlet energy and the triplet energy of the delayed fluorescent dopant are transferred into the fluorescent dopant, i.e., the organic emitting compound of the present invention, such that the emission is generated from the fluorescent dopant. Accordingly, the quantum efficiency of the OLED D is increased, and the FWHM of the OLED D is narrowed.

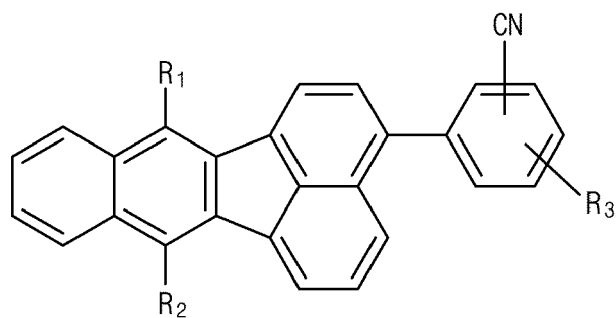
[0146] In each of the second and third layers 444 and 446, the percentage by weight of the delayed fluorescent dopant may be greater than that of the second fluorescent dopant. As a result, the energy transfer from the delayed fluorescent dopant into the second fluorescent dopant is sufficiently generated such that the quantum efficiency of the OLED D is improved.

[0147] On the other hand, since the amount of the second fluorescent dopant is relatively small in the second and third layers 444 and 446, the brightness of the OLED D may be insufficient.

[0148] However, in the OLED D of the present invention, since the first layer 442, which includes the first fluorescent dopant, is positioned between the second layer 444 and the third layer 446, each of which includes the delayed fluorescent dopant and the second fluorescent dopant, the energy is transferred from the delayed fluorescent dopant into the first and second fluorescent dopant, and thus the emission happens from the first and second dopants. Accordingly, the brightness of the OLED D is improved.

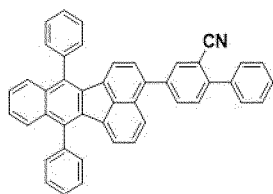
[0149] The percentage by weight of the delayed fluorescent dopant in each of the second and third layers 444 and 446 may be greater than that of the second fluorescent dopant in each of the second and third layers 444 and 446 and smaller than that of the first fluorescent dopant in the first layer 442 such that the energy transfer efficiency and the brightness are improved. inventioninventioninventioninventionThe present invention is directed to the following aspects:

[1] An organic emitting compound of Formula:

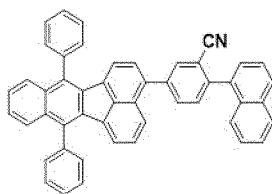


wherein each of R₁, R₂ and R₃ is independently selected from the group consisting of hydrogen, C1 to C20 alkyl group, C1 to C20 alkoxy group, C1 to C20 silyl group, C6 to C30 aryl group, C5 to C30 heteroaryl group and amine group.

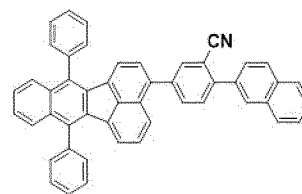
[2] The organic emitting compound according to [1], wherein the organic emitting compound is selected from the group consisting of:



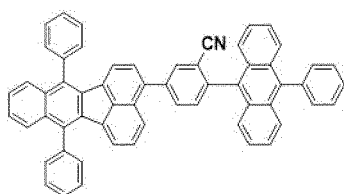
compound 1



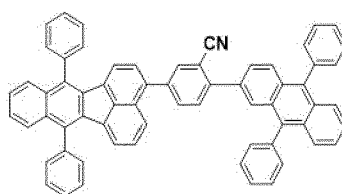
compound 2



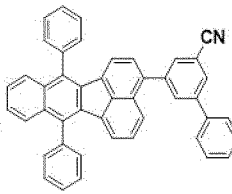
compound 3



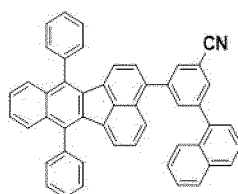
compound 4



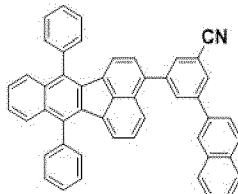
compound 5



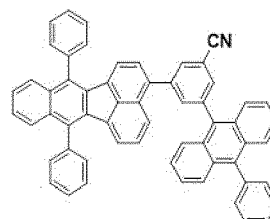
compound 6



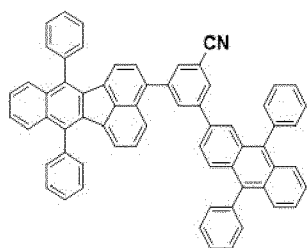
compound 7



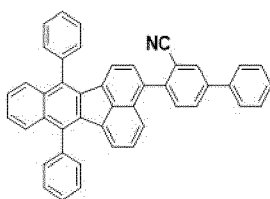
compound 8



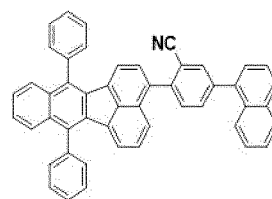
compound 9



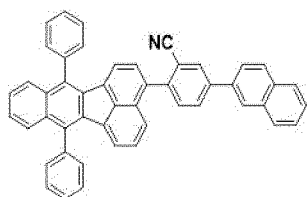
compound 10



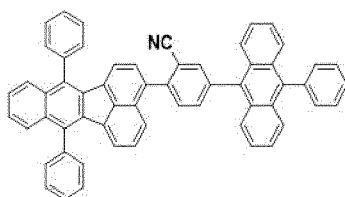
compound 11



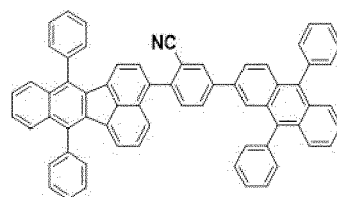
compound 12



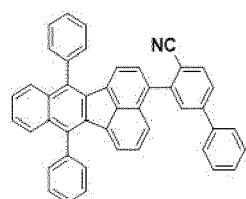
compound 13



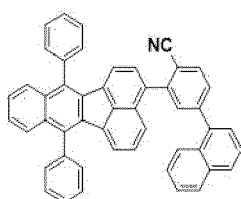
compound 14



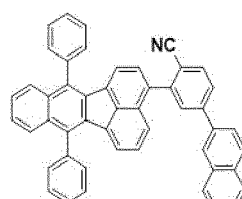
compound 15



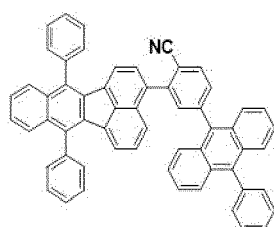
compound 16



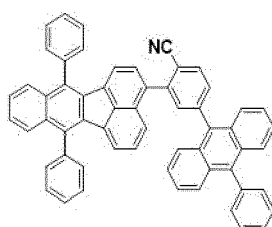
compound 17



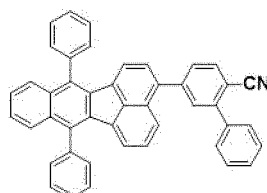
compound 18



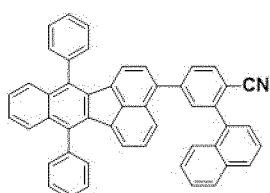
compound 19



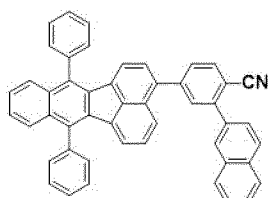
compound 20



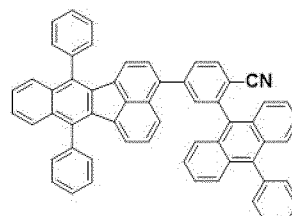
compound 21



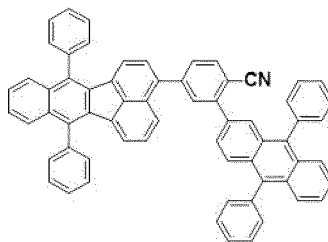
compound 22



compound 23



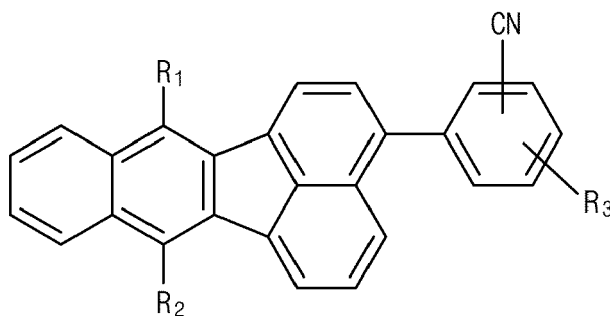
compound 24



compound 25

[3] An organic light emitting diode, comprising:

- a first electrode;
 - a second electrode facing the first electrode; and
 - a first emitting material layer positioned between the first and second electrodes and including a first host and an organic emitting compound,
- wherein the organic emitting compound is represent by Formula:



wherein each of R₁, R₂ and R₃ is independently selected from the group consisting of hydrogen, C1 to C20 alkyl group, C1 to C20 alkoxy group, C1 to C20 silyl group, C6 to C30 aryl group, C5 to C30 heteroaryl group and amine group.

[4] The organic light emitting diode according to [3], wherein the organic emitting compound is used as a first fluorescent dopant, and the first emitting material layer further includes a delayed fluorescent compound as a first delayed fluorescent dopant.

[5] The organic light emitting diode according to [4], wherein a difference between an energy level of a HOMO of the first fluorescent dopant and an energy level of a HOMO of the first delayed fluorescent dopant is equal to or less than 0.3eV.

[6] The organic light emitting diode according to [4], wherein an energy level of a singlet state of the first delayed fluorescent dopant is greater that an energy level of a singlet state of the first fluorescent dopant.

[7] The organic light emitting diode according to [4], wherein an energy level of a triplet state of the first delayed fluorescent dopant is smaller than an energy level of a triplet state of the first host and greater than an energy level of a triplet state of the first fluorescent dopant.

[8] The organic light emitting diode according to [4], further comprising:
a second emitting material layer including a second host and a second delayed fluorescent dopant and positioned between the first emitting material layer and the first electrode.

[9] The organic light emitting diode according to [8], further comprising:

an electron blocking layer between the first electrode and the second emitting material layer,
wherein the second host is same as a material of the electron blocking layer.

[10] The organic light emitting diode according to [4], further comprising:

a second emitting material layer including a second host and a second fluorescent dopant and positioned between the first emitting material layer and the first electrode.

[11] The organic light emitting diode according to [10], further comprising:

an electron blocking layer between the first electrode and the second emitting material layer,
wherein the second host is same as a material of the electron blocking layer.

[12] The organic light emitting diode according to [4], further comprising:

a second emitting material layer including a second host and a second delayed fluorescent dopant and positioned between the first emitting material layer and the second electrode.

[13] The organic light emitting diode according to [12], further comprising:

a hole blocking layer between the second electrode and the second emitting material layer,
wherein the second host is same as a material of the hole blocking layer.

[14] The organic light emitting diode according to [4], further comprising:

a second emitting material layer including a second host and a second fluorescent dopant and positioned between the first emitting material layer and the second electrode.

[15] The organic light emitting diode according to [14], further comprising:

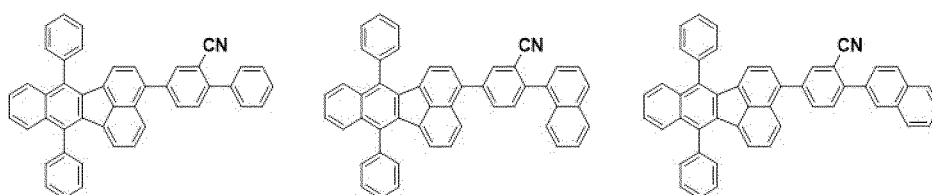
a hole blocking layer between the second electrode and the second emitting material layer,
wherein the second host is same as a material of the hole blocking layer.

[16] The organic light emitting diode according to [14], further comprising:

a third emitting material layer including a third host, a third fluorescent dopant and a second delayed fluorescent dopant and positioned between the second emitting material layer and the second electrode.

[17] The organic light emitting diode according to [16], wherein the third fluorescent dopant is the organic emitting compound.

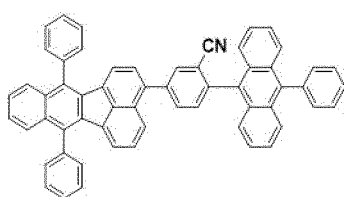
[18] The organic light emitting diode according to [3], wherein the organic emitting compound is selected from the group consisting of:



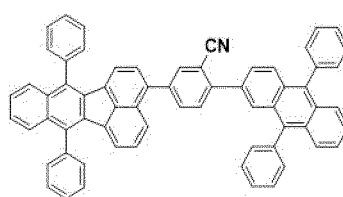
compound 1

compound 2

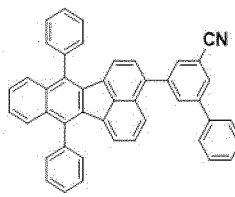
compound 3



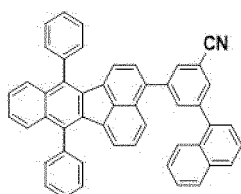
compound 4



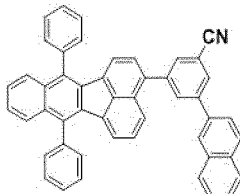
compound 5



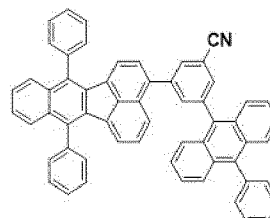
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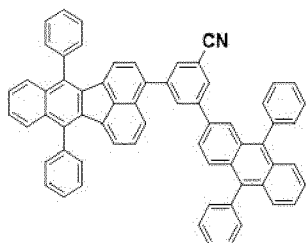
compound 7



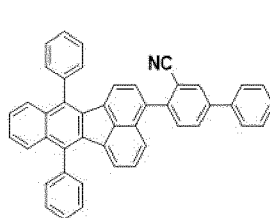
compound 8



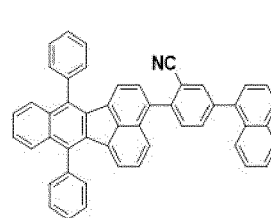
compound 9



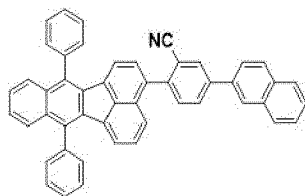
compound 10



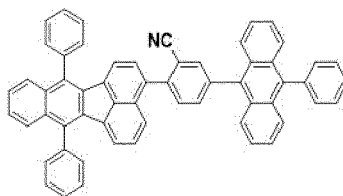
compound 11



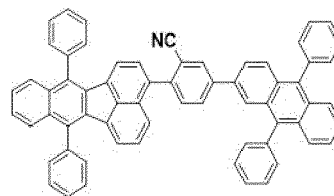
compound 12



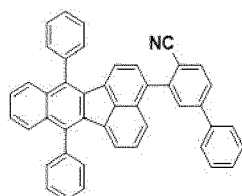
compound 13



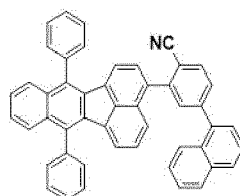
compound 14



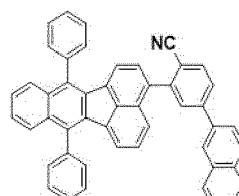
compound 15



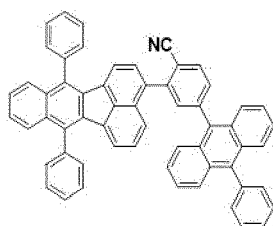
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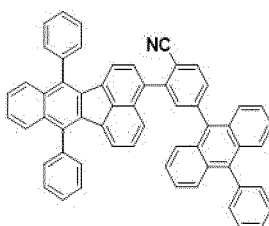
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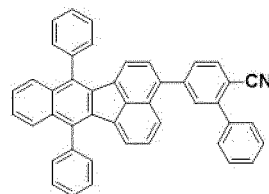
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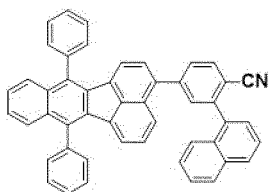
compound 19



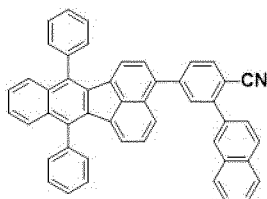
compound 20



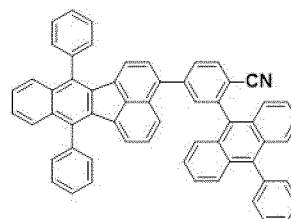
compound 21



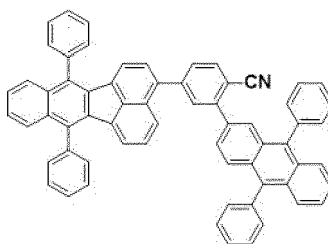
compound 22



compound 23



compound 24



compound 25

[19] An organic light emitting display device, comprising:

a substrate;

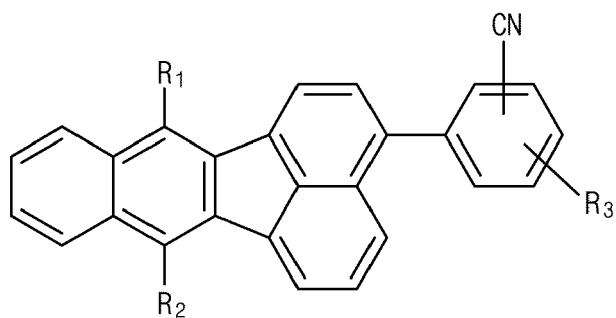
an organic light emitting diode on the substrate, the organic light emitting diode including:

a first electrode;

a second electrode facing the first electrode; and

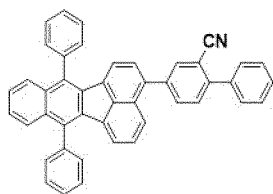
a first emitting material layer positioned between the first and second electrodes and including a first host and an organic emitting compound; and

an encapsulation film covering the organic light emitting diode,
wherein the organic emitting compound is represent by Formula:

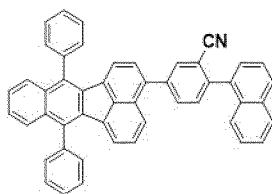


wherein each of R_1 , R_2 and R_3 is independently selected from the group consisting of hydrogen, C1 to C20 alkyl group, C1 to C20 alkoxy group, C1 to C20 silyl group, C6 to C30 aryl group, C5 to C30 heteroaryl group and amine group.

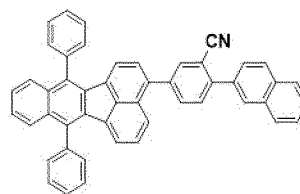
[20] The organic light emitting display device according to [19], wherein the organic emitting compound is selected from the group consisting of:



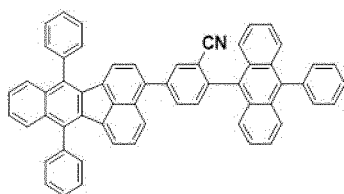
compound 1



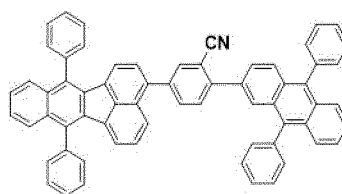
compound 2



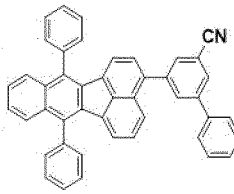
compound 3



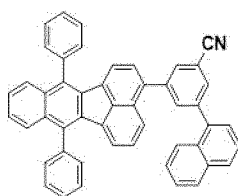
compound 4



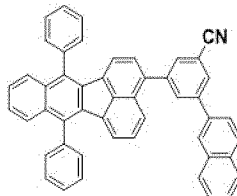
compound 5



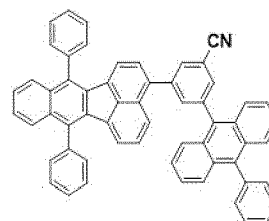
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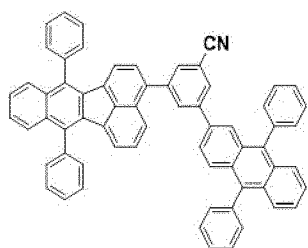
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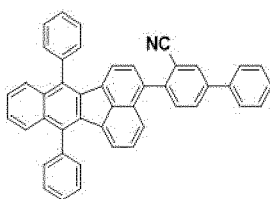
compound 8



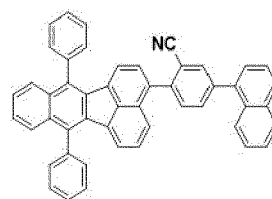
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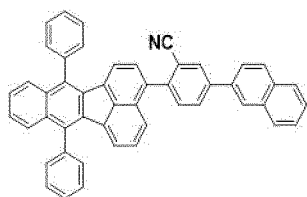
compound 10



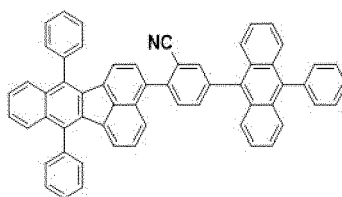
compound 11



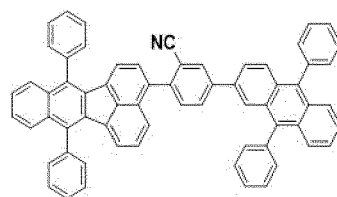
compound 12



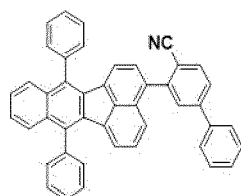
compound 13



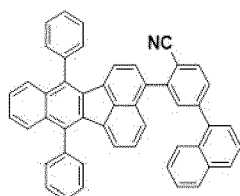
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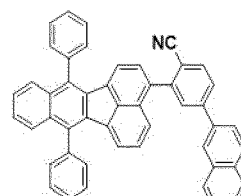
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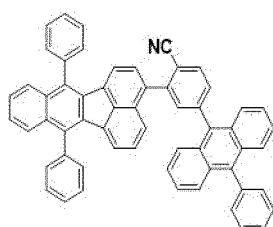
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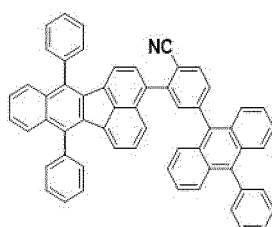
compound 17



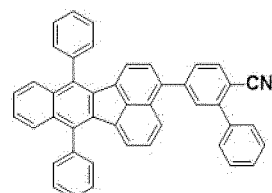
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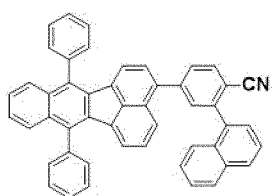
compound 19



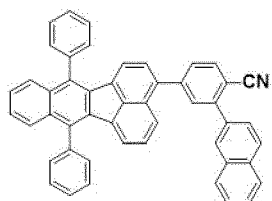
compound 20



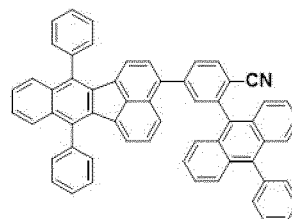
compound 21



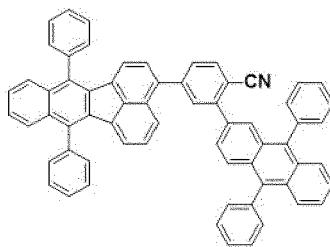
compound 22



compound 23



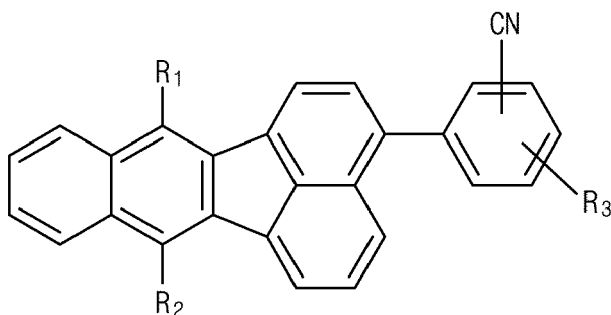
compound 24



compound 25

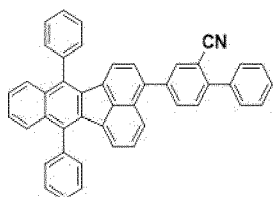
Claims

1. An organic emitting compound of Formula:

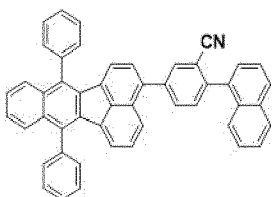


wherein each of R_1 , R_2 and R_3 is independently selected from the group consisting of hydrogen, C1 to C20 alkyl group, C1 to C20 alkoxy group, C1 to C20 silyl group, C6 to C30 aryl group, C5 to C30 heteroaryl group and amine group.

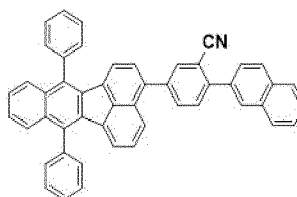
2. The organic emitting compound according to claim 1, wherein the organic emitting compound is selected from the group consisting of:



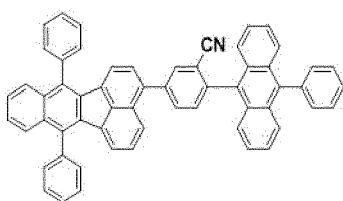
compound 1



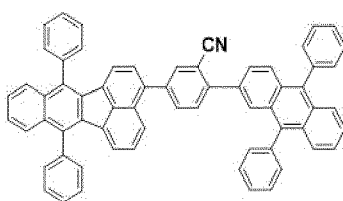
compound 2



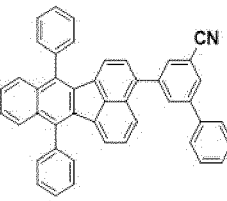
compound 3



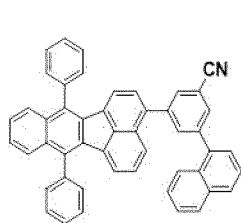
compound 4



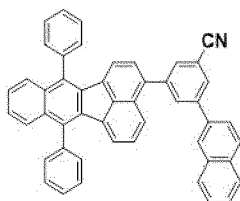
compound 5



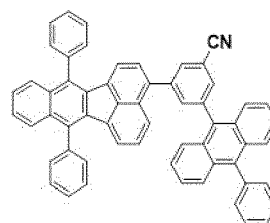
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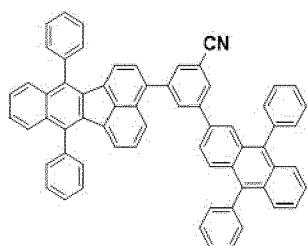
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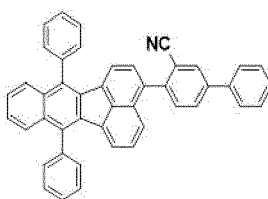
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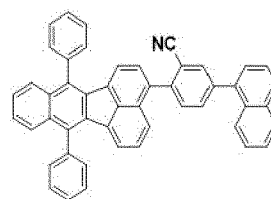
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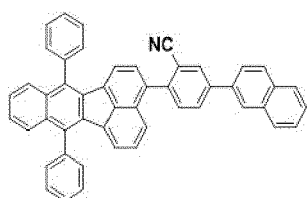
compound 10



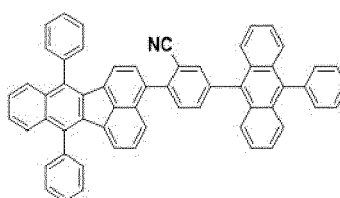
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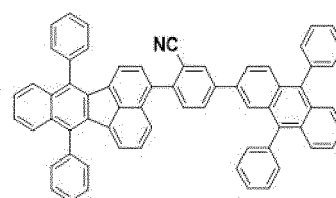
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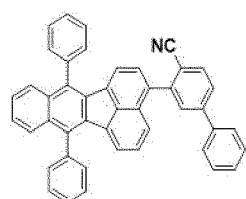
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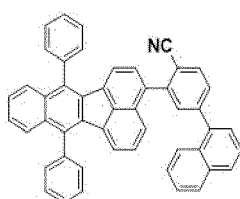
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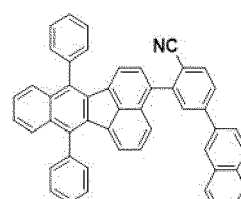
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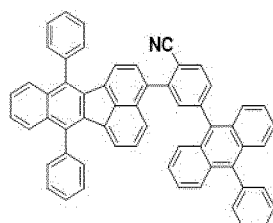
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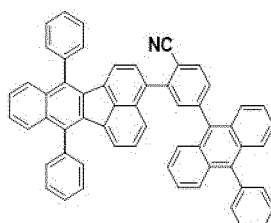
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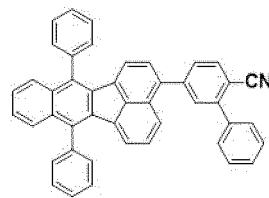
compound 18



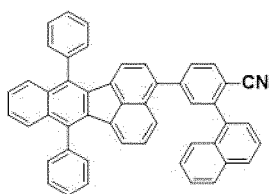
compound 19



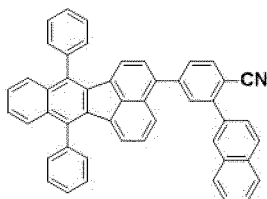
compound 20



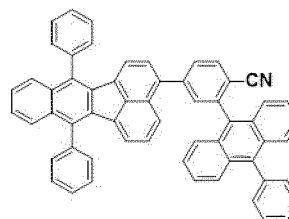
compound 21



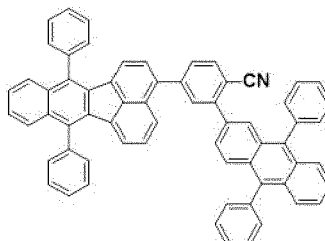
compound 22



compound 23



compound 24



compound 25

3. An organic light emitting diode, comprising:

a first electrode;

a second electrode facing the first electrode; and

a first emitting material layer positioned between the first and second electrodes and including a first host and an organic emitting compound according to claims 1 or 2.

4. The organic light emitting diode according to claim 3, wherein the organic emitting compound is used as a first fluorescent dopant, and the first emitting material layer further includes a delayed fluorescent compound as a first delayed fluorescent dopant.

5. The organic light emitting diode according to claim 4, wherein a difference between an energy level of a HOMO of the first fluorescent dopant and an energy level of a HOMO of the first delayed fluorescent dopant is equal to or less than 0.3eV.

6. The organic light emitting diode according to claim 4, wherein an energy level of a singlet state of the first delayed fluorescent dopant is greater than an energy level of a singlet state of the first fluorescent dopant.

7. The organic light emitting diode according to claim 4, wherein an energy level of a triplet state of the first delayed fluorescent dopant is smaller than an energy level of a triplet state of the first host and greater than an energy level of a triplet state of the first fluorescent dopant.

8. The organic light emitting diode according to anyone of claims 4 to 7, further comprising:

a second emitting material layer including a second host and a second delayed fluorescent dopant and positioned between the first emitting material layer and the first electrode.

9. The organic light emitting diode according to anyone of claims 4 to 7, further comprising:

a second emitting material layer including a second host and a second fluorescent dopant and positioned between the first emitting material layer and the first electrode.

10. The organic light emitting diode according to anyone of claims 4 to 7, further comprising:

a second emitting material layer including a second host and a second delayed fluorescent dopant and positioned between the first emitting material layer and the second electrode.

11. The organic light emitting diode according to anyone of claims 4 to 7, further comprising:
a second emitting material layer including a second host and a second fluorescent dopant and positioned between
the first emitting material layer and the second electrode.

5 12. The organic light emitting diode according to claim 11, further comprising:

a hole blocking layer between the second electrode and the second emitting material layer,
wherein the second host is same as a material of the hole blocking layer.

10 13. The organic light emitting diode according to claim 11, further comprising:

a third emitting material layer including a third host, a third fluorescent dopant and a second delayed fluorescent
dopant and positioned between the second emitting material layer and the second electrode.

15 14. The organic light emitting diode according to claim 13, wherein the third fluorescent dopant is the organic emitting
compound.

15 15. An organic light emitting display device, comprising:

a substrate;
20 an organic light emitting diode on the substrate, the organic light emitting diode including:

a first electrode;
a second electrode facing the first electrode; and
a first emitting material layer positioned between the first and second electrodes and including a first host
25 and an organic emitting compound according to claim 1 or 2;

and
an encapsulation film covering the organic light emitting diode.

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FIG. 1

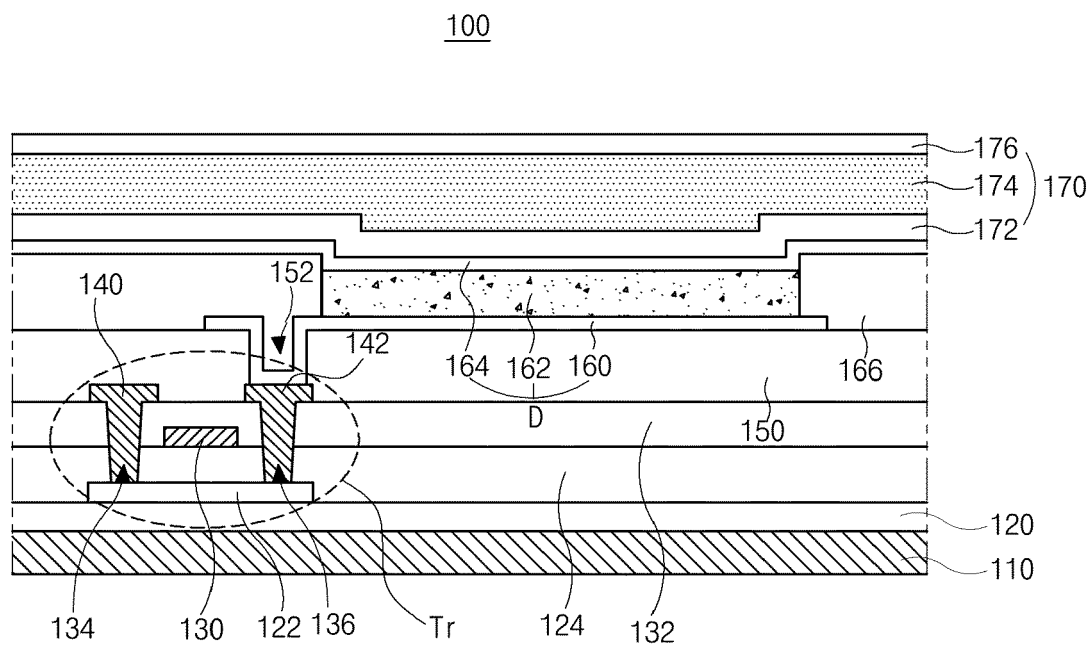


FIG. 2

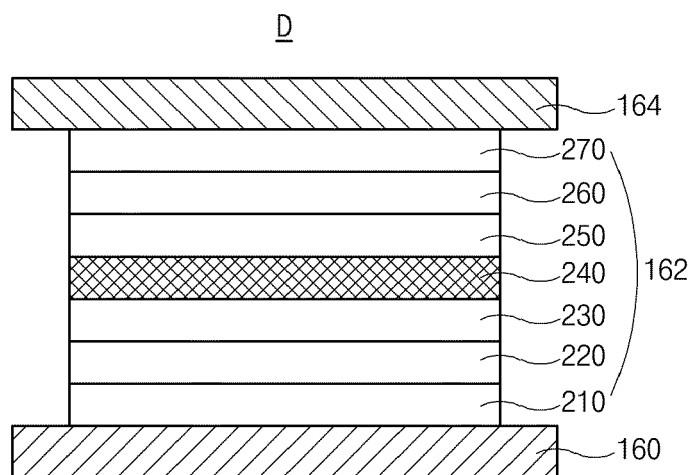


FIG. 3

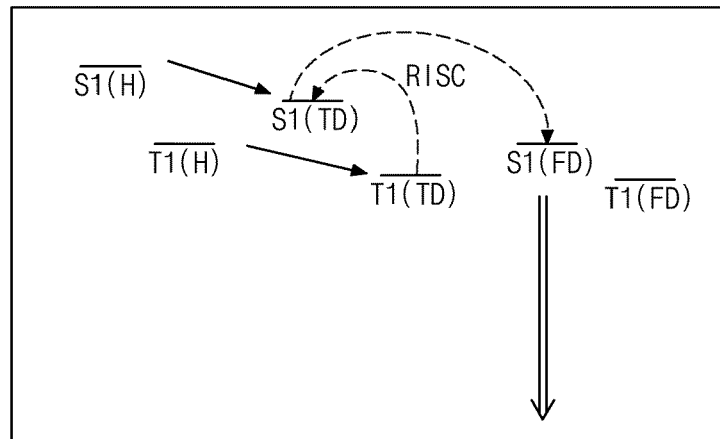


FIG. 4A

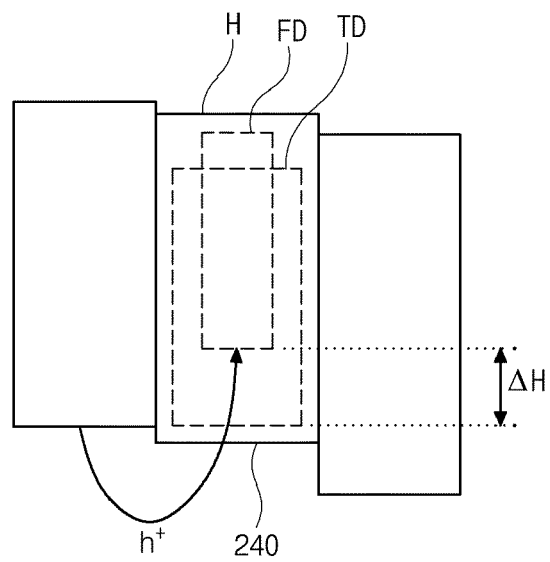


FIG. 4B

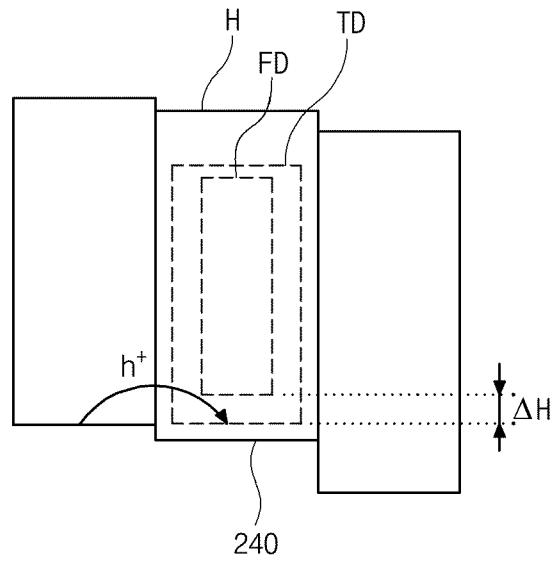


FIG. 5

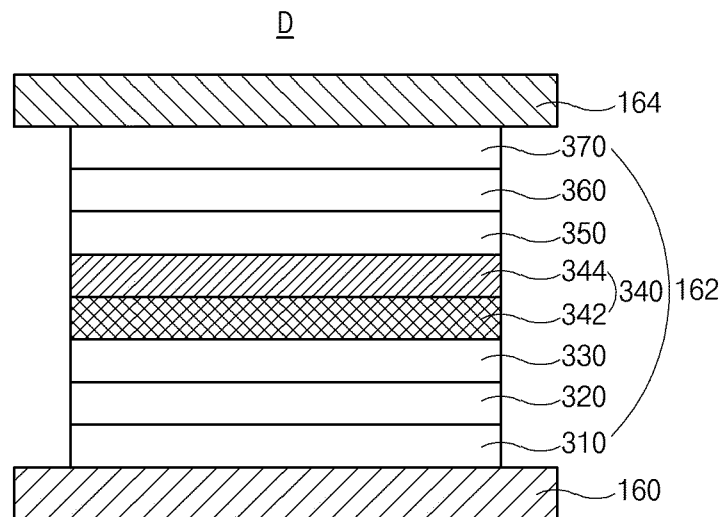
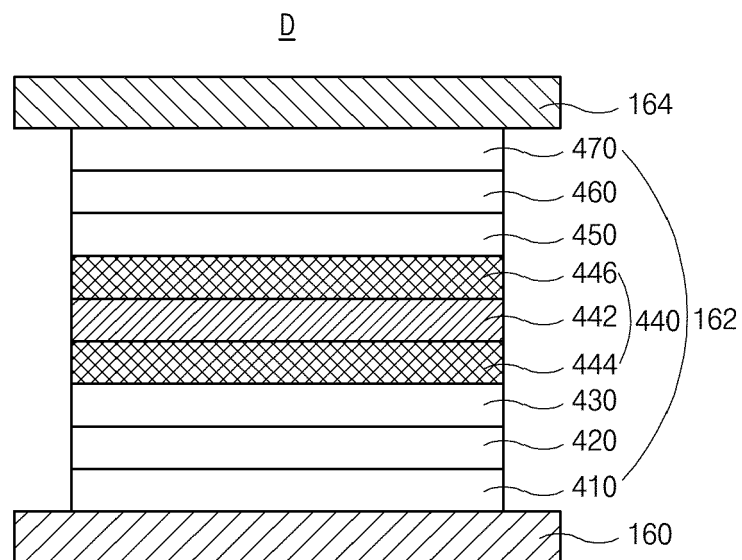


FIG. 6





EUROPEAN SEARCH REPORT

 Application Number
 EP 19 18 9867

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X	----- US 2016/149139 A1 (XIA CHUANJUN [US] ET AL) 26 May 2016 (2016-05-26) * page 40, line 1, paragraphs 65,69,79; claims 1,30; compound second compound *	1-4,15	
X	----- JP 2014 096572 A (TDK CORP) 22 May 2014 (2014-05-22) * page 21; example 3; table 1; compounds A-11-1, A-11-8 *	1-3,15	
X	----- JP 2015 204357 A (TDK CORP) 16 November 2015 (2015-11-16) * page 9; example 1; table 1; compounds C-8 *	1-3,15	
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X	----- US 2009/015144 A1 (TAKASHIMA YORIYUKI [JP] ET AL) 15 January 2009 (2009-01-15) * page 14; claim 9; compounds 5-3 *	1-3,15	
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 5 December 2019	Examiner Fratiloiu, Silvia
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

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05-12-2019

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			US 2009015144 A1	15-01-2009
			WO 2008059713 A1	22-05-2008

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

专利名称(译)	有机发光连接和有机发光二极管以及具有该有机发光二极管的显示装置		
公开(公告)号	EP3608986A1	公开(公告)日	2020-02-12
申请号	EP2019189867	申请日	2019-08-02
[标]申请(专利权)人(译)	乐金显示有限公司		
申请(专利权)人(译)	LG DISPLAY CO. , LTD.		
当前申请(专利权)人(译)	LG DISPLAY CO. , LTD.		
[标]发明人	YANG JOONG HWAN SEO BO MIN		
发明人	YOO, MI-SANG BAEK, JEONG-EUN YANG, JOONG-HWAN SEO, BO-MIN		
IPC分类号	H01L51/54		
CPC分类号	C07C255/50 C09K11/06 C09K2211/1007 C09K2211/1011 H01L51/0052 H01L51/0054 H01L51/0058 H01L51/5012 H01L51/0055 C07C2603/52 H01L27/3244 H01L51/5004 H01L51/5016 H01L51/5096 H01L2251/552		
优先权	1020180091234 2018-08-06 KR		
外部链接	Espacenet		

摘要(译)

本发明提供下式的有机发光化合物，以及包括该有机发光化合物的有机发光二极管和有机发光显示装置。

FIG. 1

