



(51) International Patent Classification:

C07D 471/04 (2006.01) H01L 51/52 (2006.01)

H01L 51/00 (2006.01) H01L 27/32 (2006.01)

H01L 51/50 (2006.01)

(21) International Application Number:

PCT/KR2021/010054

(22) International Filing Date:

02 August 2021 (02.08.2021)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

10-2020-0170431 08 December 2020 (08.12.2020) KR

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,

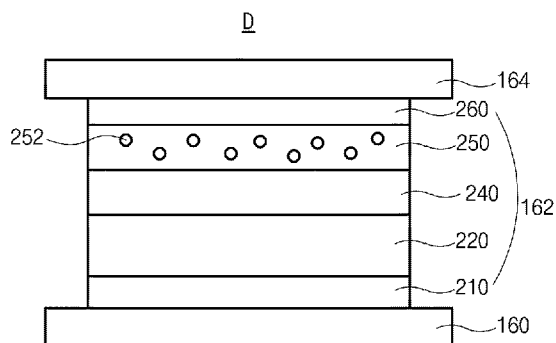
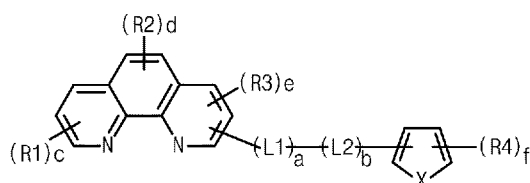
HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: ORGANIC COMPOUND AND ORGANIC LIGHT EMITTING DIODE AND ORGANIC LIGHT EMITTING DEVICE INCLUDING THE SAME



(57) Abstract: The present disclosure relates to an organic compound of Formula, and an organic light emitting diode and an organic light emitting display device including the organic compound. In Formula, X is oxygen (O) or sulfur (S), and each of R1 to R4 is independently selected from the group consisting of deuterium, halogen, cyano, C1 to C10 alkyl group, C1 to C10 alkoxy group, C3 to C30 cycloalkyl group, C6 to C30 aryl group, C6 to C30 arylamino group, and C5 to C30 heteroaryl group, wherein each of L1 and L2 is independent selected from the group consisting of C6 to C30 arylene group and C5 to C30 heteroarylene group, and wherein each of a and b is independent 0 or 1, each of c and f is independently an integer of 0 to 3, and each of d and e is independently an integer of 0 to 2.



Description

Title of Invention: ORGANIC COMPOUND AND ORGANIC LIGHT EMITTING DIODE AND ORGANIC LIGHT EMITTING DEVICE INCLUDING THE SAME

Technical Field

- [1] The present disclosure relates to an organic compound, and more specifically, to an organic compound having improved electron transporting efficiency, and an organic light emitting diode and an organic light emitting display device including the same.

Background Art

- [2] As requests for flat panel display devices having a small occupied area have been increased, an organic light emitting display device, which may be referred to as an organic electroluminescent device (OELD), including an organic light emitting diode (OLED) among the flat panel display device has been the subject of recent research and development.
- [3] 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 material layer (EML), combining the electrons with the holes, generating an exciton, and transforming the exciton from an excited state to a ground state. A flexible substrate, for example, a plastic substrate, can be used as a base substrate where elements are formed. In addition, the organic light emitting display device can be operated at a voltage (e.g., 10V or below) lower than a voltage required to operate other display devices. Moreover, the organic light emitting display device has advantages in the power consumption and the color purity.
- [4] To provide sufficient emitting efficiency and lifespan of the OLED, the development of an electron transporting material having sufficient electron transporting efficiency is required.

Disclosure of Invention

Technical Problem

- [5] Accordingly, the present disclosure is directed to an organic compound, an OLED and an organic light emitting device that substantially obviate one or more of the problems due to the limitations and disadvantages of the related art.
- [6] An object of the present disclosure is to provide an organic compound having improved electron transporting efficiency.
- [7] Another object of the present disclosure is to provide an OLED and an organic light emitting display device including the organic compound and having improved emitting

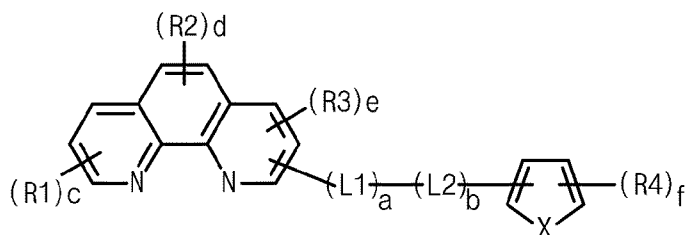
efficiency and lifespan and lowered driving voltage.

- [8] Additional features and advantages of the disclosure will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice of the disclosure. The objectives and other advantages of the disclosure will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

Solution to Problem

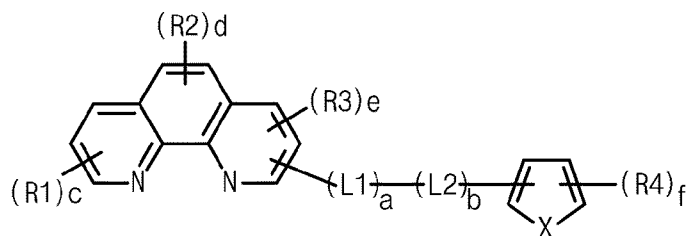
- [9] According to an aspect, the present disclosure provides an organic compound of Formula, wherein X is oxygen (O) or sulfur (S), and each of R1 to R4 is independently selected from the group consisting of deuterium, halogen, cyano, C1 to C10 alkyl group, C1 to C10 alkoxy group, C3 to C30 cycloalkyl group, C6 to C30 aryl group, C6 to C30 arylamino group, and C5 to C30 heteroaryl group, wherein each of L1 and L2 is independent selected from the group consisting of C6 to C30 arylene group and C5 to C30 heteroarylene group, and wherein each of a and b is independent 0 or 1, each of c and f is independently an integer of 0 to 3, and each of d and e is independently an integer of 0 to 2.

[10]



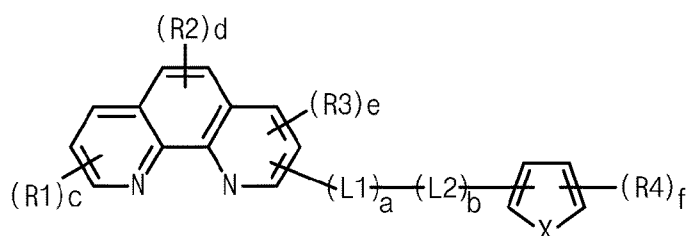
- [11] According to another aspect, the present disclosure provides an organic light emitting diode that comprises a first electrode; a second electrode facing the first electrode; and a first emitting part including a first emitting material layer and a first electron transporting layer and positioned between the first and second electrodes, wherein the first electron transporting layer includes a first electron transporting material and is positioned between the first emitting material layer and the second electrode, wherein the first electron transporting material is an organic compound of Formula, wherein X is oxygen (O) or sulfur (S), and each of R1 to R4 is independently selected from the group consisting of deuterium, halogen, cyano, C1 to C10 alkyl group, C1 to C10 alkoxy group, C3 to C30 cycloalkyl group, C6 to C30 aryl group, C6 to C30 arylamino group, and C5 to C30 heteroaryl group, wherein each of L1 and L2 is independent selected from the group consisting of C6 to C30 arylene group and C5 to C30 heteroarylene group, and wherein each of a and b is independent 0 or 1, each of c and f is independently an integer of 0 to 3, and each of d and e is independently an integer of 0 to 2.

[12]



[13] According to another aspect, the present disclosure provides an organic light emitting diode that comprises a first electrode; a second electrode facing the first electrode; a first emitting part including a first emitting material layer and positioned between the first and second electrodes; a second emitting part including a second emitting material layer and positioned between the first emitting part and the second electrode; and a first n-type charge generation layer including a first n-type charge generation material and positioned between the first and second emitting parts, wherein the first n-type charge generation material is an organic compound of Formula, wherein X is oxygen (O) or sulfur (S), and each of R1 to R4 is independently selected from the group consisting of deuterium, halogen, cyano, C1 to C10 alkyl group, C1 to C10 alkoxy group, C3 to C30 cycloalkyl group, C6 to C30 aryl group, C6 to C30 arylamino group, and C5 to C30 heteroaryl group, wherein each of L1 and L2 is independent selected from the group consisting of C6 to C30 arylene group and C5 to C30 heteroarylene group, and wherein each of a and b is independent 0 or 1, each of c and f is independently an integer of 0 to 3, and each of d and e is independently an integer of 0 to 2.

[14]



[15] According to another aspect, the present disclosure provides an organic light emitting display device that includes a substrate; the above organic light emitting diode over the substrate; and an encapsulation film covering the organic light emitting diode.

[16] It is to be understood that both the foregoing general description and the following detailed description are examples and are explanatory and are intended to provide further explanation of the disclosure as claimed.

Advantageous Effects of Invention

[17] An organic compound of the present disclosure has a structure, where a thiophene moiety or a furan moiety is combined to a phenanthroline moiety directly or through a linker, to provide high electron transporting efficiency.

- [18] The organic compound of the present disclosure is included in (or used for) an electron transporting layer and/or an n-type charge generation layer of an OLED so that the OLED and an organic light emitting device have increased emitting efficiency and lifespan and decreased driving voltage.

Brief Description of Drawings

- [19] The accompanying drawings, which are included to provide a further understanding of the disclosure, are incorporated in and constitute a part of this specification, illustrate implementations of the disclosure and together with the description serve to explain the principles of embodiments of the disclosure.
- [20] FIG. 1 is a schematic circuit diagram of an organic light emitting display device of the present disclosure.
- [21] FIG. 2 is a schematic cross-sectional view of an organic light emitting display device according to a first embodiment of the present disclosure.
- [22] FIG. 3 is a schematic cross-sectional view of an OLED according to a second embodiment of the present disclosure.
- [23] FIG. 4 is a schematic cross-sectional view of an organic light emitting display device according to a third embodiment of the present disclosure.
- [24] FIG. 5 is a schematic cross-sectional view of an OLED according to a fourth embodiment of the present disclosure.
- [25] FIG. 6 is a schematic cross-sectional view of an OLED according to a fifth embodiment of the present disclosure.

Mode for the Invention

- [26] Reference will now be made in detail to aspects of the disclosure, examples of which are illustrated in the accompanying drawings.
- [27] The present disclosure provides new organic compound, an OLED including the organic compound in an electron transporting layer and/or an n-type charge generation layer, and an organic light emitting device including the OLED. For example, the organic light emitting device may be an organic light emitting display device or an organic lightening device. As an example, an organic light emitting display device, which is a display device including the OLED of the present disclosure, will be mainly described.
- [28] FIG. 1 is a schematic circuit diagram of an organic light emitting display device of the present disclosure.
- [29] As shown in FIG. 1, an organic light emitting display device includes a gate line GL, a data line DL, a power line PL, a switching thin film transistor TFT Ts, a driving TFT Td, a storage capacitor Cst, and an OLED D. The gate line GL and the data line DL cross each other to define a pixel region P. The pixel region P may include a red pixel

region, a green pixel region and a blue pixel region.

[30] The switching TFT Ts is connected to the gate line GL and the data line DL, and the driving TFT Td and the storage capacitor Cst are connected to the switching TFT Ts and the power line PL. The OLED D is connected to the driving TFT Td.

[31] In the organic light emitting display device, when the switching TFT Ts is turned on by a gate signal applied through the gate line GL, a data signal from the data line DL is applied to the gate electrode of the driving TFT Td and an electrode of the storage capacitor Cst.

[32] When the driving TFT Td is turned on by the data signal, an electric current is supplied to the OLED D from the power line PL. As a result, the OLED D emits light. In this case, when the driving TFT Td is turned on, a level of an electric current applied from the power line PL to the OLED D is determined such that the OLED D can produce a gray scale.

[33] The storage capacitor Cst serves to maintain the voltage of the gate electrode of the driving TFT Td when the switching TFT Ts is turned off. Accordingly, even if the switching TFT Ts is turned off, a level of an electric current applied from the power line PL to the OLED D is maintained to next frame.

[34] As a result, the organic light emitting display device displays a desired image.

[35] FIG. 2 is a schematic cross-sectional view of an organic light emitting display device according to a first embodiment of the present disclosure.

[36] As shown in FIG. 2, the organic light emitting display device 100 includes a substrate 110, a TFT Tr over the substrate 110, and an OLED D on a planarization layer and connected to the TFT Tr. For example, a red pixel region, a green pixel region and a blue pixel region may be defined on the substrate 110, and the OLED D is positioned in each pixel region. Namely, the OLED D respectively emitting red, green and blue light may be disposed in the red pixel region, the green pixel region and the blue pixel region.

[37] The substrate 110 may be a glass substrate or a flexible substrate. For example, the flexible substrate may be a polyimide (PI) substrate, a polyethersulfone (PES) substrate, a polyethylenenaphthalate (PEN) substrate, a polyethylene terephthalate (PET) substrate or a polycarbonate (PC) substrate.

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

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

[40] 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 is 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.

[41] A gate insulating layer 124 is 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.

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

[43] In FIG. 2, the gate insulating layer 124 is 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.

[44] An interlayer insulating layer 132, which is formed of an insulating material, is 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.

[45] The interlayer insulating layer 132 includes 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 are positioned at both sides of the gate electrode 130 to be spaced apart from the gate electrode 130.

[46] The first and second contact holes 134 and 136 are 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 are formed only through the interlayer insulating layer 132.

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

[48] The source electrode 140 and the drain electrode 142 are 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.

[49] 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. Namely, the TFT Tr serves as a driving element.

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

[51] 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.

[52] 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.

[53] 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.

[54] A planarization layer 150 is formed on an entire surface of the substrate 110 to cover the TFT Tr. The planarization layer 150 has a drain contact hole 152 exposing the drain electrode 142 of the TFT Tr.

[55] A first electrode 160 is disposed on the planarization layer 150 and is separately formed in each pixel region. The first electrode 160 is connected to the drain electrode 142 of the TFT Tr through the drain contact hole 152.

[56] The first electrode 160 may be an anode and may be formed of a conductive material, e.g., a transparent conductive oxide (TCO), having a relatively high work function. For example, the first electrode 160 may be formed of indium-tin-oxide (ITO), indium-zinc-oxide (IZO), indium-tin-zinc-oxide (ITZO), tin oxide (SnO), zinc oxide (ZnO), indium-copper-oxide (ICO) or aluminum-zinc-oxide (Al:ZnO, AZO).

[57] When the organic light emitting display device 100 is operated in a bottom-emission type, the first electrode 160 may have a single-layered structure of the transparent conductive material layer. When the Organic light emitting display 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 silver (Ag) or aluminum-palladium-copper (APC) alloy. In this instance, the first electrode 160 may have a triple-layered structure of ITO/Ag/ITO or ITO/APC/ITO.

[58] In addition, a bank layer 166 is formed on the planarization 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.

[59] The organic light emitting layer 162 as an emitting unit is formed on the first electrode 160. The organic light emitting layer 162 may include an emitting material layer (EML) including an emitting material and an electron transporting layer (ETL) on or over the EML. In addition, the organic light emitting layer 162 may further include at least one of a hole injection layer (HIL), a hole transporting layer (HTL), an electron blocking layer (EBL), a hole blocking layer (HBL), and an electron injection layer (EIL). As described below, the ETL includes an organic compound having a structure, where a thiophene moiety or a furan moiety is combined to a phenanthroline moiety directly or through a linker, so that the electron is efficiently transferred into

the EML by the ETL.

- [60] The second electrode 164 is formed over the substrate 110 where the organic light emitting layer 162 is formed. The second electrode 164 covers 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), silver (Ag) or their alloy, e.g., Al-Mg alloy (AlMg) or Ag-Mg alloy (MgAg). In the top-emission type organic light emitting display device 100, the second electrode 164 may have a thin profile (small thickness) to provide a light transmittance property (or a semi-transmittance property).
- [61] Namely, one of the first and second electrodes 160 and 164 is a transparent (or semi-transparent) electrode, and the other one of the first and second electrodes 160 and 164 is a reflective electrode.
- [62] The first electrode 160, the organic light emitting layer 162 and the second electrode 164 constitute the OLED D.
- [63] An encapsulation film (or an encapsulation layer) 170 is formed on the second electrode 164 to prevent penetration of moisture into the OLED D. The encapsulation film 170 includes 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. The encapsulation film 170 may be omitted.
- [64] The organic light emitting display device 100 may include a color filter layer (not shown). The color filter layer may include red, green and blue color filters corresponding to the red, green and blue pixel regions, respectively. The color purity of the organic light emitting display device 100 may be improved by the color filter layer.
- [65] The organic light emitting display device 100 may further include a polarization plate (not shown) for reducing an ambient light reflection. For example, the polarization plate may be a circular polarization plate. In the bottom-emission type organic light emitting display device 100, the polarization plate may be disposed under the substrate 110. In the top-emission type organic light emitting display device 100, the polarization plate may be disposed on or over the encapsulation film 170.
- [66] In addition, in the top-emission type organic light emitting display device 100, 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 organic light emitting display device may be provided.
- [67] FIG. 3 is a schematic cross-sectional view of an OLED according to a second embodiment of the present disclosure.
- [68] As shown in FIG. 3, the OLED D1 includes the first and second electrodes 160 and 164, which face each other, and the organic light emitting layer 162 therebetween. The

organic light emitting layer 162 includes an EML 240 between the first and second electrodes 160 and 164 and an ETL 250 between the second electrode 164 and the EML 240.

[69] The first electrode 210 may be an anode, and the second electrode 230 may be a cathode. One of the first and second electrodes 160 and 164 is a transparent (or semi-transparent) electrode, and the other one of the first and second electrodes 160 and 164 is a reflective electrode.

[70] The hole is provided from the first electrode 160 into or toward the EML 240, and the electron is provided from the second electrode 160 into or toward the EML 240 through the ETL 250.

[71] The organic light emitting layer 162 may further include the HTL 220 between the first electrode 160 and the EML 240.

[72] In addition, the organic light emitting layer 162 may further include at least one of an HIL 210 between the first electrode 160 and the HTL 220 and an EIL 260 between the second electrode 164 and the ETL 250.

[73] Although not shown, the organic light emitting layer 162 may further include at least one of an EBL between the HTL 220 and the EML 240 and an HBL between the EML 240 and the ETL 250.

[74] For example, the HIL 210 may include at least one compound selected from the group consisting of 4,4',4''-tris(3-methylphenylamino)triphenylamine (MTDATA), 4,4',4''-tris(N,N-diphenyl-amino)triphenylamine(NATA), 4,4',4''-tris(N-(naphthalene-1-yl)-N-phenyl-amino)triphenylamine(1T-NATA), 4,4',4''-tris(N-(naphthalene-2-yl)-N-phenyl-amino)triphenylamine(2T-NATA), copper phthalocyanine(CuPc), tris(4-carbazoyl-9-yl-phenyl)amine(TCTA), N,N'-diphenyl-N,N'-bis(1-naphthyl)-1,1'-biphenyl-4,4''-diamine(NPB; NPD), 1,4,5,8,9,11-hexaazatriphenylenehexacarbonitrile(dipyrazino[2,3-f:2'3'-h]quinoxaline-2,3,6,7,10,11-hexacarbonitrile; HAT-CN), 1,3,5-tris[4-(diphenylamino)phenyl]benzene(TDAPB), poly(3,4-ethylenedioxythiophene)polystyrene sulfonate(PEDOT/PSS), and N-(biphenyl-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluoren-2-amine, but it is not limited thereto.

[75] The HTL 220 may include at least one compound selected from the group consisting of N,N'-diphenyl-N,N'-bis(3-methylphenyl)-1,1'-biphenyl-4,4'-diamine; TPD), NPB(NPD), 4,4'-bis(N-carbazoyl)-1,1'-biphenyl(CBP), poly[N,N'-bis(4-butylphenyl)-N,N'-bis(phenyl)-benzidine](Poly-TPD), (poly[(9,9-dioctylfluorenyl-2,7-diyl)-co-(4,4'-(N-(4-sec-butylphenyl)diphenylamine))]) (TFB), di-[4-(N,N-di-p-tolyl-amino)-phenyl]cyclohexane(TAPC), 3,5-di(9H-carbazol-9-yl)-N,N-diphenylaniline(DCDPA), N-

(biphenyl-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluoren-2-amine, and N-

(biphenyl-4-yl)-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)biphenyl-4-amine, but it is not limited thereto.

- [76] The EBL may include at least one compound selected from the group consisting of TCTA, tris[4-(diethylamino)phenyl]amine, N-(biphenyl-4-yl)-9,9-dimethyl-N-(4-(9-phenyl-9H-carbazol-3-yl)phenyl)-9H-fluoren-2-amine, TAPC, MTDATA, 1,3-bis(carbazol-9-yl)benzene(mCP), 3,3'-bis(N-carbazolyl)-1,1'-biphenyl(mCBP), CuPc, N,N'-bis[4-[bis(3-methylphenyl)amino]phenyl]-N,N'-diphenyl-[1,1'-biphenyl]-4,4'-diamine(DNTPD), TDAPB, DCDPA, and 2,8-bis(9-phenyl-9H-carbazol-3-yl)dibenzo[b,d]thiophene), but it is not limited thereto.

- [77] The HBL may include at least one compound selected from the group consisting of tris-(8-hydroxyquinoline aluminum(Alq₃), 2-biphenyl-4-yl-5-(4-t-butylphenyl)-1,3,4-oxadiazole(PBD), spiro-PBD, lithium quinolate(Liq), 1,3,5-tris(N-phenylbenzimidazol-2-yl)benzene(TPBi), bis(2-methyl-8-quinolinolato-N1,O8)-(1,1'-biphenyl-4-olato)aluminum(BAlq), 4,7-diphenyl-1,10-phenanthroline(Bphen), 2,9-bis(naphthalene-2-yl)4,7-diphenyl-1,10-phenanthroline(NBphen), 2,9-dimethyl-4,7-diphenyl-1,10-phenanthroline(BCP), 3-(4-biphenyl)-4-phenyl-5-tert-butylphenyl-1,2,4-triazole(TAZ), 4-(naphthalen-1-yl)-3,5-diphenyl-4H-1,2,4-triazole(NTAZ), 1,3,5-tri(p-pyrid-3-yl-phenyl)benzene(TpPyPB), 2,4,6-tris(3'-(pyridin-3-yl)biphenyl-3-yl)1,3,5-triazine(TmPPPyTz), Poly[9,9-bis(3'-((N,N-dimethyl)-N-ethylammonium)-propyl)-2,7-fluorene]-alt-2,7-(9,9-dioctylfluorene)](PFNBr), tris(phenylquinoxaline(TPQ), and diphenyl-4-triphenylsilyl-phenylphosphine oxide(TSPO1), but it is not limited thereto.

- [78] The EIL 260 may include at least one of an alkali halide compound, such as LiF, CsF, NaF, or BaF₂, and an organometallic compound, such as Liq, lithium benzoate, or sodium stearate, but it is not limited thereto.

- [79] The EML 240 in the red pixel region includes a host and a red dopant, the EML 240 in the green pixel region includes a host and a green dopant, and the EML 240 in the blue pixel region includes a host and a blue dopant. Each of the red dopant, the green dopant and the blue dopant may be independently a fluorescent compound, a phosphorescent compound or a delayed fluorescent compound.

- [80] For example, in the EML 240 in the red pixel region, the host may be CBP (4,4'-bis(carbazol-9-yl)biphenyl), and the red dopant may be selected from PIQIr (acac)(bis(1-phenylisoquinoline)acetylacetonate iridium), PQIr

(acac)(bis(1-phenylquinoline)acetylacetonate iridium), PQIr (tris(1-phenylquinoline)iridium), and PtOEP (octaethylporphyrin platinum). However, it is not limited thereto. The EML 240 in the red pixel region may have an emission wavelength range of about 600 to 650 nm.

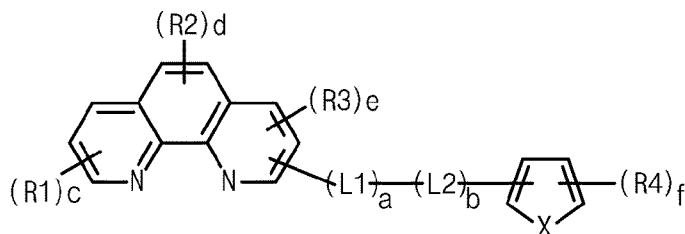
[81] In the EML 240 in the green pixel region, the host may be CBP (4,4'-bis(carbazol-9-yl)biphenyl), and the green dopant may be Ir(ppy)₃ (fac tris(2-phenylpyridine)iridium) or Alq₃ (tris(8-hydroxyquinolino)aluminum). However, it is not limited thereto. The EML 240 in the green pixel region may have an emission wavelength range of about 510 to 570 nm.

[82] In the EML 240 in the blue pixel region, the host may be an anthracene derivative, and the blue dopant may be a boron derivative. However, it is not limited thereto. For example, the host may be a compound in Formula 5, and the blue dopant may be a compound in Formula 6. In the EML 240 in the blue pixel region, the blue dopant may have a weight % of about 1 to 20, preferably about 1 to 10. The EML 240 in the blue pixel region may have an emission wavelength range of about 440 to 480 nm.

[83] The ETL 250 includes an organic compound of the present disclosure having a structure, where a thiophene moiety or a furan moiety is combined to a phenanthroline moiety directly or through a linker, as an electron transporting material 252. The organic compound of the present disclosure is represented by Formula 1-1.

[84] [Formula 1-1]

[85]

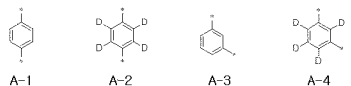


[86] In Formula 1-1, X is oxygen (O) or sulfur (S), and each of R1 to R4 is independently selected from the group consisting of deuterium, halogen, cyano, C1 to C10 alkyl group, C1 to C10 alkoxy group, C3 to C30 cycloalkyl group, C6 to C30 aryl group, C6 to C30 arylamino group, and C5 to C30 heteroaryl group. Each of L1 and L2 is independently selected from the group consisting of C6 to C30 arylene group and C5 to C30 heteroarylene group. Each of a and b is independent 0 or 1, each of c and f is independently an integer of 0 to 3, and each of d and e is independently an integer of 0 to 2.

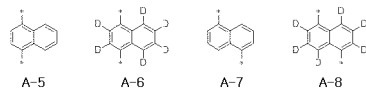
[87] For example, C6 to C30 aryl group may be selected from the group consisting of phenyl, biphenyl, terphenyl, naphthyl, anthracenyl, pentanenyl, indenyl, indenindenyl, heptalenyl, biphenylenyl, indacenyl, phenanthrenyl, benzophenanthrenyl, dibenzophenanthrenyl, azulenyl, pyrenyl, fluoranthenyl, triphenylenyl, chrysenyl,

- tetraphenyl, tetrasenyl, picenyl, pentaphenyl, pentacenyl, fluorenyl, indenofluorenyl and spiro-fluorenyl, and C6 to C30 arylene group may be their arylene group.
- [88] C5 to C30 heteroaryl group may be selected from the group consisting of pyrrolyl, pyridinyl, pyrimidinyl, pyrazinyl, pyridazinyl, triazinyl, tetrazinyl, imidazolyl, pyrazolyl, indolyl, isoindolyl, indazolyl, indoliziny, pyrroliziny, carbazolyl, benzo-carbazolyl, dibenzocarbazolyl, indolocarbazolyl, indenocarbazolyl, benzofuro-carbazolyl, benzothienocarbazolyl, quinolinyl, isoquinolinyl, phthalazinyl, quinoxalinyl, sinolinyl, quinazolinyl, quinoxolinyl, quinolinyl, purinyl, phthalazinyl, quinoxalinyl, benzoquinolinyl, benzoisoquinolinyl, benzoquinazolinyl, benzo-quinoxalinyl, acridinyl, phenanthrolinyl, perimidinyl, phenanthridinyl, pteridinyl, cinnolinyl, naphtharidinyl, furanyl, oxazinyl, oxazolyl, oxadiazolyl, triazolyl, dioxynyl, benzofuranyl, dibenzofuranyl, thiopyranyl, xantenyl, chromaenyl, isochromenyl, thioazinyl, thiophenyl, benzothiophenyl, dibenzothiophenyl, difuropyrazinyl, benzo-furodibenzofuranyl, benzothienobenzothiophenyl, benzothienodibenzothiophenyl, ben-zothienobenzofuranyl, and benzothienodibenzofuranyl, and C5 to C30 heteroarylene group may be their heteroarylene group.
- [89] Each of C1 to C10 alkyl group, C1 to C10 alkoxy group, C3 to C30 cycloalkyl group, C6 to C30 aryl group, C6 to C30 arylamino group, C5 to C30 heteroaryl group, C6 to C30 arylene group and C5 to C30 heteroarylene group may be unsubstituted or substituted with deuterium or halogen (e.g., fluorine).
- [90] For example, each of R1 to R3 may be independently selected from the group consisting of deuterium, fluorine, cyano, methoxy, trifluoromethyl, trifluoromethoxy, methyl, phenyl, pyridyl, naphthyl, and quinolinyl. Each of R1 to R3 may be unsubstituted or substituted with deuterium.
- [91] R4 may be C6 to C30 aryl group. R4 may be selected from the group consisting of phenyl, naphthyl, phenanthrenyl, pyrenyl, anthracenyl, and phenylanthracenyl, and f may be an integer of 1 to 3. For example, f may be 2 or 3, and at least one of R4 may be a polycyclic aryl group, e.g., phenanthrenyl, pyrenyl, anthracenyl, or phenylanthracenyl. Preferably, f may be 3, two of R4 may be phenyl, and the other of R4 may be a polycyclic aryl group, e.g., phenanthrenyl, pyrenyl, anthracenyl, or phenylanthracenyl. R4 may be unsubstituted or substituted with deuterium.
- [92] Each of L1 and L2 may be C6 to C30 arylene group, e.g., phenylene or naphthylene. For example, each of L1 and L2 may be unsubstituted or substituted with deuterium, C1 to C10 alkyl or CD₃. At least one of a and b may be 1.
- [93] For example, each of L1 and L2 may be independently selected from the groups in Formula 1-2.
- [94] [Formula 1-2]

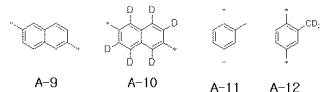
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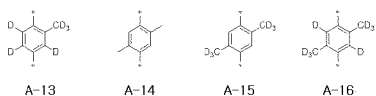
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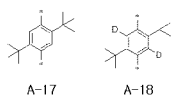
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[98]



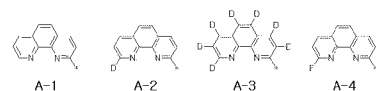
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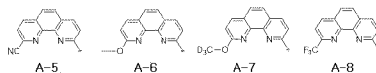
[100] The phenanthroline moiety in Formula 1-1 may be selected from the groups in Formula 1-3.

[101] [Formula 1-3]

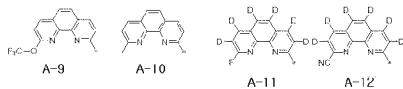
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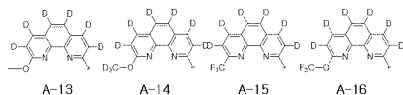
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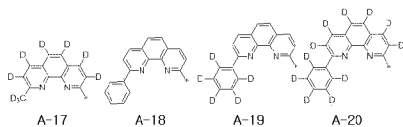
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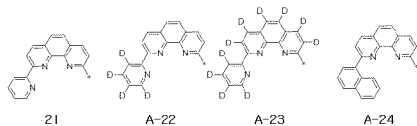
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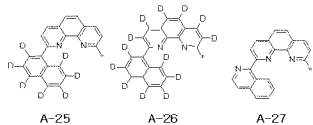
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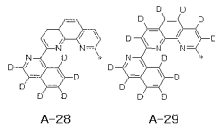
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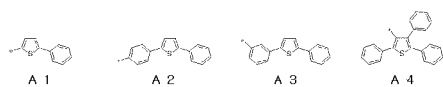
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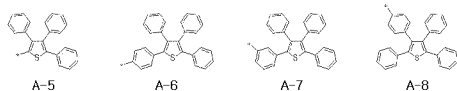
[110] A thiophene moiety, i.e., X=S, in Formula 1-1 may be selected from the groups in Formula 1-4.

[111] [Formula 1-4]

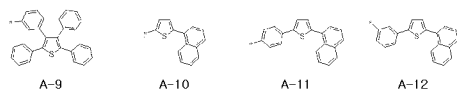
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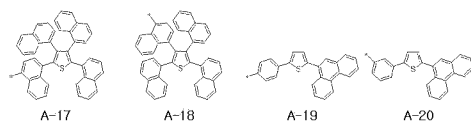
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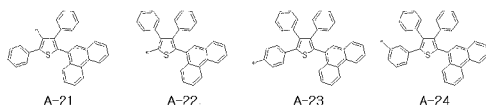
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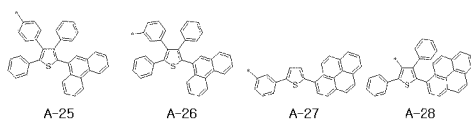
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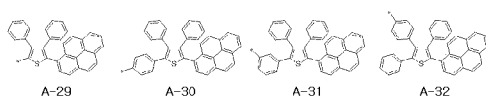
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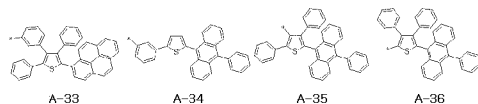
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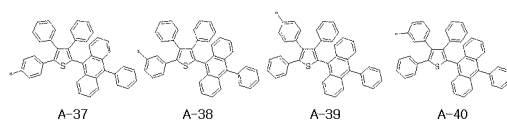
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[120]



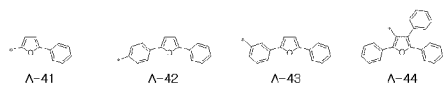
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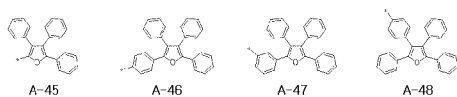
[122] A furan moiety, i.e., $X=O$, in Formula 1-1 may be selected from the groups in Formula 1-5.

[123] [Formula 1-5]

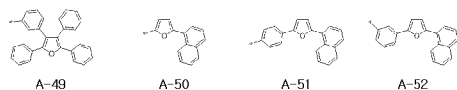
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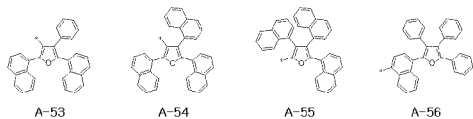
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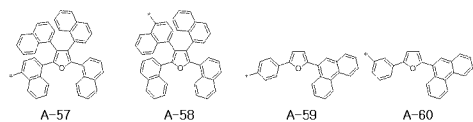
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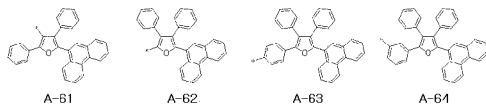
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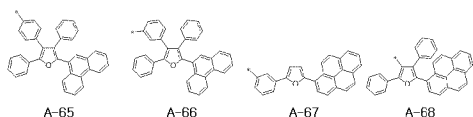
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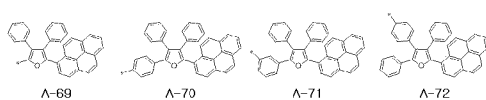
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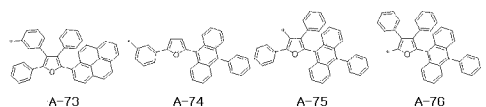
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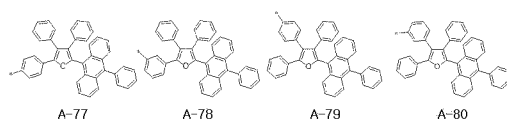
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[132]



[133]

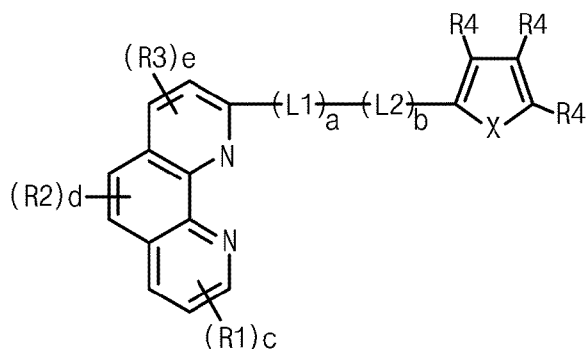


[134] The organic compound of the present disclosure has a structure, where a thiophene moiety or a furan moiety is combined to a phenanthroline moiety directly or through a linker, to provide high electron transporting property. For example, when in Formula 1-1, a 2th-position of the thiophene moiety or the furan moiety is connected (combined or linked) to the phenanthroline moiety directly or through the linker, i.e., L1 and/or L2, and three hydrogen atoms in the thiophene moiety or the furan moiety are substituted with C6 to C30 aryl, i.e., f=3, the electron transporting property of the organic compound is further improved.

[135] The organic compound in Formula 1-1 may be represented by Formula 1-6.

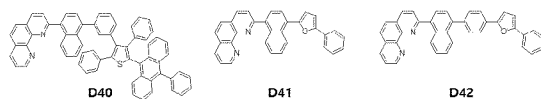
[136] [Formula 1-6]

[137]

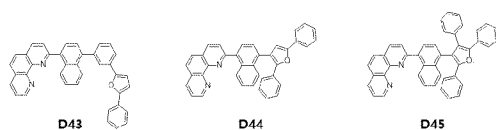




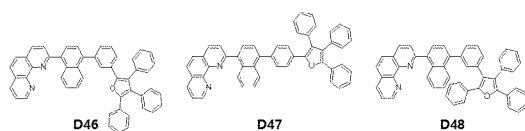
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[154]



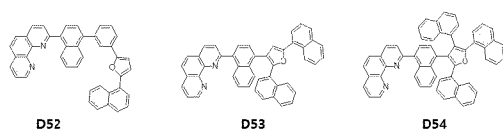
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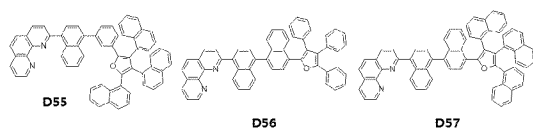
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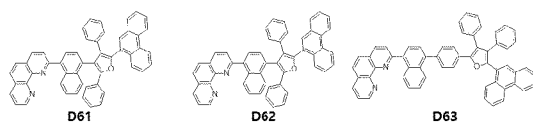
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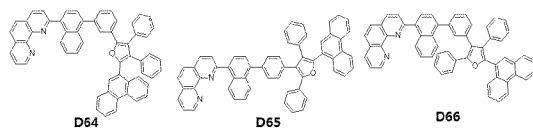
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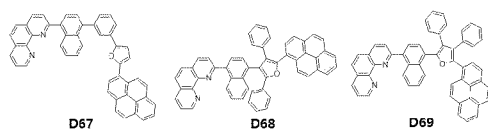
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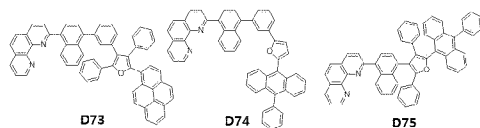
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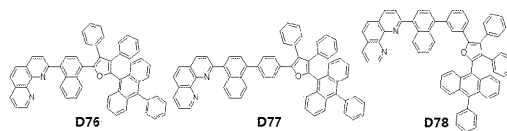
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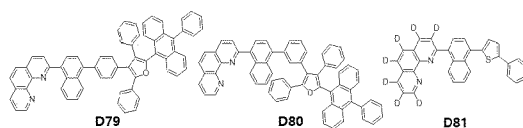
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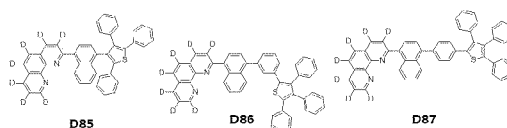
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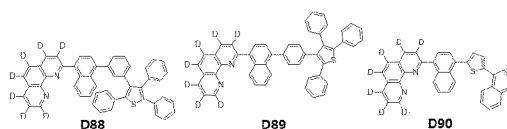
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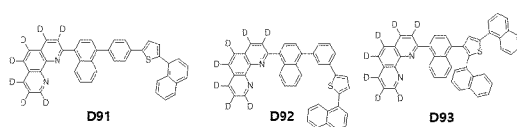
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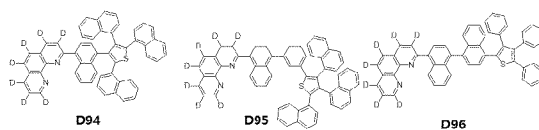
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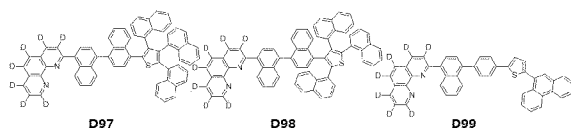
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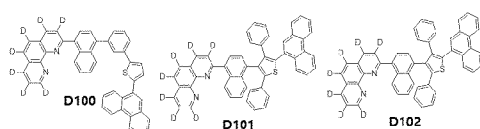
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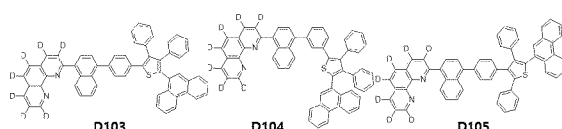
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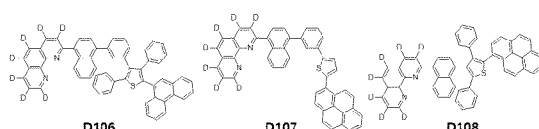
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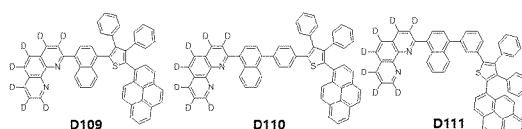
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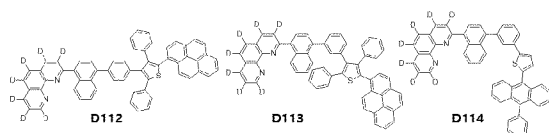
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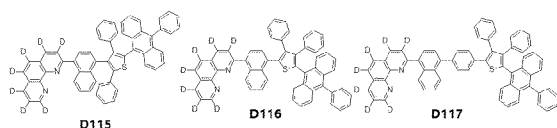
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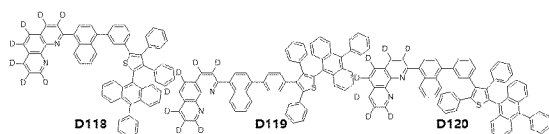
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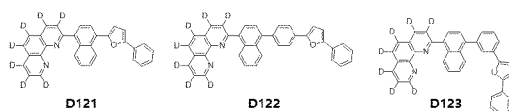
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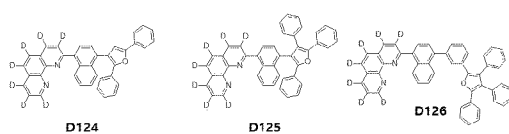
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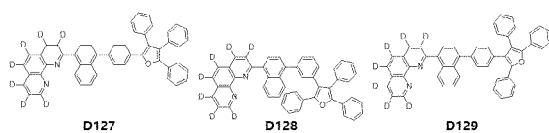
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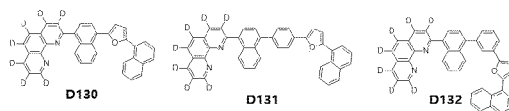
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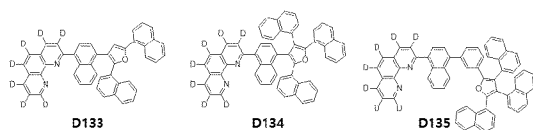
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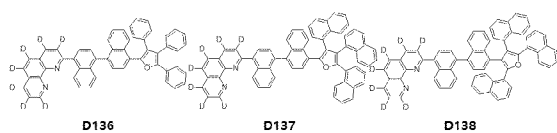
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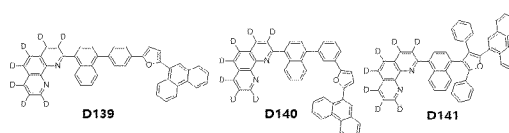
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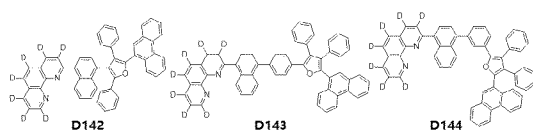
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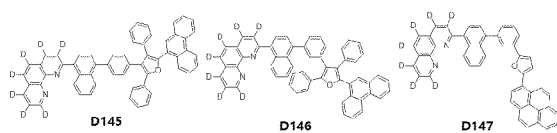
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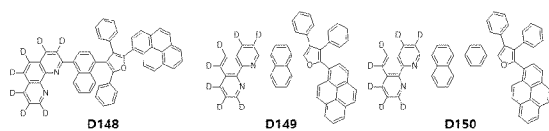
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[188]



[189]



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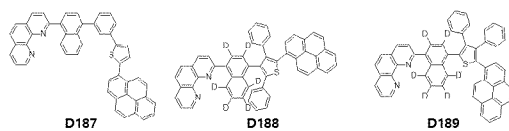
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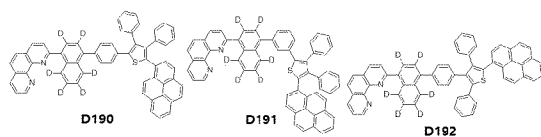
D181 **D182** **D183**

D184 **D185** **D186**

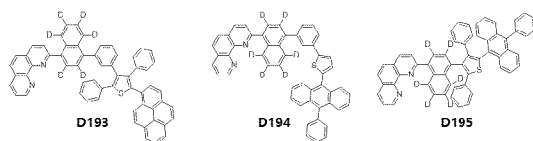
[202]



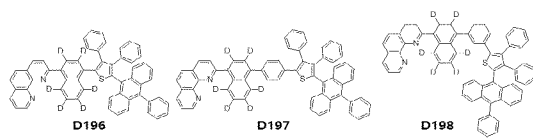
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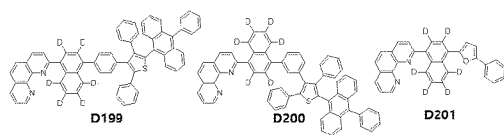
[204]



[205]



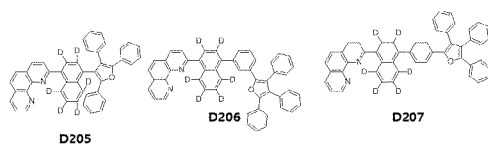
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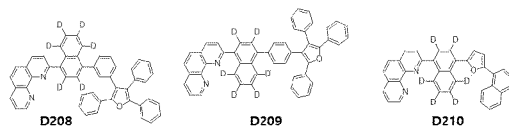
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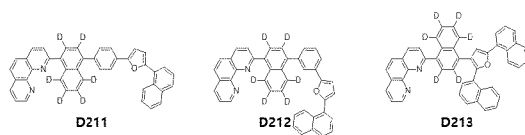
[208]



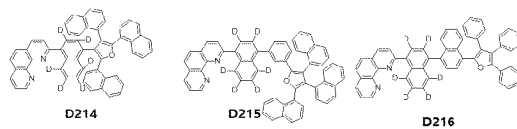
[209]



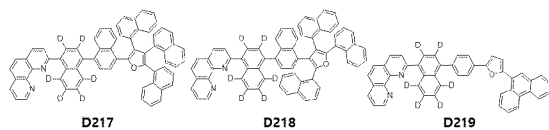
[210]



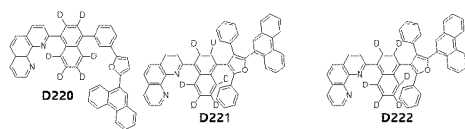
[211]

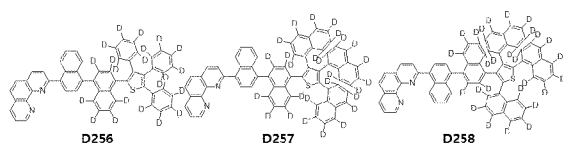
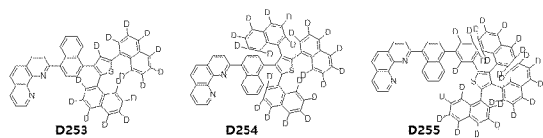
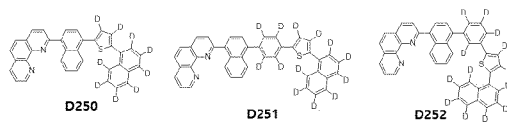
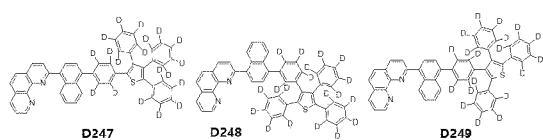
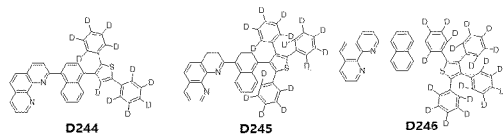
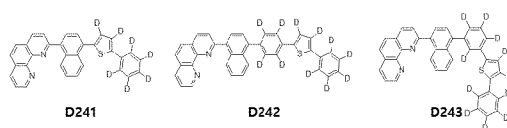
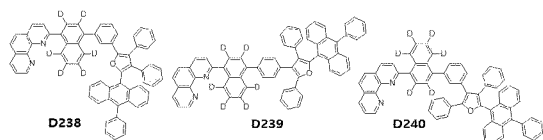
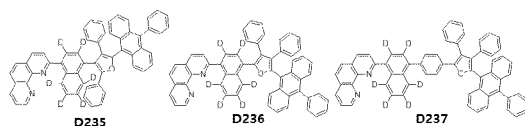
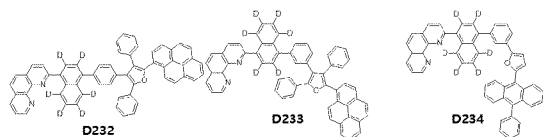
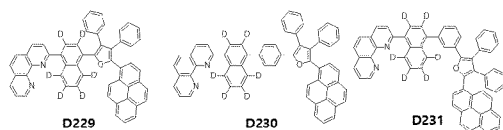
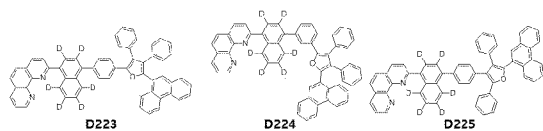


[212]

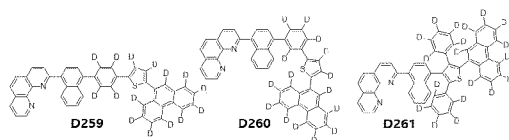


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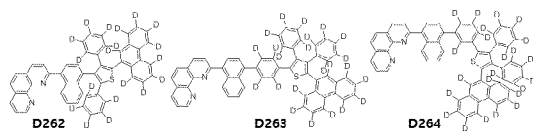




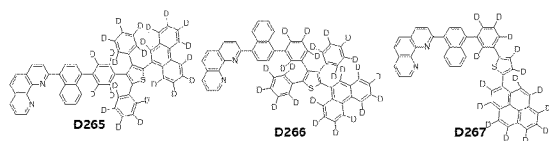
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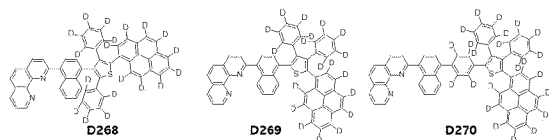
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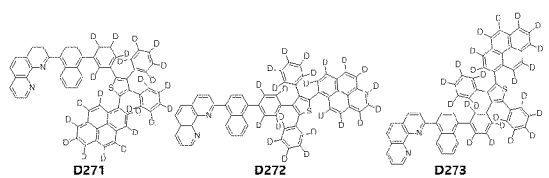
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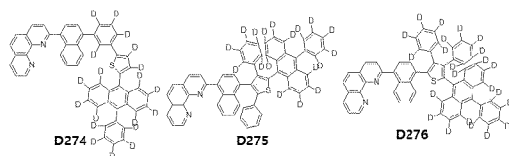
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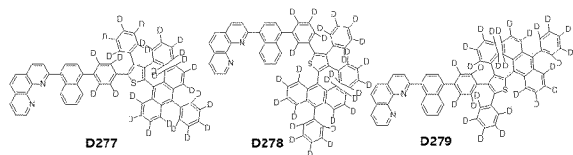
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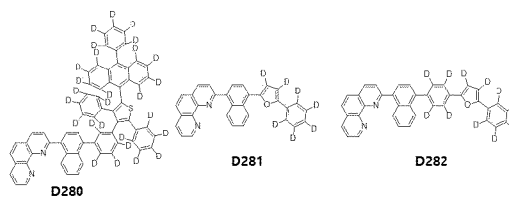
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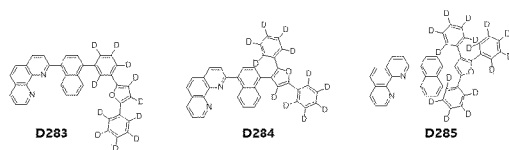
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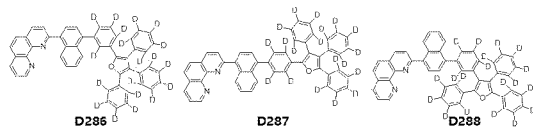
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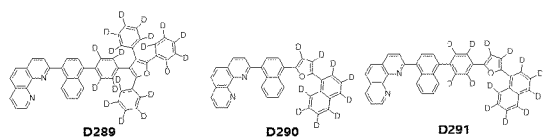
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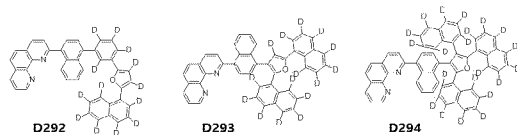
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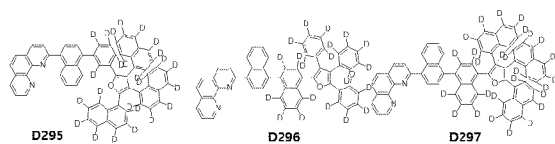
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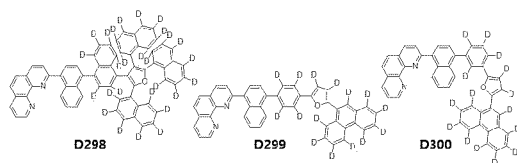
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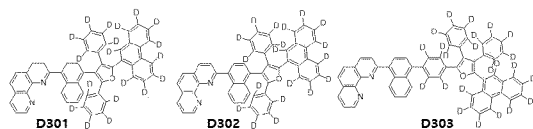
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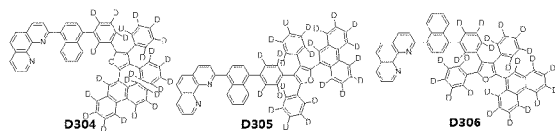
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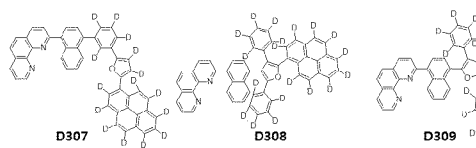
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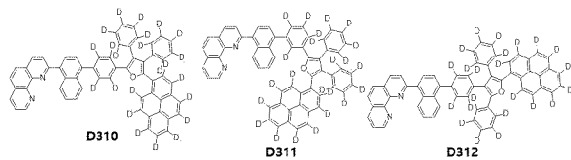
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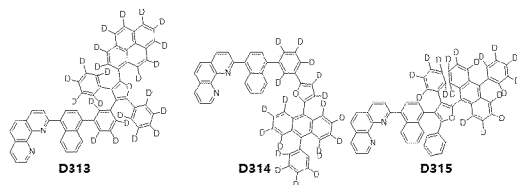
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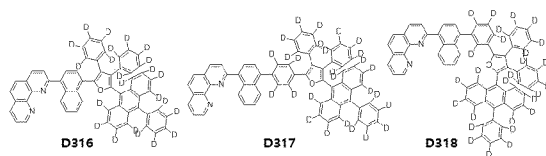
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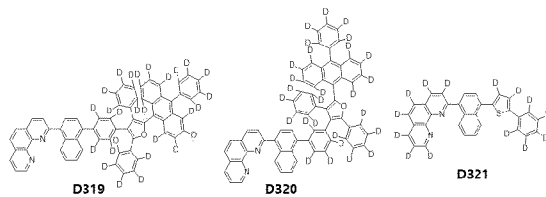
[244]



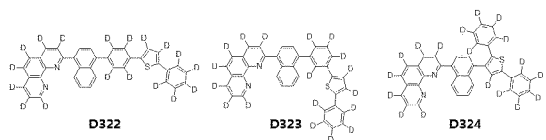
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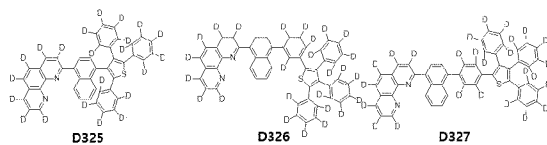
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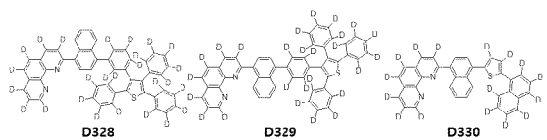
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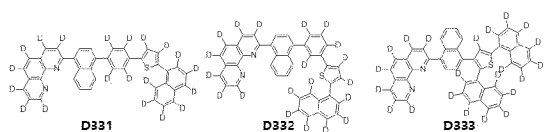
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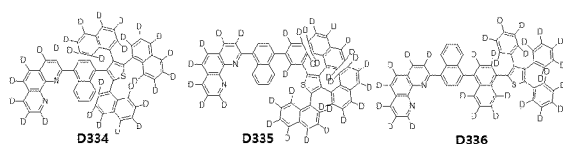
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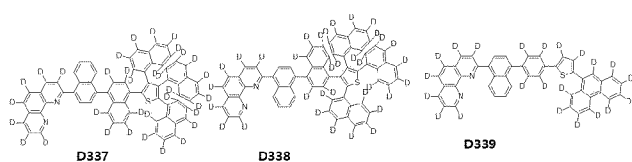
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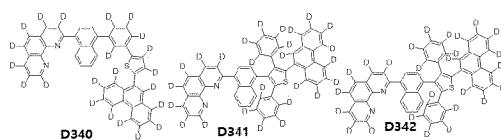
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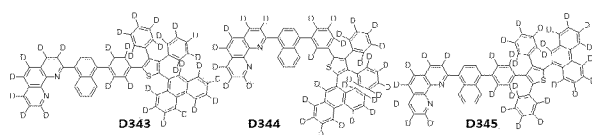
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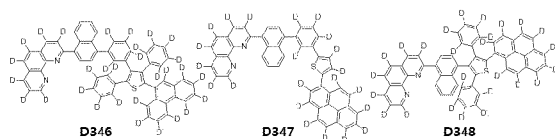
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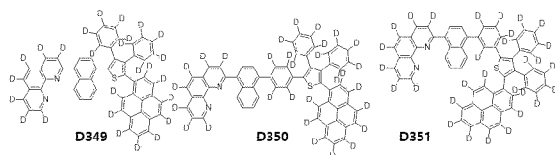
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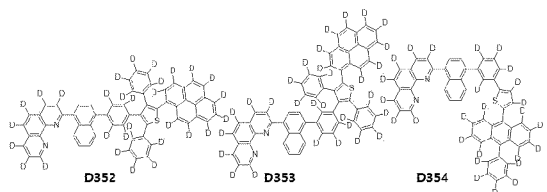
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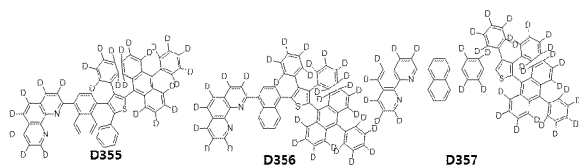
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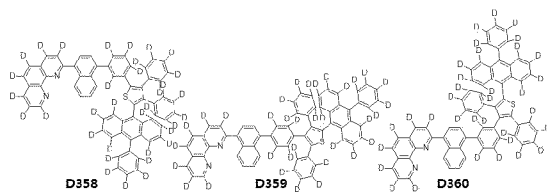
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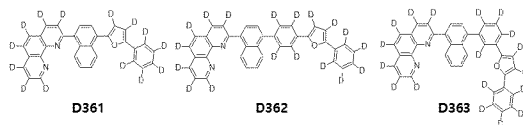
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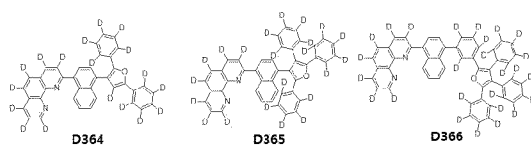
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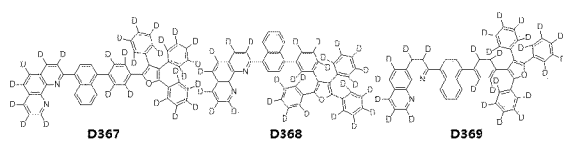
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[261]



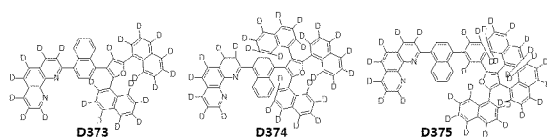
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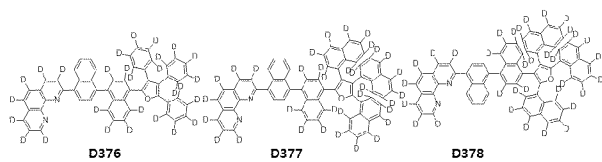
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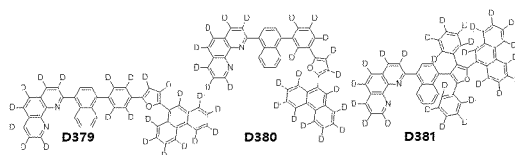
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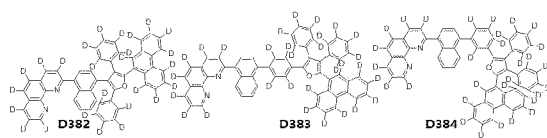
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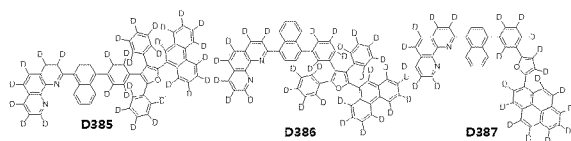
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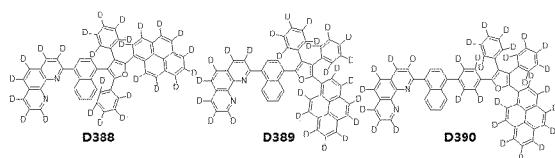
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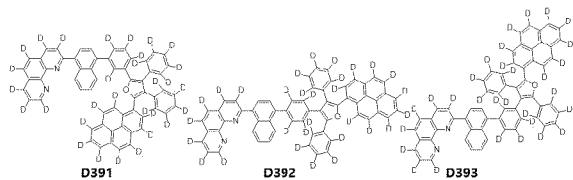
[268]



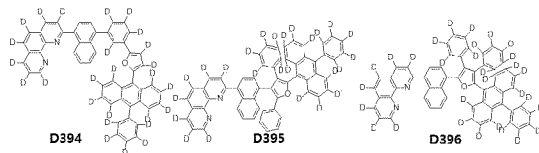
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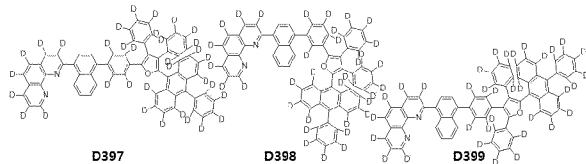
[270]



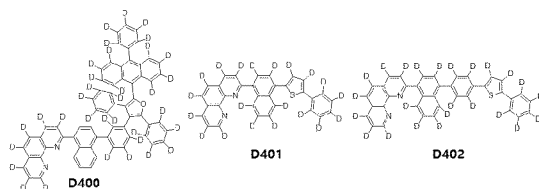
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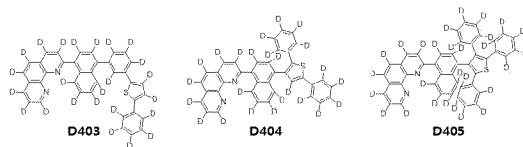
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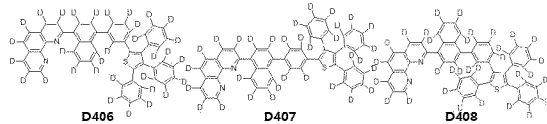
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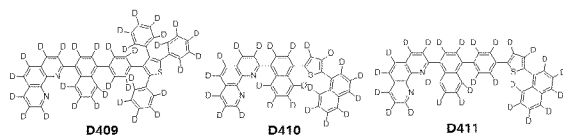
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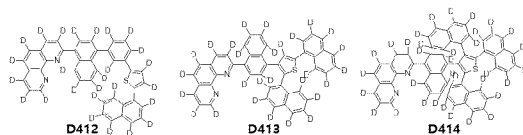
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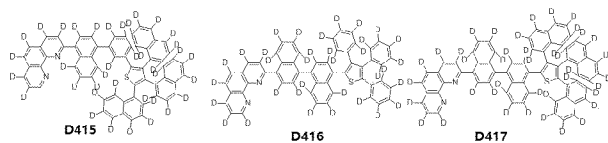
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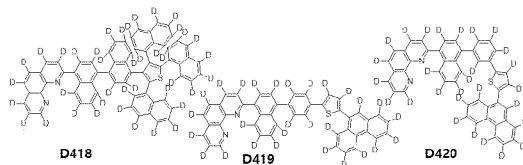
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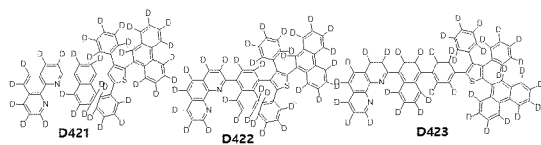
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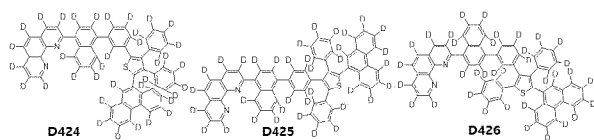
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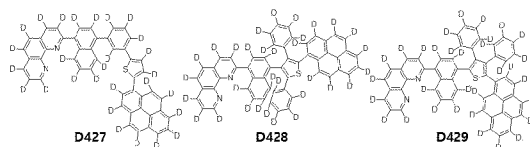
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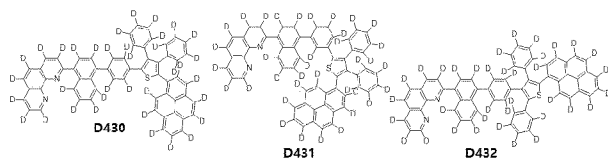
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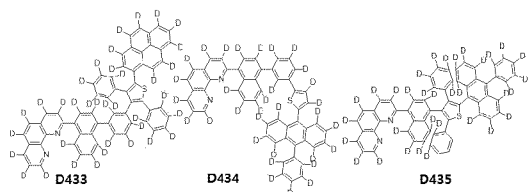
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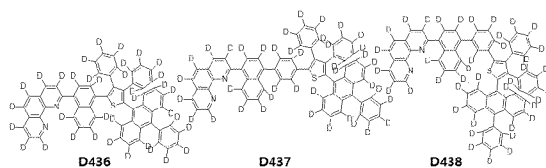
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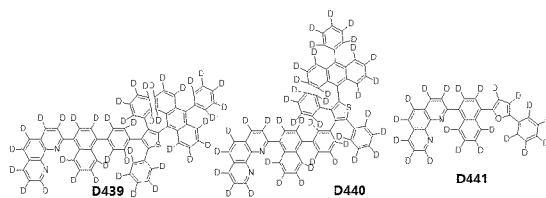
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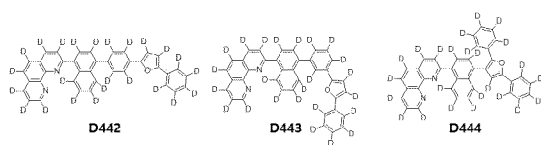
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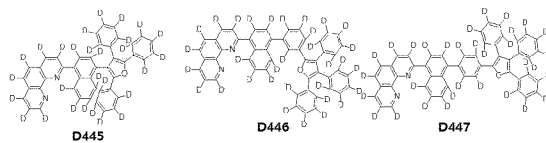
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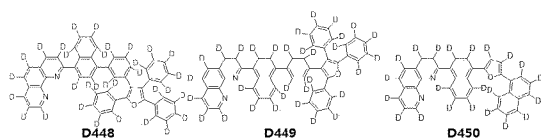
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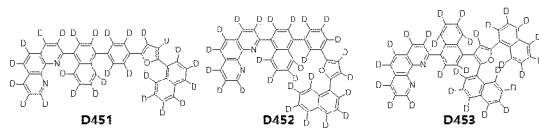
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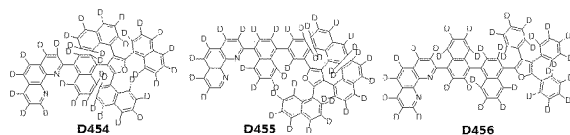
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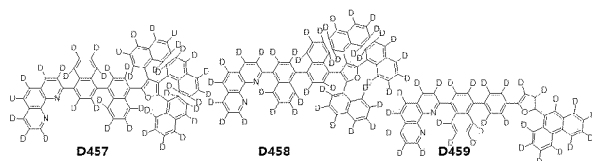
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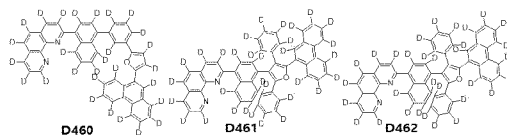
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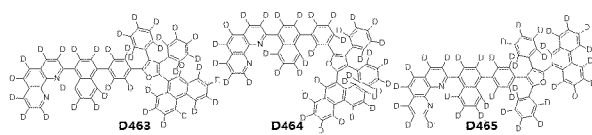
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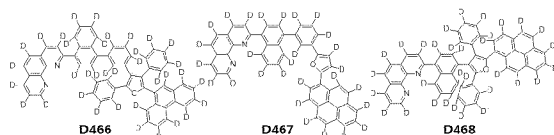
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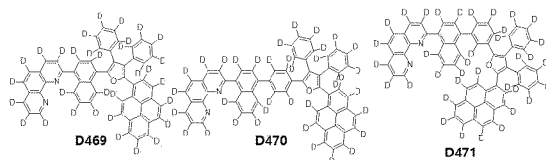
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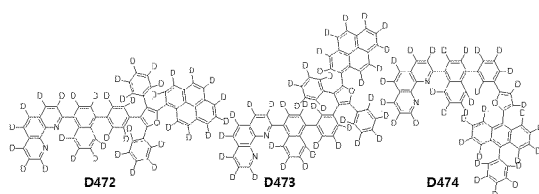
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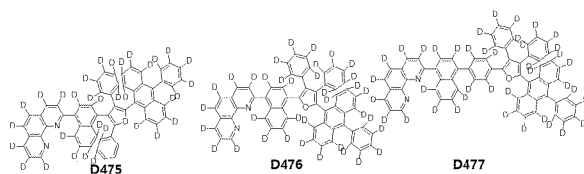
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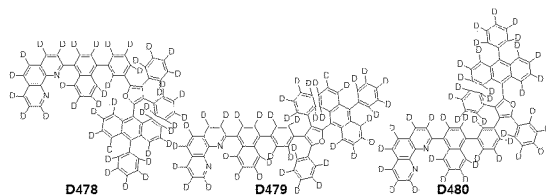
[297]



[298]



[299]



[300]

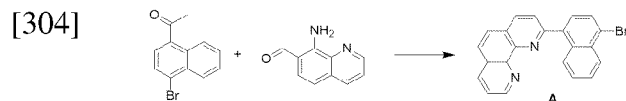
[Synthesis]

[301]

1. Synthesis of compound D1

[302] (1) Intermediate A

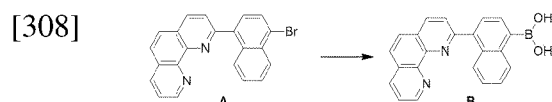
[303] [Reaction Formula 1-1]



[305] In a round-bottom flask, 1-bromo-4-acetylnaphthalene (14.5 g, 0.058 mol), 8-aminoquinoline-7-carbaldehyde (10 g, 0.058 mol), absolute EtOH (ethanol, 800 ml), and KOH (potassium hydroxide, 13 g, 0.232 mol) were added and refluxed for 15 hours. After the reaction mixture was cooled to room temperature, the organic layer was recovered by extraction with CH₂Cl₂/H₂O. The organic layer was concentrated under reduced pressure and recrystallized with EtOAc (ethyl acetate) to obtain the intermediate A (10.5 g, 0.027 mol, 47%).

[306] (2) Intermediate B

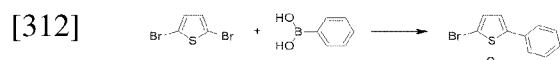
[307] [Reaction Formula 1-2]



[309] In a round-bottom flask, the intermediate A (10 g, 0.026 mol), bis(pinacolato)diboron (7.9 g, 0.04 mol), [1,1'-bis(diphenylphosphino)ferrocene]dichloropalladium(II) (1.1 g, 0.2 mmol), KOAc (potassium acetate, 9.2 g, 0.09 mol) and 1,4-dioxane (200 ml) were added and refluxed for 12 hours. The reaction solution was cooled to room temperature, filtered using celite, and washed with CHCl₃. The residual solution was concentrated under reduced pressure and recrystallized with EtOAc to obtain the intermediate B (7.9 g, 0.023 mol, 88%).

[310] (3) Intermediate C

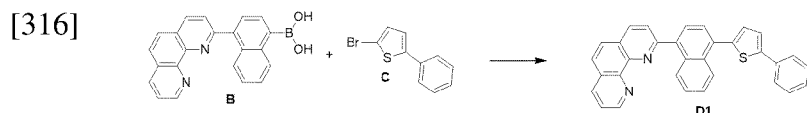
[311] [Reaction Formula 1-3]



[313] In a round-bottom flask, 2,5-dibromothiophene (10.0 g, 0.041 mol), benzeneboronic acid (4.88 g, 0.040 mol), tetrakis(triphenylphosphine)palladium(0) (1.8 g, 0.2 mmol), and K₂OC₃ (16.6 g, 0.12 mol) was dissolved in a mixed solvent of toluene (150 mL) and EtOH (60 mL) and refluxed for 12 hours. The reaction mixture was cooled to room temperature, and the reaction solution was filtered to obtain a crude product. After dissolving the crude product in CH₂Cl₂, the organic solution was dried using MgSO₄ and the solvent was removed. The silica column chromatography (eluent = CHCl₃) is performed to the mixture to obtain the intermediate C (8.14 g, 0.034 mol, 85%).

[314] (4) Compound D1

[315] [Reaction Formula 1-4]

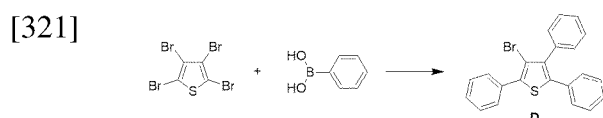


[317] The compound D1 (8.38 g, 0.018 mol, 82%) was obtained by proceeding in the same manner as for the synthesis of the intermediate C using the intermediate B (7.9 g, 0.022 mol) and the intermediate C (6.5 g, 0.027 mol).

[318] 2. Synthesis of compound D5

[319] (1) intermediate D

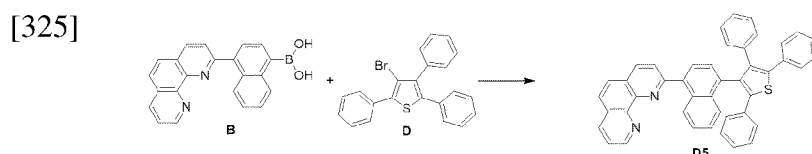
[320] [Reaction Formula 2-1]



[322] The intermediate D (6.3g, 0.016mol, 64%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using 2,3,4,5-tetrabromothiophene (10.0g, 0.025mol) and benzene boronic acid (9.1g, 0.075mol).

[323] (2) compound D5

[324] [Reaction Formula 2-2]

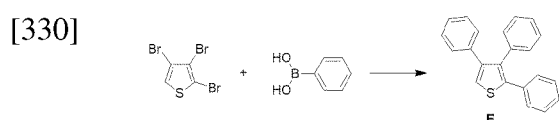


[326] The compound D5 (2.94g, 0.0048mol, 80%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (2.1g, 0.006mol) and the intermediate D (2.5g, 0.064mol).

[327] 3. Synthesis of compound D7

[328] (1) intermediate E

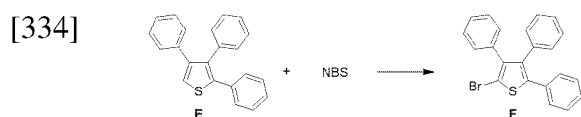
[329] [Reaction Formula 3-1]



[331] The intermediate E (6.3g, 0.016mol, 64%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using 2,3,4-tribromothiophene (10.0g, 0.025mol) and benzene boronic acid (9.1g, 0.075mol).

[332] (2) intermediate F

[333] [Reaction Formula 3-2]

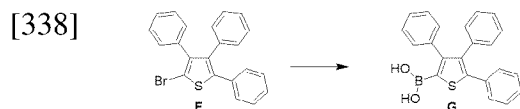


[335] The intermediate E (6.0g, 0.019mol) and N-bromo succinimide (NBS, 3.7g,

0.021mol) were dissolved in CHCl_3 (200 mL) and stirred at room temperature for 5 hours. Distilled water (200 mL) was added to the reaction mixture, $\text{Na}_2\text{S}_2\text{O}_3$ (5 g) was added while stirring at room temperature, and the mixture was stirred for 1 hour. The reaction mixture was extracted with $\text{CH}_2\text{Cl}_2/\text{H}_2\text{O}$ to recover the organic layer. The organic layer was concentrated under reduced pressure and recrystallized with CH_2Cl_2 and petroleum ether to obtain the intermediate F (7.1g, 0.018 mol, 95%).

[336] (3) intermediate G

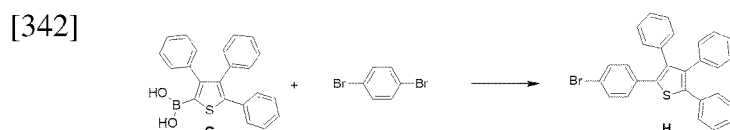
[337] [Reaction Formula 3-3]



[339] The intermediate F (10g, 0.026 mol), bis(pinacolato)diboron (7.8g, 0.02 mol), [1,1'-bis(diphenylphosphino)ferrocene]dichloropalladium(II) (0.55g, 0.1mmol), KOAc (4.6g, 0.045 mol) and 1,4-dioxane (150 ml) were added and refluxed for 12 hours. The reaction solution was cooled to room temperature, filtered using celite, and washed with CHCl_3 . The residual solution was concentrated under reduced pressure and recrystallized with hexane to obtain the intermediate G (7.9 g, 0.022 mol, 85%).

[340] (4) intermediate H

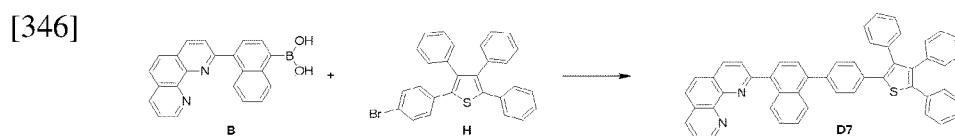
[341] [Reaction Formula 3-4]



[343] The intermediate H (5.1g, 0.011mol, 79%) was obtained by proceeding in the same manner as for the synthesis of the intermediate C using the intermediate G (5.0g, 0.014mol) and 1,4-dibromobenzene (6.6g, 0.028mol).

[344] (5) compound D7

[345] [Reaction Formula 3-5]

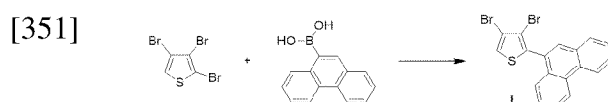


[347] The compound D7 (3.2g, 4.6 mmol, 87%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (1.9g, 5.4 mmol) and the intermediate H (2.5g, 5.3 mmol).

[348] 4. Synthesis of compound D23

[349] (1) intermediate I

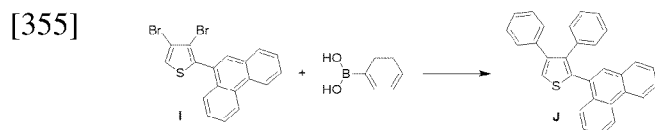
[350] [Reaction Formula 4-1]



[352] The intermediate I (6.2 g, 14.8 mmol, 79%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using 2,3,4-tribromothiophene (6.0 g, 18.7 mmol) and phenanthren-9-yl boronic acid (4.2 g, 18.9 mmol).

[353] (2) intermediate J

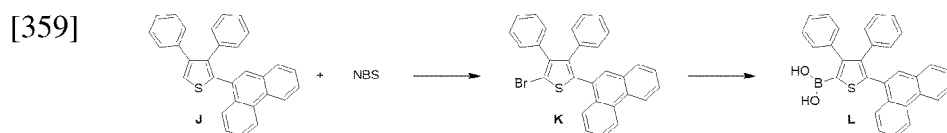
[354] [Reaction Formula 4-2]



[356] The intermediate J (5.5 g, 13.3 mmol, 90%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate I (6.2 g, 14.8 mmol) and benzene boronic acid (4.0 g, 32.8 mmol).

[357] (3) intermediate L

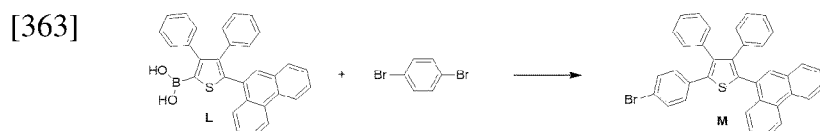
[358] [Reaction Formula 4-3]



[360] The intermediate K was obtained by proceeding in the same manner as for the synthesis of the Intermediate F using the intermediate J (5.5 g, 13.3 mmol), and the intermediate L (4.9 g, 10.7 mmol, 80%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate G using the intermediate K.

[361] (4) intermediate M

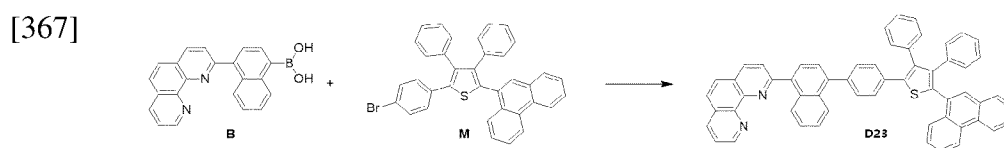
[362] [Reaction Formula 4-4]



[364] The intermediate M (3.9 g, 6.9 mmol, 78%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate L (4.0 g, 8.8 mmol) and 1,4-dibromobenzene (3.0 g, 12.7 mmol).

[365] (5) compound D23

[366] [Reaction Formula 4-5]

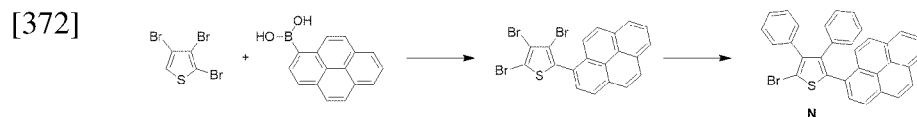


[368] The compound D23 (3.8 g, 4.8 mmol, 70%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (2.4 g, 6.9 mmol) and the intermediate M (3.9 g, 6.9 mmol).

[369] 5. Synthesis of compound D29

[370] (1) intermediate N

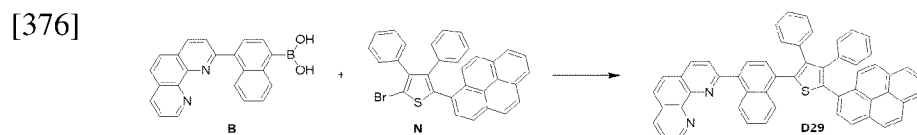
[371] [Reaction Formula 5-1]



[373] The intermediate N (5.3 g, 10.3 mmol, 69%) was obtained by proceeding in the same manner as for the synthesis of the intermediate C using 2,3,4-tribromothiophene (4.9 g, 15.3 mmol) and pyren-1-yl boronic acid (3.7 g, 15.0 mmol).

[374] (2) compound D29

[375] [Reaction Formula 5-2]

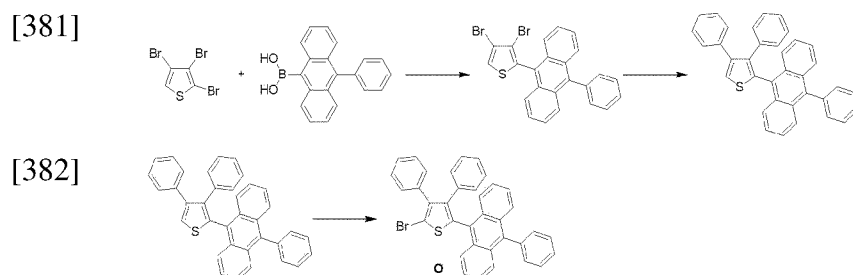


[377] The compound D29 (5.8 g, 7.8 mmol, 76%) was obtained by proceeding in the same manner as for the synthesis of the intermediate C using the intermediate B (3.7 g, 10.6 mmol) and the intermediate N (5.3 g, 10.3 mmol).

[378] 6. Synthesis of compound D38

[379] (1) intermediate O

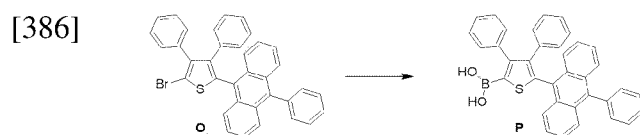
[380] [Reaction Formula 6-1]



[383] The intermediate O (5.2 g, 9.16 mmol, 61%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate K using 2,3,4-tribromothiophene (4.9 g, 15.3 mmol) and 10-phenyl-anthracene-9-yl boronic acid (4.5 g, 15.1 mmol).

[384] (2) intermediate P

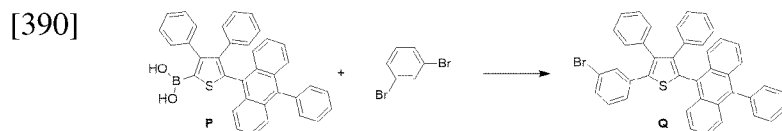
[385] [Reaction Formula 6-2]



[387] The intermediate P (4.6 g, 8.64 mmol, 94%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate B using the intermediate O (5.2 g, 9.16 mmol).

[388] (3) intermediate Q

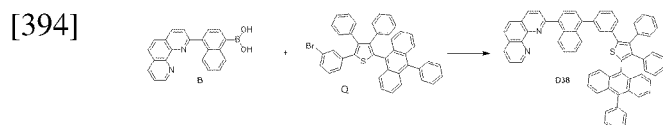
[389] [Reaction Formula 6-3]



[391] The intermediate Q (5.1 g, 7.9 mmol, 92%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate P (4.6 g, 8.6 mmol) and 1,3-dibromobenzene (3.0 g, 12.7 mmol).

[392] (4) compound D38

[393] [Reaction Formula 6-4]

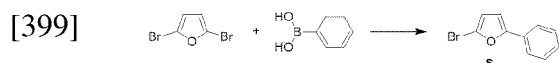


[395] The compound D38 (4.2 g, 4.8 mmol, 61%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (3.0 g, 8.6 mmol) and the intermediate Q (5.1 g, 7.9 mmol).

[396] 7. Synthesis of compound D41

[397] (1) intermediate S

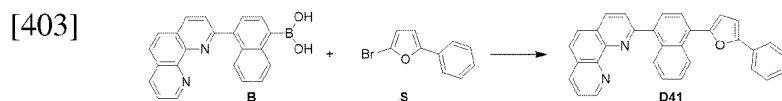
[398] [Reaction Formula 7-1]



[400] The intermediate S (8.5 g, 0.038 mol, 86%) was obtained by proceeding in the same manner as for the synthesis of the intermediate C using 2,5-dibromofuran (10.0 g, 0.044 mol) and benzene boronic acid (6.0 g, 0.049 mol).

[401] (2) compound D41

[402] [Reaction Formula 7-2]

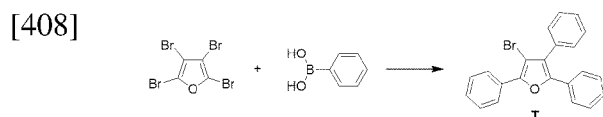


[404] The compound D41 (8.4 g, 0.019 mol, 83%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (8.0 g, 0.023mol) and the intermediate S (6.5g, 0.029mol).

[405] 8. Synthesis of compound D45

[406] (1) intermediate T

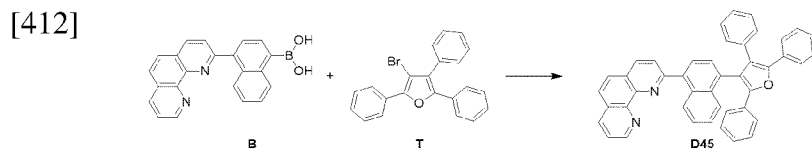
[407] [Reaction Formula 8-1]



[409] The intermediate T (4.92 g, 0.0131 mol, 50%) was obtained by proceeding in the same manner as for the synthesis of the intermediate C using 2,3,4,5-tetrabromofuran (10.0g, 0.0261 mol) and benzene boronic acid (10.0g, 0.0820 mol).

[410] (2) compound D45

[411] [Reaction Formula 8-2]

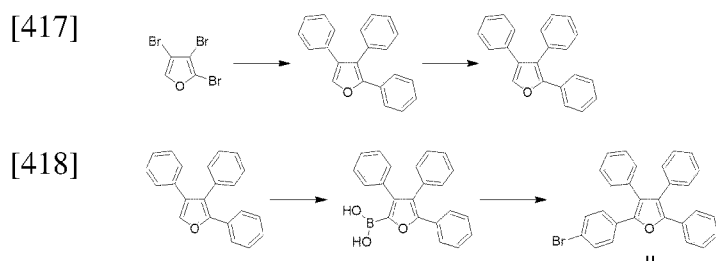


[413] The compound D45 (5.20 g, 0.00866 mol, 72%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (4.20 g, 0.0120 mol) and the intermediate T (4.92 g, 0.0131 mol).

[414] 9. Synthesis of compound D47

[415] (1) intermediate U

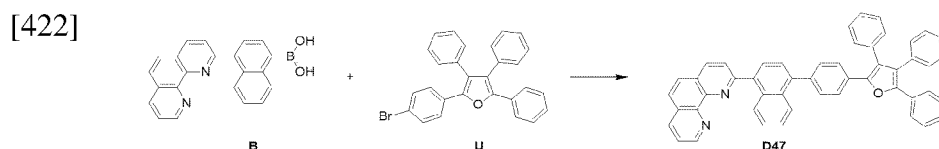
[416] [Reaction Formula 9-1]



[419] The intermediate U (5.3 g, 0.0117 mol, 36%) was obtained by sequentially proceeding in the same manner as for the synthesis of the intermediate E, the synthesis of the intermediate F, the synthesis of the intermediate G, and the synthesis of the intermediate H using 2,3,4-tribromofuran (10.0g, 0.0328 mol).

[420] (2) compound D47

[421] [Reaction Formula 9-2]

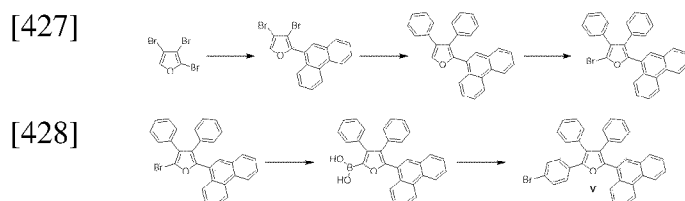


[423] The compound D47 (5.3 g, 0.0078 mol, 65%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (4.8 g, 0.014 mol) and the intermediate U (5.3 g, 0.012 mol).

[424] 10. Synthesis of compound D63

[425] (1) intermediate V

[426] [Reaction Formula 10-1]



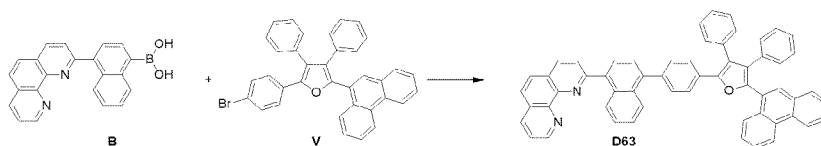
[429] The intermediate V (6.82 g, 0.0124 mol, 38%) was obtained by sequentially

proceeding in the same manner as for the synthesis of the intermediate I, the synthesis of the intermediate J, the synthesis of the intermediate K, the synthesis of the intermediate L, and the synthesis of the intermediate M using 2,3,4-tribromofuran (10.0g, 0.0328 mol).

[430] (2) compound D63

[431] [Reaction Formula 10-2]

[432]



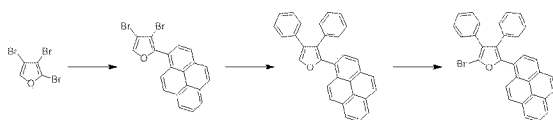
[433] The compound D63 (7.1 g, 0.0091 mol, 76%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (4.8 g, 0.014 mol) and the intermediate V (6.8 g, 0.012 mol).

[434] 11. Synthesis of compound D69

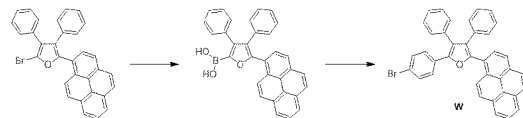
[435] (1) intermediate W

[436] [Reaction Formula 11-1]

[437]



[438]

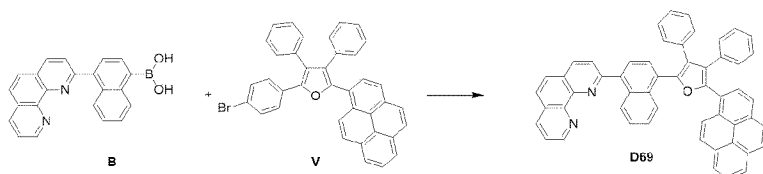


[439] The intermediate W (5.7 g, 0.00990 mol, 30%) was obtained by sequentially proceeding in the same manner as for the synthesis of the intermediate I, the synthesis of the intermediate J, the synthesis of the intermediate K, the synthesis of the intermediate L, and the synthesis of the intermediate M using 2,3,4-tribromofuran (10.0g, 0.0328 mol).

[440] (2) compound D69

[441] [Reaction Formula 11-2]

[442]

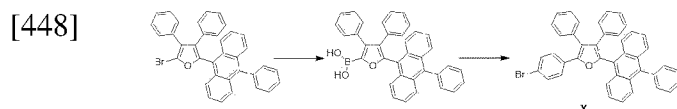
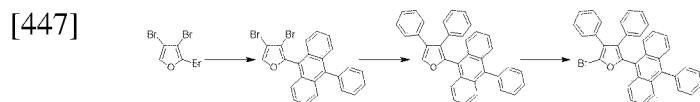


[443] The compound D69 (5.2 g, 0.0072 mol, 72%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (4.0 g, 0.011 mol) and the intermediate W (5.7 g, 0.0099 mol).

[444] 12. Synthesis of compound D78

[445] (1) intermediate X

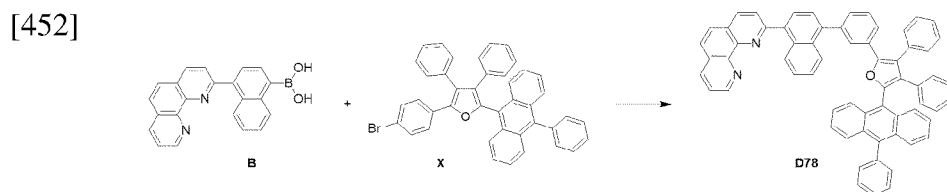
[446] [Reaction Formula 12-1]



[449] The intermediate X (5.2 g, 0.0083 mol, 25%) was obtained by sequentially proceeding in the same manner as for the synthesis of the intermediate I, the synthesis of the intermediate J, the synthesis of the intermediate K, the synthesis of the intermediate L, and the synthesis of the intermediate M using 2,3,4-tribromofuran (10.0g, 0.0328 mol).

[450] (2) compound D78

[451] [Reaction Formula 12-2]



[453] The compound D78 (4.8 g, 0.0056 mol, 67%) was obtained by proceeding in the same manner as for the synthesis of the Intermediate C using the intermediate B (3.3 g, 0.0094 mol) and the intermediate X (5.2 g, 0.0083 mol).

[454]

[455] In the OLED D, since the ETL 250 includes the electron transporting material 252 being the organic compound of the present disclosure, the electron transporting property from the second electrode 164 as the cathode into (or toward) the EML 240 is improved. Accordingly, in the OLED D and the organic light emitting display device 100, the driving voltage is decreased, and the emitting efficiency and the lifespan are increased.

[456] [OLED]

[457] On an anode (ITO), an HIL (100Å, the compound in Formula 3), an HTL (1000Å, the compound in Formula 4), an EML (250Å, host (the compound in Formula 5) and dopant (the compound in Formula 6), 3wt%), an ETL (300Å), an EIL (20Å, LiF) and a cathode (Al) are sequentially stacked to form the OLED.

[458] 1. Comparative Example (Ref)

[459] The ETL is formed by using the compound in Formula 7.

[460] 2. Examples

[461] (1) Example 1 (Ex1)

[462] The ETL is formed by using the compound D1 in Formula 2.

[463] (2) Example 2 (Ex2)

[464] The ETL is formed by using the compound D5 in Formula 2.

[465] (3) Example 3 (Ex3)

[466] The ETL is formed by using the compound D7 in Formula 2.

[467] (4) Example 4 (Ex4)

[468] The ETL is formed by using the compound D23 in Formula 2.

[469] (5) Example 5 (Ex5)

[470] The ETL is formed by using the compound D29 in Formula 2.

[471] (6) Example 6 (Ex6)

[472] The ETL is formed by using the compound D38 in Formula 2.

[473] (7) Example 7 (Ex7)

[474] The ETL is formed by using the compound D41 in Formula 2.

[475] (8) Example 8 (Ex8)

[476] The ETL is formed by using the compound D45 in Formula 2.

[477] (9) Example 9 (Ex9)

[478] The ETL is formed by using the compound D47 in Formula 2.

[479] (10) Example 10 (Ex10)

[480] The ETL is formed by using the compound D63 in Formula 2.

[481] (11) Example 11 (Ex11)

[482] The ETL is formed by using the compound D69 in Formula 2.

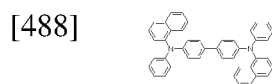
[483] (12) Example 12 (Ex12)

[484] The ETL is formed by using the compound D78 in Formula 2.

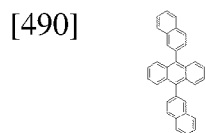
[485] [Formula 3]



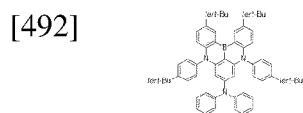
[487] [Formula 4]



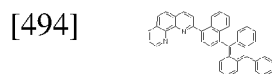
[489] [Formula 5]



[491] [Formula 6]



[493] [Formula 7]



[495] The emitting properties, i.e., the driving voltage (ΔV), the efficiency and the lifespan, of the OLED in Comparative Example and Examples 1 to 12 are measured and listed in Table 1.

[496] [Table 1]

[497]

	ETL	ΔV	efficiency	lifespan
Ref	Formula7	0.00	100	100
Ex1	D1	-0.14	99	84
Ex2	D5	-0.14	108	105
Ex3	D7	-0.18	114	113
Ex4	D23	-0.23	110	118
Ex5	D29	-0.28	118	115
Ex6	D38	-0.25	112	109
Ex7	D41	-0.10	88	81
Ex8	D45	-0.13	99	100
Ex9	D47	-0.15	108	110
Ex10	D63	-0.21	113	115
Ex11	D69	-0.22	115	108
Ex12	D78	-0.19	119	114

[498] As shown in Table 1, in comparison to the OLED of Ref, the ETL of the OLED of Ex1 to Ex12 includes the organic compound of the present disclosure having a structure, where a thiophene moiety or a furan moiety is combined to a phenanthroline moiety directly or through a linker, the OLED has advantages in the driving voltage, the emitting efficiency and the lifespan.

[499] In addition, in comparison to the OLED of Ex1 and Ex7 using the organic compound, in which hydrogen is presented in a meta-position of the thiophene moiety or a meta-position of the furan moiety, in the OLED of Ex2 to Ex6 using the organic compound, in which aryl substituent is presented in the meta-position of the thiophene moiety, and the OLED of Ex8 to Ex12, in which aryl substituent is presented in the meta-position of the furan moiety, the driving voltage is significantly reduced, and the emitting efficiency and the lifespan are significantly improved.

[500] Moreover, in comparison to the OLED of Ex1 to Ex3, in which only monocyclic aryl substituent is presented at the thiophene moiety, and the OLED of Ex7 to Ex9, in which only monocyclic aryl substituent is presented at the furan moiety, in the OLED of Ex4 to Ex6, in which a polycyclic aryl substituent is presented at the thiophene moiety, and the OLED of Ex10 to Ex12, in which a polycyclic aryl substituent is presented at the furan moiety, the driving voltage is further reduced, and the emitting efficiency and the lifespan are further improved.

[501] FIG. 4 is a schematic cross-sectional view of an organic light emitting device according to a third embodiment of the present disclosure. FIG. 5 is a schematic cross-sectional view of an OLED according to a fourth embodiment of the present disclosure, and FIG. 6 is a schematic cross-sectional view of an OLED device according to a fifth embodiment of the present disclosure.

[502] As shown in FIG. 4, the organic light emitting display device 300 includes a first substrate 310, where a red pixel BP, a green pixel GP and a blue pixel BP are defined, a second substrate 370 facing the first substrate 310, an OLED D, which is positioned

between the first and second substrates 310 and 370 and providing white emission, and a color filter layer 380 between the OLED D and the second substrate 370.

- [503] Each of the first and second substrates 310 and 370 may be a glass substrate or a flexible substrate. For example, each of the first and second substrates 310 and 370 may be a polyimide (PI) substrate, a polyethersulfone (PES) substrate, a polyethylenenaphthalate (PEN) substrate, a polyethylene terephthalate (PET) substrate or a polycarbonate (PC) substrate.
- [504] A buffer layer 320 is formed on the substrate, and the TFT Tr corresponding to each of the red, green and blue pixels RP, GP and BP is formed on the buffer layer 320. The buffer layer 320 may be omitted.
- [505] A semiconductor layer 322 is formed on the buffer layer 320. The semiconductor layer 322 may include an oxide semiconductor material or polycrystalline silicon.
- [506] A gate insulating layer 324 is formed on the semiconductor layer 322. The gate insulating layer 324 may be formed of an inorganic insulating material such as silicon oxide or silicon nitride.
- [507] A gate electrode 330, which is formed of a conductive material, e.g., metal, is formed on the gate insulating layer 324 to correspond to a center of the semiconductor layer 322.
- [508] An interlayer insulating layer 332, which is formed of an insulating material, is formed on the gate electrode 330. The interlayer insulating layer 332 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.
- [509] The interlayer insulating layer 332 includes first and second contact holes 334 and 336 exposing both ends of the semiconductor layer 322. The first and second contact holes 334 and 336 are positioned at both sides of the gate electrode 330 to be spaced apart from the gate electrode 330.
- [510] A source electrode 340 and a drain electrode 342, which are formed of a conductive material, e.g., metal, are formed on the interlayer insulating layer 332.
- [511] The source electrode 340 and the drain electrode 342 are spaced apart from each other with respect to the gate electrode 330 and respectively contact both ends of the semiconductor layer 322 through the first and second contact holes 334 and 336.
- [512] The semiconductor layer 322, the gate electrode 330, the source electrode 340 and the drain electrode 342 constitute the TFT Tr. The TFT Tr serves as a driving element. Namely, the TFT Tr may correspond to the driving TFT Td (of FIG. 1).
- [513] Although not shown, the gate line and the data line cross each other to define the pixel, 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.
- [514] 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.

- [515] A planarization layer 350, which includes a drain contact hole 352 exposing the drain electrode 342 of the TFT Tr, is formed to cover the TFT Tr.
- [516] A first electrode 360, which is connected to the drain electrode 342 of the TFT Tr through the drain contact hole 352, is separately formed in each pixel and on the planarization layer 350. The first electrode 360 may be an anode and may be formed of a conductive material, e.g., a transparent conductive oxide (TCO), having a relatively high work function. The first electrode 360 may further include a reflection electrode or a reflection layer. For example, the reflection electrode or the reflection layer may be formed of silver (Ag) or aluminum-palladium-copper (APC) alloy. In the top-emission type organic light emitting display device 300, the first electrode 360 may have a triple-layered structure of ITO/Ag/ITO or ITO/APC/ITO.
- [517] A bank layer 366 is formed on the planarization layer 350 to cover an edge of the first electrode 360. Namely, the bank layer 366 is positioned at a boundary of the pixel and exposes a center of the first electrode 360 in the pixel. Since the OLED D emits the white light in the red, green and blue pixels RP, GP and BP, the organic emitting layer 362 may be formed as a common layer in the red, green and blue pixels RP, GP and BP without separation. The bank layer 366 may be formed to prevent a current leakage at an edge of the first electrode 360 and may be omitted.
- [518] An organic emitting layer 362 is formed on the first electrode 360.
- [519] Referring to FIG. 5, the organic light emitting layer 362 includes a first emitting part 410 including a first EML 416 and a first ETL 420, a second emitting part 430 including a second EML 434 and a second ETL 440, and a charge generation layer (CGL) 450 between the first and second emitting parts 410 and 430.
- [520] The CGL 450 is positioned between the first and second emitting parts 410 and 430, and the first emitting part 410, the CGL 450 and the second emitting part 430 are sequentially stacked on the first electrode 360. Namely, the first emitting part 410 is positioned between the first electrode 360 and the CGL 450, and the second emitting part 420 is positioned between the second electrode 364 and the CGL 450.
- [521] The first emitting part 410 may further include a first HTL 414 between the first electrode 360 and the first EML 416. In addition, the first emitting part 410 may further include an HIL 412 between the first electrode 360 and the first HTL 414.
- [522] Although not shown, the first emitting part 410 may further include at least one of an EBL between the first HTL 414 and the first EML 416 and an HBL between the first EML 416 and the first ETL 420.
- [523] The second emitting part 430 may further include a second HTL 432 between the second EML 434 and the CGL 450. In addition, the second emitting part 430 may

further include an EIL 436 between the second ETL 440 and the second electrode 364.

[524] Although not shown, the second emitting part 430 may further include at least one of an EBL between the second HTL 432 and the second EML 434 and an HBL between the second EML 434 and the second ETL 440.

[525] One of the first and second EMLs 416 and 434 provides the blue emission, and the other one of the first and second EMLs 416 and 434 provides the yellow-green emission. For example, the first EML 416, which may provide the blue emission, may include a host and a blue dopant, and the second EML 434, which may provide the yellow-green emission, may include a host and a yellow-green dopant. Alternatively, the second EML 434 may have a double-layered structure including a first layer, which provides the red emission, and a second layer, which provides the green emission. In this instance, the first layer, which may provide the red emission, may include a host and a red dopant, and the second layer, which may provide the green emission, may include a host and a green dopant.

[526] For example, in the first EML 416 providing the blue emission, the host may be an anthracene derivative, the blue dopant may be a boron derivative.

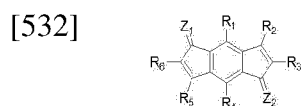
[527] The CGL 450 includes an n-type CGL 452 and a p-type CGL 454. The n-type CGL 452 is positioned between the first ETL 418 and the second HTL 432, and the p-type CGL 454 is positioned between the n-type CGL 452 and the second HTL 432.

[528] The n-type CGL 452 provides the electron toward the first ETL 418, and the electron is transferred into the first EML 416 through the first ETL 418. The p-type CGL 454 provides the hole toward the second HTL 432, and the hole is transferred into the second EML 434 through the second HTL 432. As a result, in the OLED D having a two-stack (double-stack) structure, the driving voltage is reduced, and the emitting efficiency is improved.

[529] The p-type CGL 454 may be formed of an organic material doped with a metal or a p-type dopant. For example, the metal doped in the p-type CGL 454 may be selected from the group consisting of Al, Cu, Fe, Pb, Zn, Au, Pt, W, In, Mo, Ni, and Ti, and the p-type dopant may be F4-TCNQ. The organic material in the p-type CGL 454 may be selected from the group consisting of NPB, TPD, N,N,N',N'-tetranaphthalenyl-benzidine (TNB), and HAT-CN.

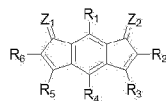
[530] Alternatively, the p-type CGL 454 may include a compound represented by Formula 8-1 or 8-2.

[531] [Formula 8-1]



[533] [Formula 8-2]

[534]



[535]

In Formulas 8-1 and 8-2, each of R_1 to R_6 is independently selected from the group consisting of hydrogen, C6 to C30 aryl group, C6 to C30 heteroaryl group, C1 to C12 alkyl group, C1 to C12 alkoxy group, C2 to C12 ether group, cyano, fluorine, trifluoromethyl, trifluoromethoxy, and trimethylsilyl, and at least one of R_1 to R_6 is cyano.

[536]

Each of Z_1 and Z_2 is independently represented by Formula 9.

[537]

[Formula 9]

[538]



[539]

In Formula 9, each of A and B is independently selected from the group consisting of hydrogen, C6 to C30 aryl group, C6 to C30 heteroaryl group, C1 to C12 alkyl group, C1 to C12 alkoxy group, C2 to C12 ether group, cyano, fluorine, trifluoromethyl, trifluoromethoxy, and trimethylsilyl.

[540]

Each of aryl group, heteroaryl group, alkyl group, alkoxy group, and ether group may be unsubstituted or substituted with at least one of C6 to C30 aryl group, C6 to C30 heteroaryl group, C1 to C12 alkyl group, cyano, fluorine, trifluoromethyl, trifluoromethoxy, and trimethylsilyl.

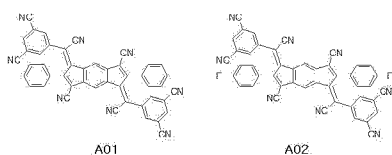
[541]

The compound in the p-type CGL 454, which is represented by Formula 8-1 or 8-2, may be one of the compounds in Formula 10.

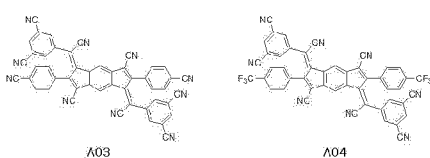
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[Formula 10]

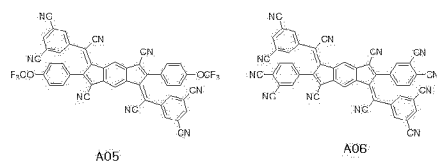
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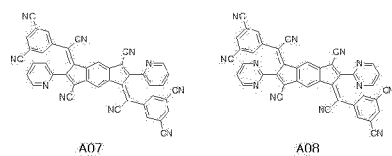
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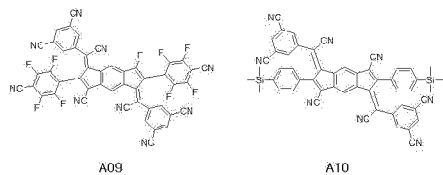
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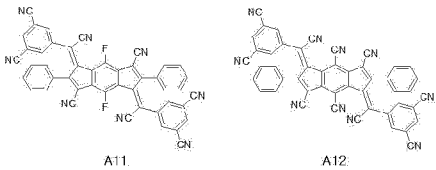
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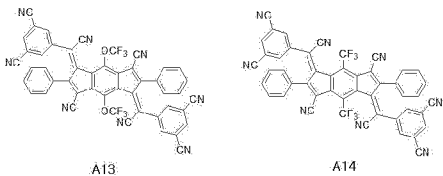
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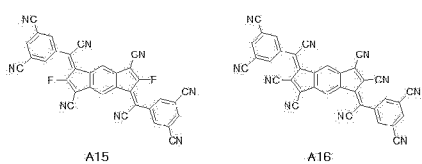
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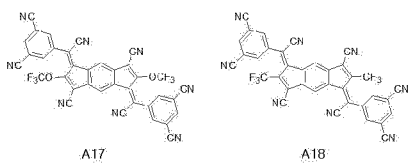
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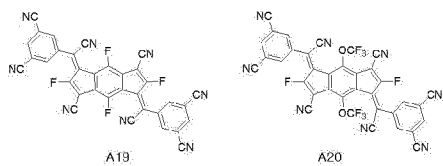
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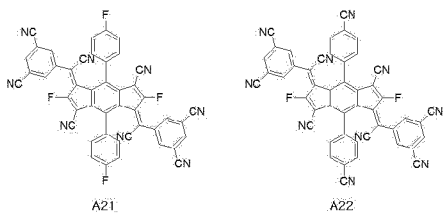
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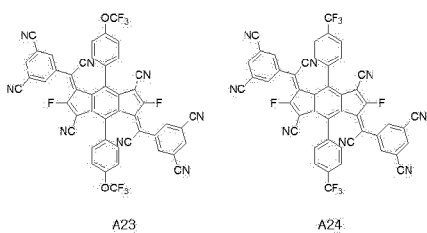
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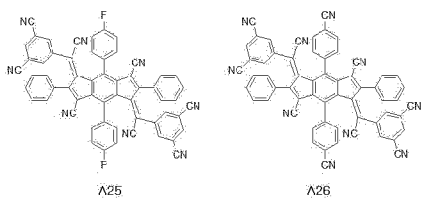
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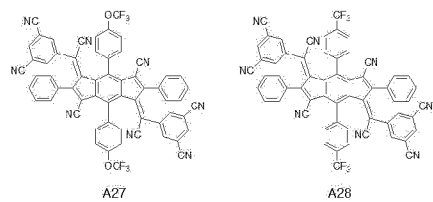
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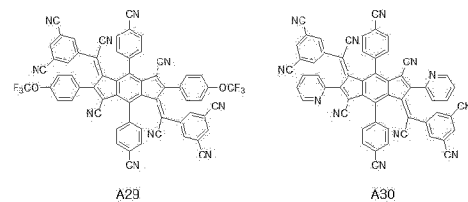
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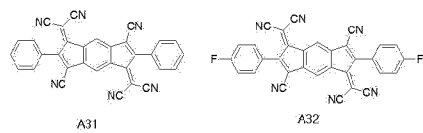
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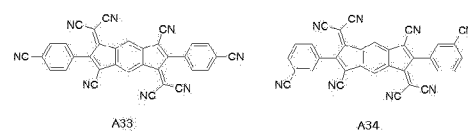
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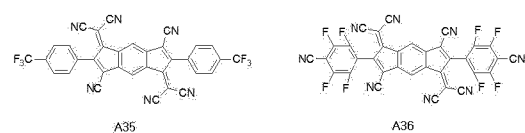
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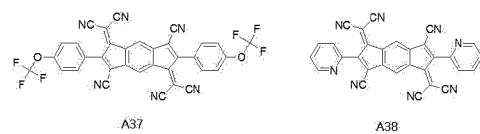
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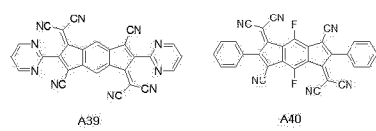
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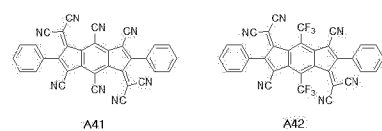
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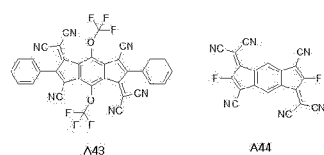
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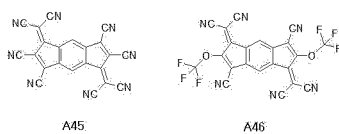
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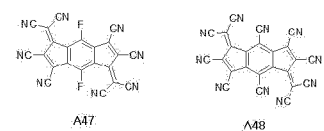
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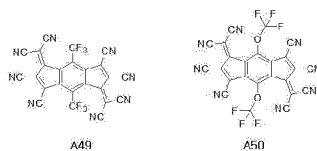
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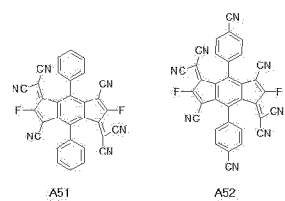
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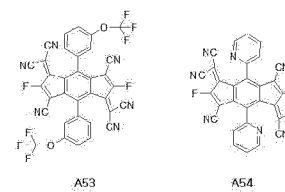
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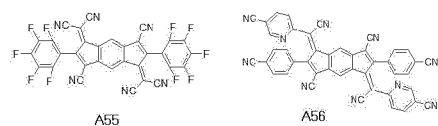
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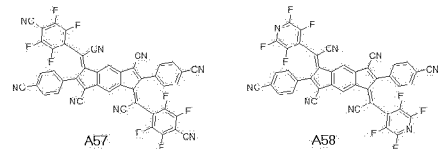
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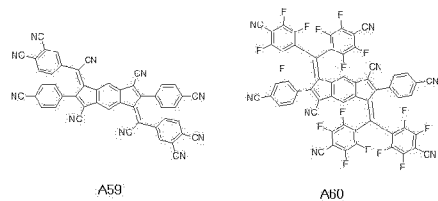
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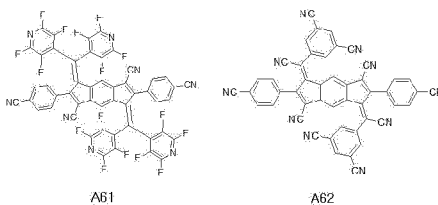
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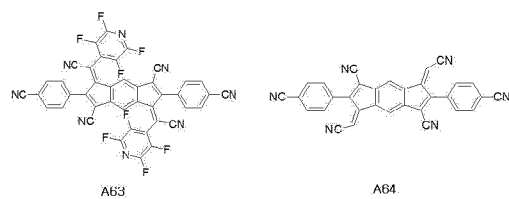
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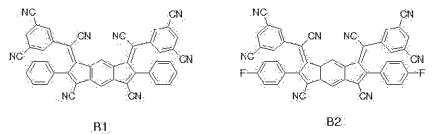
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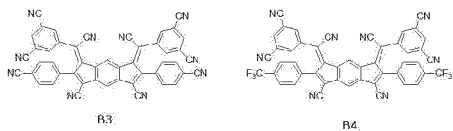
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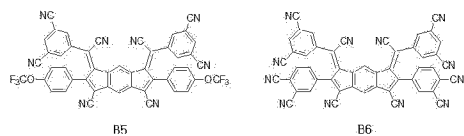
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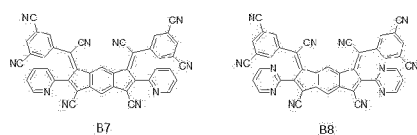
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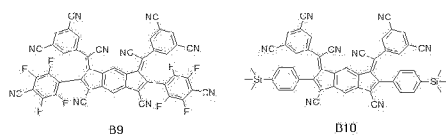
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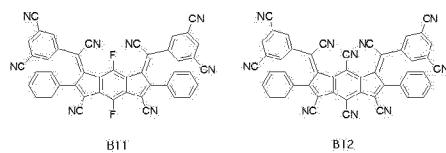
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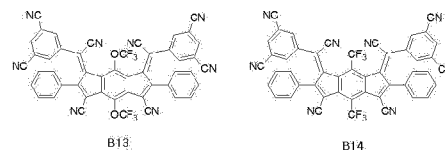
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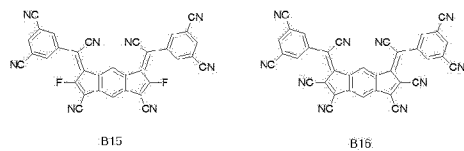
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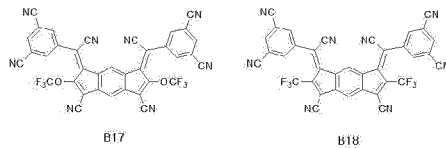
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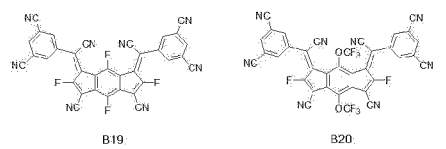
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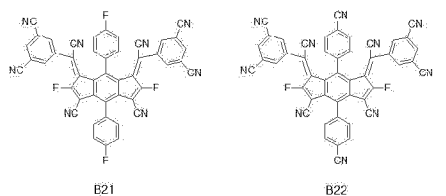
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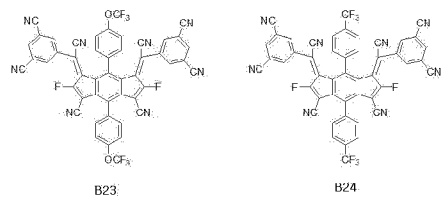
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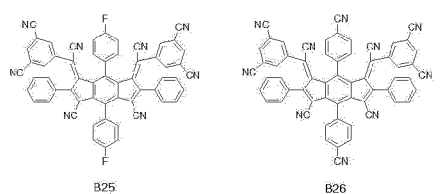
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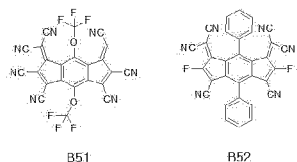
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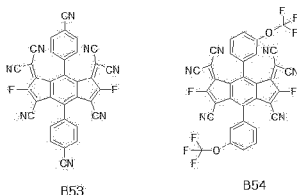
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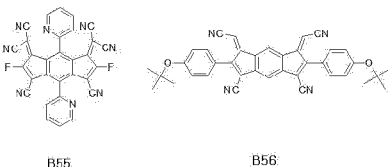
[600]



[601]



[602]



[603] At least one of the first ETL 420, the n-type CGL 452 and the second ETL 440 includes the organic compound in Formula 1-1. For example, the first ETL 420 may include the organic compound of the present disclosure as a first electron transporting material 422. The second ETL 440 may include the organic compound of the present disclosure as a second electron transporting material 442. The n-type CGL 452 may include the organic compound of the present disclosure as an n-type charge generation material 456.

[604] The first electron transporting material 422 of the first ETL 420, the second electron transporting material 442 of the second ETL 440, and the n-type charge generation material 456 of the n-type CGL 452 may be same or different.

[605] When the n-type CGL 452 includes the organic compound of the present disclosure as the n-type charge generation material 456, the n-type CGL 452 may further include an auxiliary n-type charge generation material (not shown). For example, the auxiliary n-type charge generation material may be alkali metal, e.g., Li, Cs, K, Rb, Na or Fr, or alkali earth metal, e.g., Be, Mg, Ca, Sr, Ba or Ra. In the n-type CGL 452, the auxiliary n-type charge generation material may have a weight % of about 0.1 to 10 wt%, preferably about 0.5 to 5 wt%.

[606] The OLED D including the first emitting part 410 providing the blue emission and the second emitting part 430 providing the yellow-green emission provides the white emission, and the CGL 450 including the organic compound of the present disclosure is provided between the first and second emitting parts 410 and 430. As a result, the OLED D has advantages in the driving voltage, the emitting efficiency and the lifespan.

[607] Referring to FIG. 6, the organic emitting layer 362 includes a first emitting part 510 including a first EML 516 and a first ETL 520, a second emitting part 530 including a

second EML 534 and a second ETL 540, a third emitting part 550 including a third EML 554 and a third ETL 560, a first CGL 570 between the first and second emitting parts 510 and 530 and a second CGL 580 between the second and third emitting parts 530 and 550.

[608] The first CGL 570 is positioned between the first and second emitting parts 510 and 530, and the second CGL 580 is positioned between the second and third emitting parts 530 and 550. Namely, the first emitting part 510, the first CGL 570, the second emitting part 530, the second CGL 580 and the third emitting part 550 are sequentially stacked on the first electrode 360. In other words, the first emitting part 510 is positioned between the first electrode 360 and the first CGL 570, the second emitting part 530 is positioned between the first and second CGLs 570 and 580, and the third emitting part 550 is positioned between the second electrode 360 and the second CGL 580.

[609] The first emitting part 510 may further include a first HTL 514 between the first electrode 360 and the first EML 516. In addition, the first emitting part 510 may further include an HIL 512 between the first electrode 360 and the first HTL 514.

[610] Although not shown, the first emitting part 510 may further include at least one of an EBL between the first HTL 514 and the first EML 516 and an HBL between the first EML 516 and the first ETL 520.

[611] The second emitting part 530 may further include a second HTL 532 under the second EML 534.

[612] Although not shown, the second emitting part 510 may further include at least one of an EBL between the second HTL 532 and the second EML 534 and an HBL between the second EML 534 and the second ETL 550.

[613] The third emitting part 550 may further include a third HTL 552 between the third EML 554 and the second CGL 580. In addition, the third emitting part 550 may further include an EIL 556 between the third ETL 560 and the second electrode 364.

[614] Although not shown, the third emitting part 550 may further include at least one of an EBL between the third HTL 552 and the third EML 554 and an HBL between the third EML 554 and the third ETL 560.

[615] Each of the first and third EMLs 516 and 554 provides the blue emission, and the third EML 534 provides the yellow-green emission. For example, the first and third EMLs 516 and 554, each of which may provide the blue emission, may include a host and a blue dopant, and the second EML 534, which may provide the yellow-green emission, may include a host and a yellow-green dopant. Alternatively, the second EML 534 may have a double-layered structure including a first layer, which provides the red emission, and a second layer, which provides the green emission. In addition, the second EML 534 may have a triple-layered structure including a first layer, which

provides the red emission and includes a host and a red dopant, a second layer, which provides the yellow-green emission and includes a host and a yellow-green dopant, and a third layer, which provides the green emission and includes a host and a green dopant.

- [616] For example, in the first and third EMLs 516 and 554 each providing the blue emission, the host may be an anthracene derivative, the blue dopant may be a boron derivative.
- [617] The first CGL 570 includes a first n-type CGL 572 and a first p-type CGL 574. The first n-type CGL 572 is positioned between the first ETL 520 and the second HTL 532, and the first p-type CGL 574 is positioned between the first n-type CGL 572 and the second HTL 532.
- [618] The second CGL 580 includes a second n-type CGL 582 and a second p-type CGL 584. The second n-type CGL 582 is positioned between the second ETL 540 and the third HTL 552, and the second p-type CGL 584 is positioned between the second n-type CGL 582 and the third HTL 552.
- [619] The first n-type CGL 572 provides the electron toward the first ETL 520, and the electron is transferred into the first EML 516 through the first ETL 520. The first p-type CGL 574 provides the hole toward the second HTL 532, and the hole is transferred into the second EML 534 through the second HTL 532.
- [620] The second n-type CGL 582 provides the electron toward the second ETL 540, and the electron is transferred into the second EML 534 through the second ETL 540. The second p-type CGL 584 provides the hole toward the third HTL 552, and the hole is transferred into the third EML 554 through the third HTL 552.
- [621] As a result, in the OLED D having a three-stack (triple-stack) structure, the driving voltage is reduced, and the emitting efficiency is improved.
- [622] For example, each of the first and second p-type CGLs 574 and 584 may include one of HAT-CN, and the compound represented by Formula 8-1 or 8-2. In addition, each of the first and second p-type CGLs 574 and 584 may further include a metal or a p-type dopant.
- [623] At least one of the first ETL 520, the first n-type CGL 572, the second ETL 540, the second n-type CGL 582, and the third ETL 560 includes the organic compound in Formula 1-1. For example, the first ETL 520 may include the organic compound of the present disclosure as a first electron transporting material 522. The second ETL 540 may include the organic compound of the present disclosure as a second electron transporting material 542. The third ETL 560 may include the organic compound of the present disclosure as a third electron transporting material 562. The first n-type CGL 572 may include the organic compound of the present disclosure as a first n-type charge generation material 576. The second n-type CGL 582 may include the organic

- compound of the present disclosure as a second n-type charge generation material 586.
- [624] The first electron transporting material 522 of the first ETL 520, the second electron transporting material 542 of the second ETL 540, the third electron transporting material 562 of the third ETL 560, the first n-type charge generation material 576 of the first n-type CGL 572, and the second n-type charge generation material 586 of the second n-type CGL 582 may be same or different.
- [625] When each of the first and second n-type CGLs 572 and 582 includes the organic compound of the present disclosure as the first and second n-type charge generation materials 576 and 586, respectively, each of the first and second n-type CGLs 572 and 582 may further include an auxiliary n-type charge generation material (not shown). For example, the auxiliary n-type charge generation material may be alkali metal, e.g., Li, Cs, K, Rb, Na or Fr, or alkali earth metal, e.g., Be, Mg, Ca, Sr, Ba or Ra. In each of the first and second n-type CGLs 572 and 582, the auxiliary n-type charge generation material may have a weight % of about 0.1 to 10 wt%, preferably about 0.5 to 5 wt%.
- [626] The OLED D including the first and third emitting part 510 and 550 each providing the blue emission and the second emitting part 530 providing the yellow-green emission provides the white emission, and the first and second CGLs 570 and 580 including the organic compound of the present disclosure is provided between the first and second emitting parts 510 and 530 and between the second and third emitting parts 530 and 550, respectively. As a result, the OLED D has advantages in the driving voltage, the emitting efficiency and the lifespan.
- [627] Referring to FIG. 4 again, a second electrode 364 is formed over the substrate 310 where the organic emitting layer 362 is formed.
- [628] In the organic light emitting display device 300, since the light emitted from the organic emitting layer 362 is incident to the color filter layer 380 through the second electrode 364, the second electrode 364 has a thin profile for transmitting the light.
- [629] The first electrode 360, the organic emitting layer 362 and the second electrode 364 constitute the OLED D.
- [630] The color filter layer 380 is positioned over the OLED D and includes a red color filter 382, a green color filter 384 and a blue color filter 386 respectively corresponding to the red, green and blue pixel regions RP, GP and BP. The red color filter 382 may include at least one of red dye and red pigment, the green color filter 384 may include at least one of green dye and green pigment, and the blue color filter 386 may include at least one of blue dye and blue pigment.
- [631] Although not shown, the color filter layer 380 may be attached to the OLED D by using an adhesive layer. Alternatively, the color filter layer 380 may be formed directly on the OLED D.
- [632] An encapsulation film (not shown) may be formed to prevent penetration of moisture

into the OLED D. For example, the encapsulation film may include a first inorganic insulating layer, an organic insulating layer and a second inorganic insulating layer sequentially stacked, but it is not limited thereto. The encapsulation film may be omitted.

[633] 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.

[634] In the OLED of FIG. 4, the first and second electrodes 360 and 364 are a reflection electrode and a transparent (or semi-transparent) electrode, respectively, and the color filter layer 380 is disposed over the OLED D. Alternatively, when the first and second electrodes 360 and 364 are a transparent (or semi-transparent) electrode and a reflection electrode, respectively, the color filter layer 380 may be disposed between the OLED D and the first substrate 310.

[635] A color conversion layer (not shown) may be formed between the OLED D and the color filter layer 380. The color conversion layer may include a red color conversion layer, a green color conversion layer and a blue color conversion layer respectively corresponding to the red, green and blue pixel regions RP, GP and BP. The white light from the OLED D is converted into the red light, the green light and the blue light by the red, green and blue color conversion layer, respectively. For example, the color conversion layer may include a quantum dot. Accordingly, the color purity of the organic light emitting display device 300 may be further improved.

[636] The color conversion layer may be included instead of the color filter layer 380.

[637] As described above, in the organic light emitting display device 300, the OLED D in the red, green and blue pixel regions RP, GP and BP emits the white light, and the white light from the organic light emitting diode D passes through the red color filter 382, the green color filter 384 and the blue color filter 386. As a result, the red light, the green light and the blue light are provided from the red pixel region RP, the green pixel region GP and the blue pixel region BP, respectively.

[638] In FIG. 4, the OLED D emitting the white light is used for a display device. Alternatively, the OLED D may be formed on an entire surface of a substrate without at least one of the driving element and the color filter layer to be used for a lightening device. The display device and the lightening device each including the OLED D of the present disclosure may be referred to as an organic light emitting device.

[639] In the OLED D and the organic light emitting display device 300, at least one of the ETL and the n-type CGL includes the organic compound of the present disclosure such that the electron transporting property into the EML is improved. Accordingly, in the OLED and the display device 300, the driving voltage is decreased, and the emitting efficiency and the lifespan are increased.

[640] While the present disclosure has been described with reference to exemplary em-

bodiments and examples, these embodiments and examples are not intended to limit the scope of the present disclosure. Rather, it will be apparent to those skilled in the art that various modifications and variations can be made in the present disclosure without departing from the spirit or scope of the invention. Thus, it is intended that the present disclosure cover the modifications and variations of the present disclosure provided they come within the scope of the appended claims and their equivalents.

[641] The various embodiments described above can be combined to provide further embodiments. All of patents, patent application publications, patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet are incorporated herein by reference, in their entirety. Aspects of the embodiments can be modified, if necessary to employ concepts of the various patents, applications and publications to provide yet further embodiments.

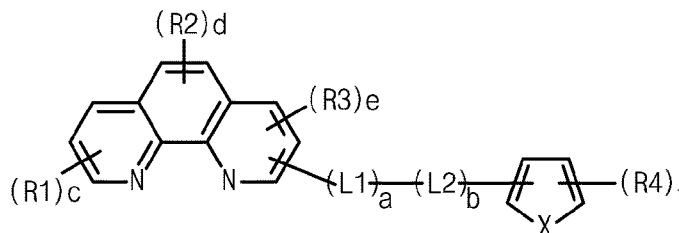
[642] These and other changes can be made to the embodiments in light of the above-detailed description. In general, in the following claims, the terms used should not be construed to limit the claims to the specific embodiments disclosed in the specification and the claims, but should be construed to include all possible embodiments along with the full scope of equivalents to which such claims are entitled. Accordingly, the claims are not limited by the disclosure.

Claims

[Claim 1]

An organic compound of Formula 1:

[Formula 1]



wherein X is oxygen (O) or sulfur (S), and each of R1 to R4 is independently selected from the group consisting of deuterium, halogen, cyano, C1 to C10 alkyl group, C1 to C10 alkoxy group, C3 to C30 cycloalkyl group, C6 to C30 aryl group, C6 to C30 arylamino group, and C5 to C30 heteroaryl group,

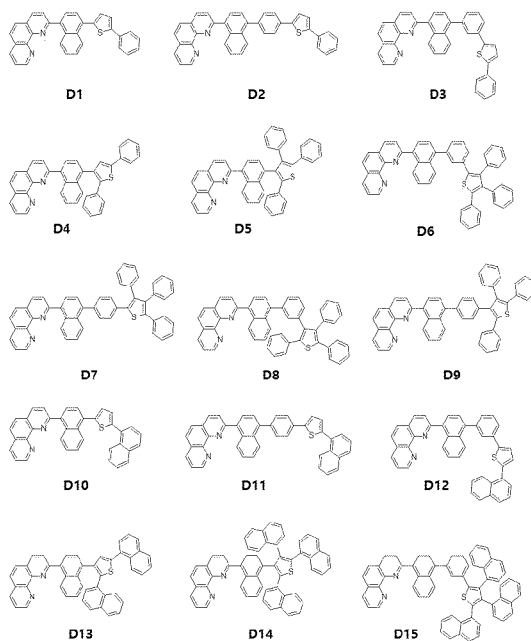
wherein each of L1 and L2 is independent selected from the group consisting of C6 to C30 arylene group and C5 to C30 heteroarylene group, and

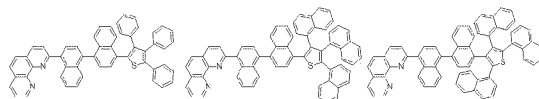
wherein each of a and b is independent 0 or 1, each of c and f is independently an integer of 0 to 3, and each of d and e is independently an integer of 0 to 2.

[Claim 2]

The organic compound according to claim 1, wherein the organic compound is one of compounds in Formula 2:

[Formula 2]

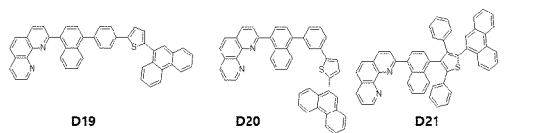




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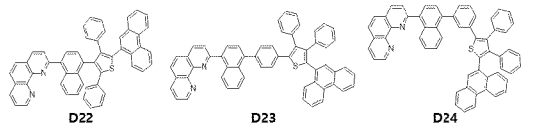
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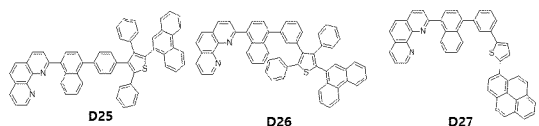
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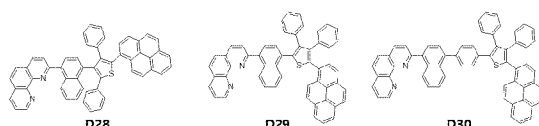
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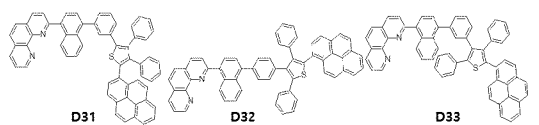
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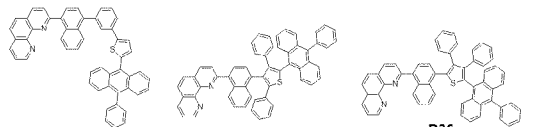
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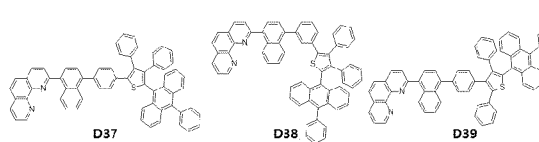
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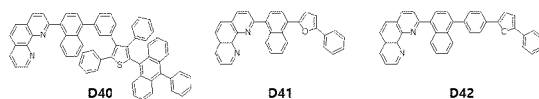
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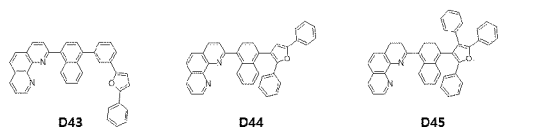
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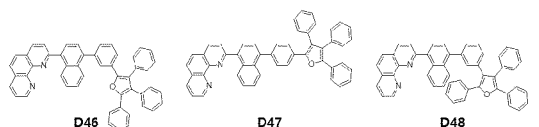
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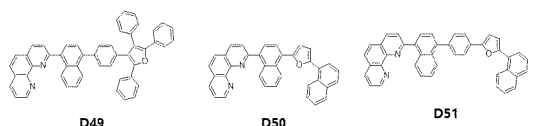
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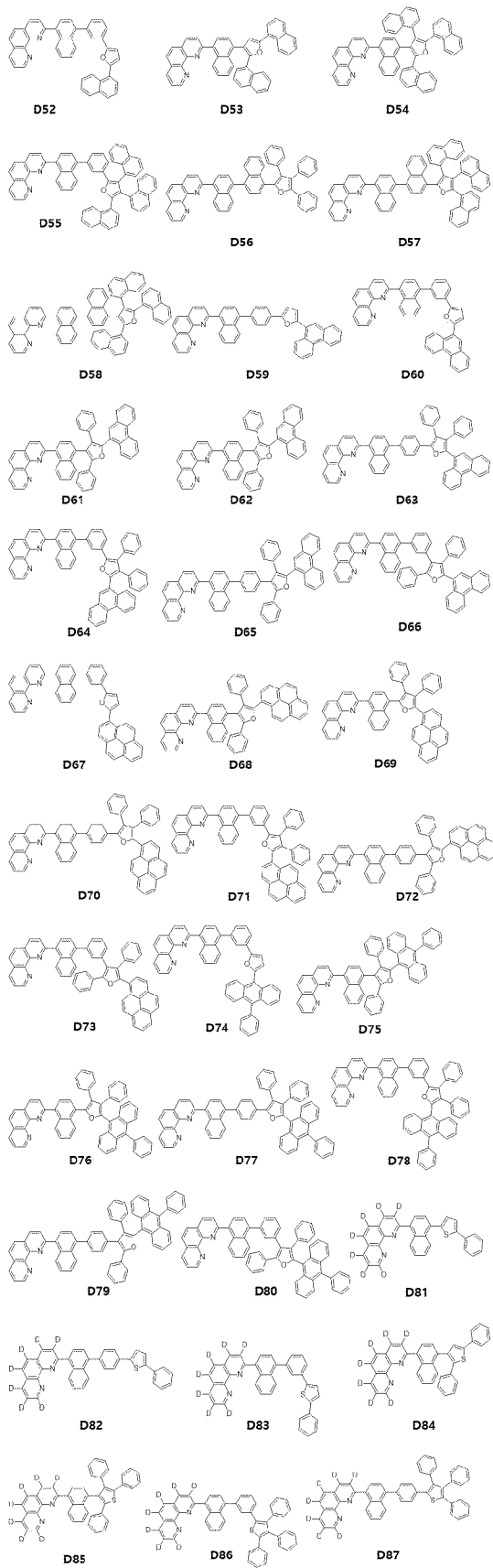
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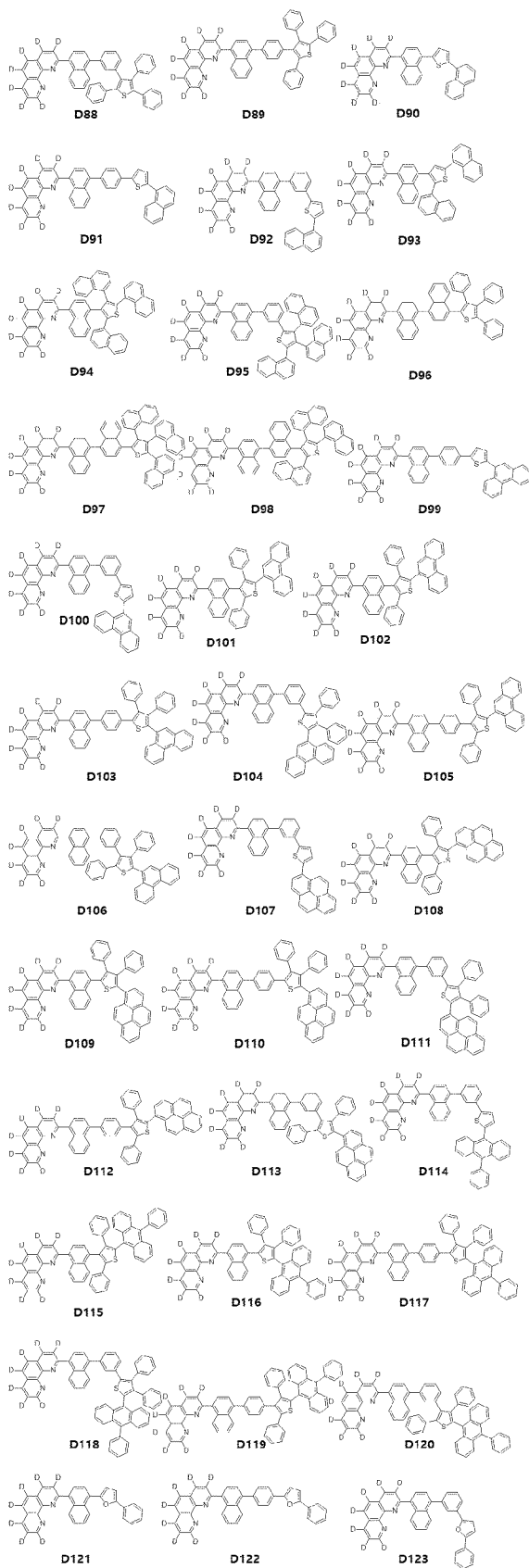


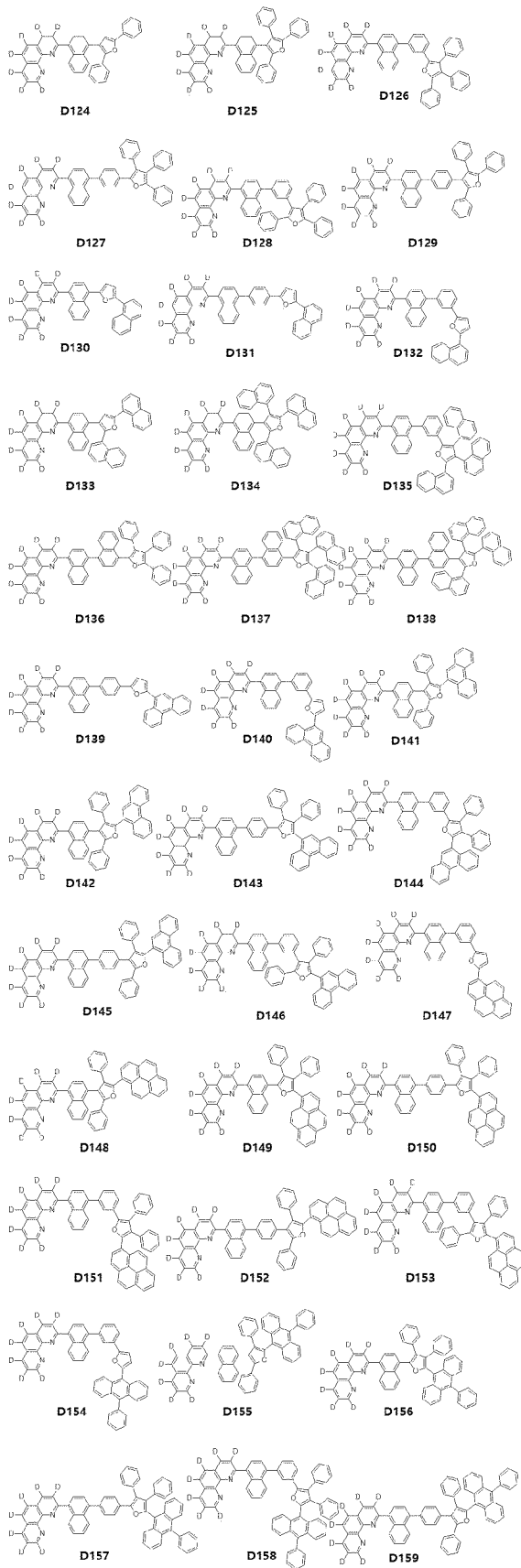
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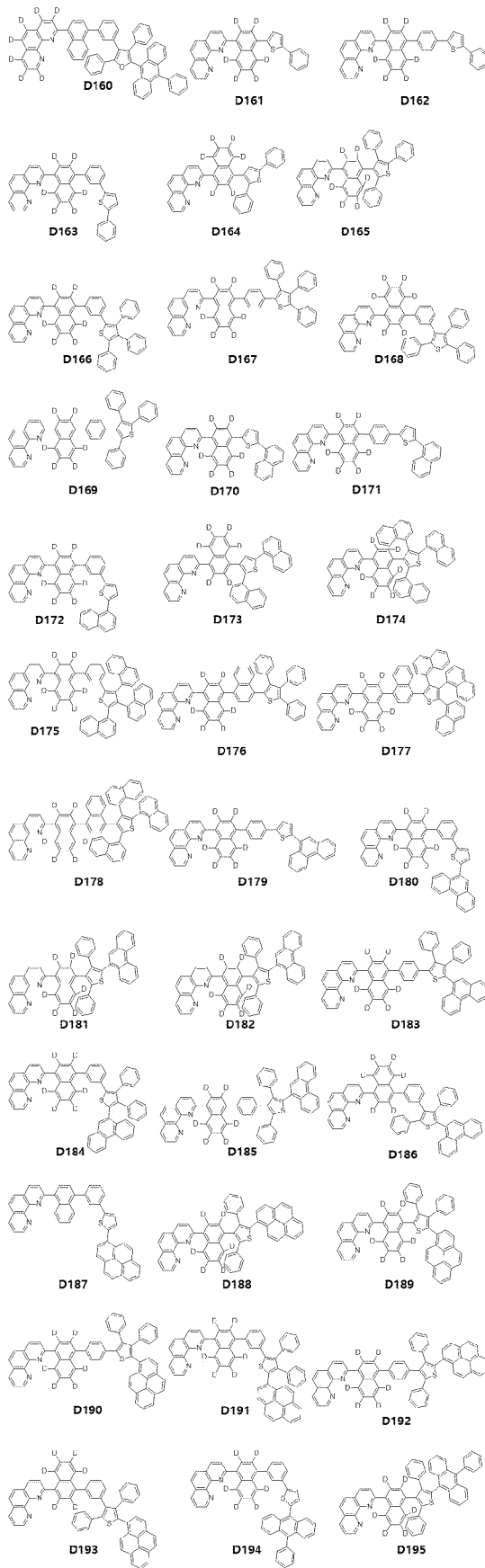
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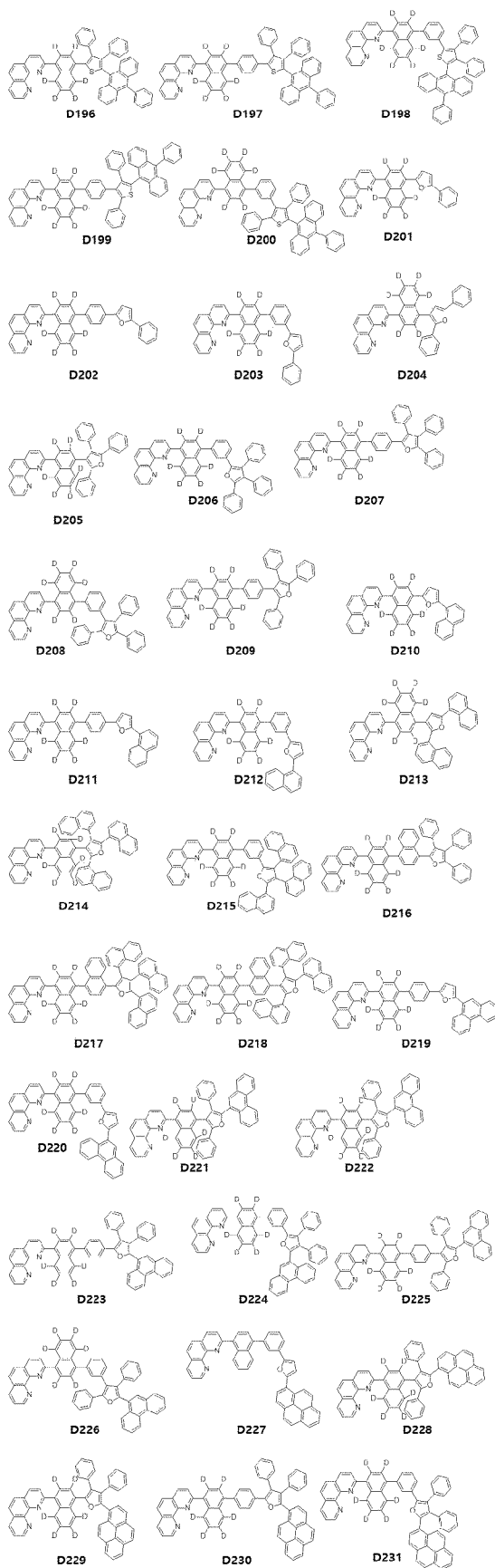
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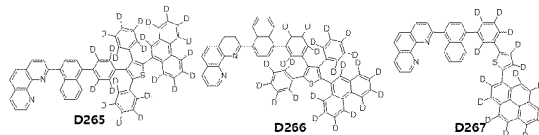
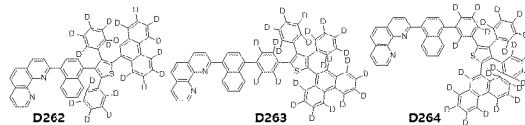
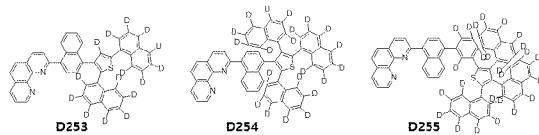
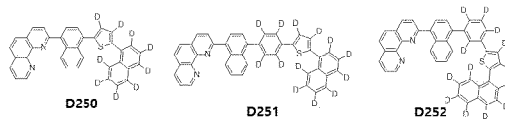
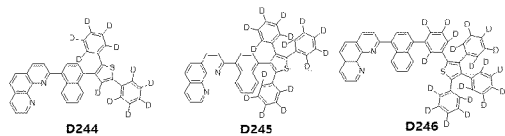
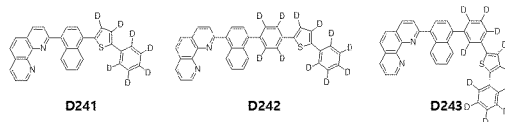
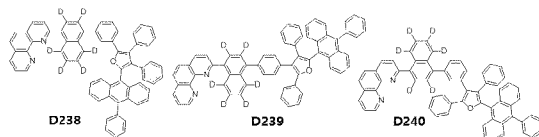
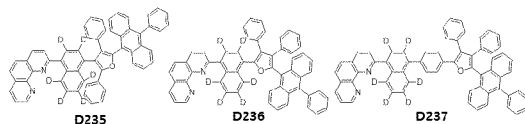
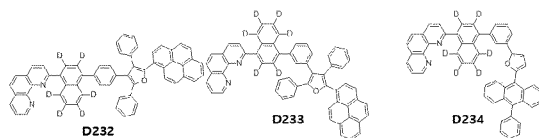


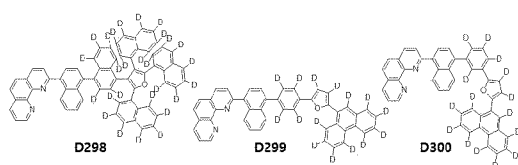
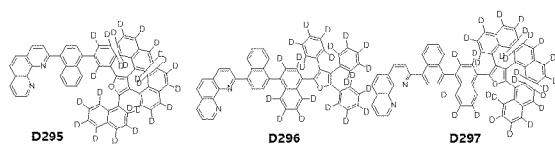
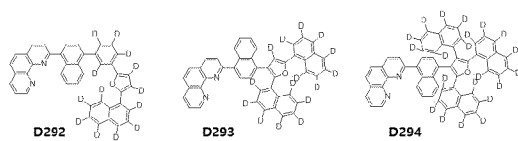
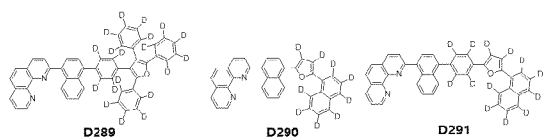
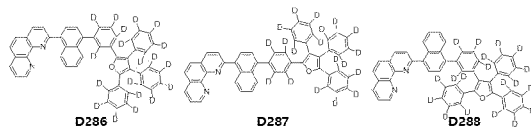
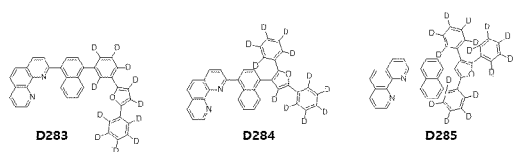
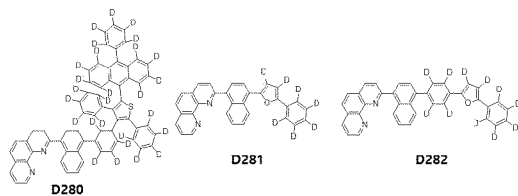
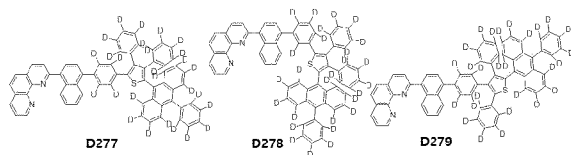
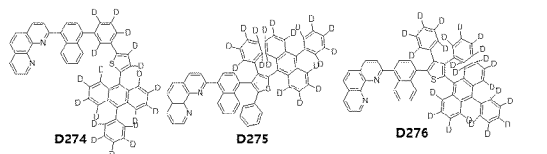
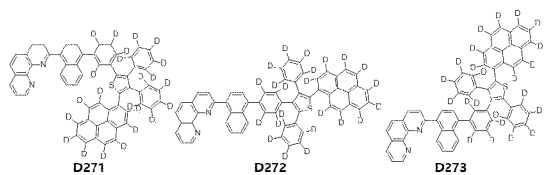
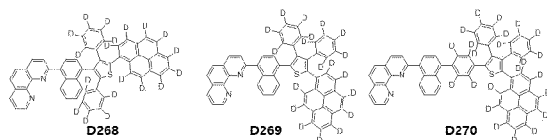


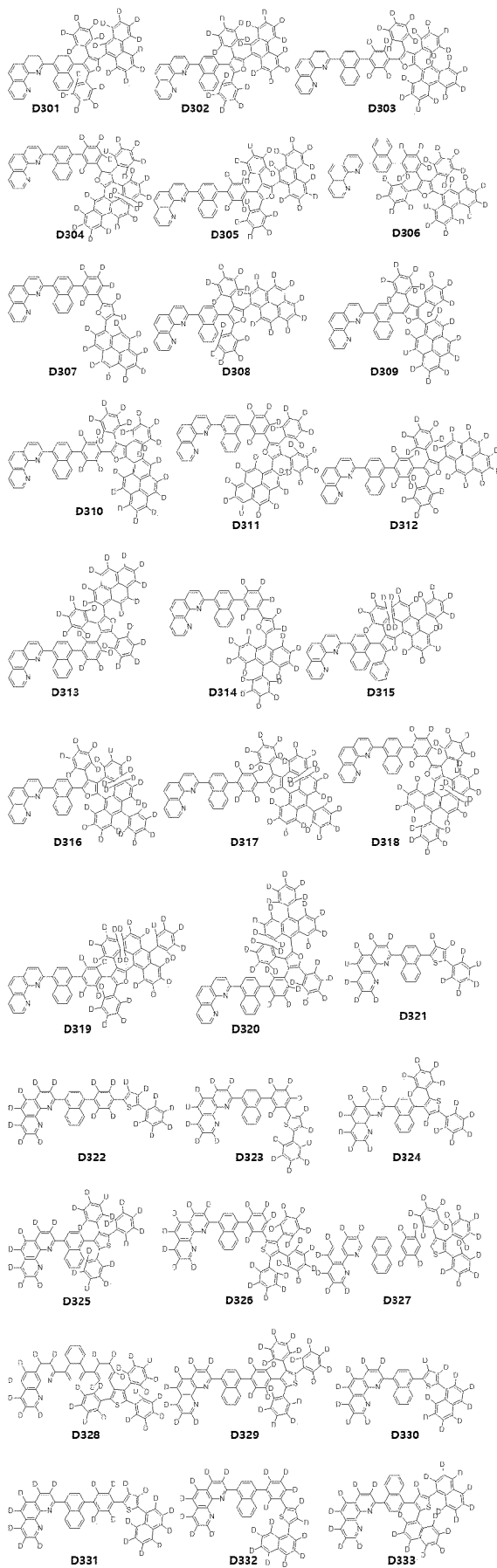


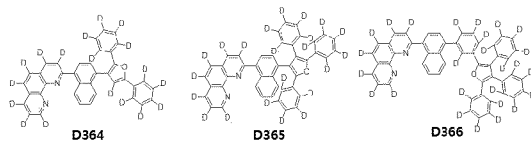
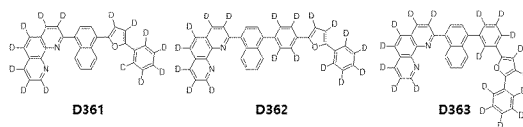
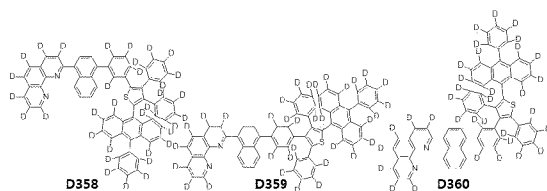
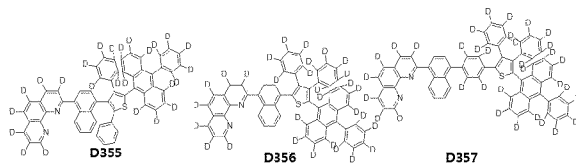
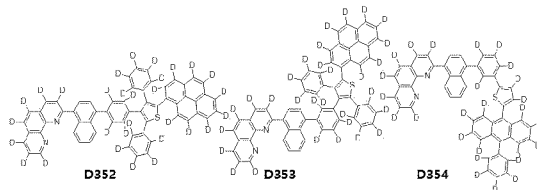
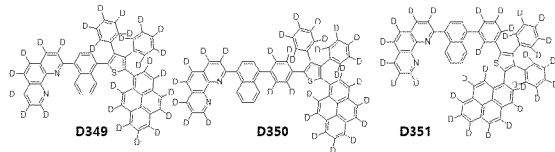
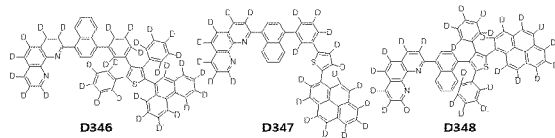
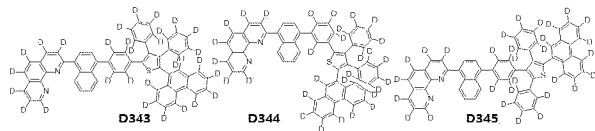
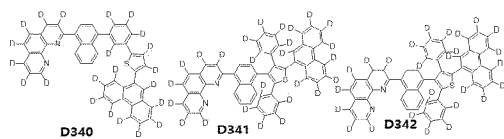
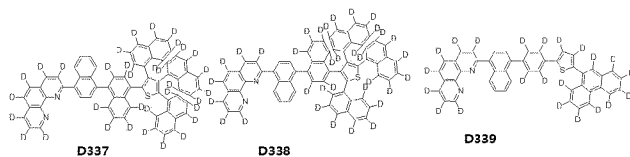
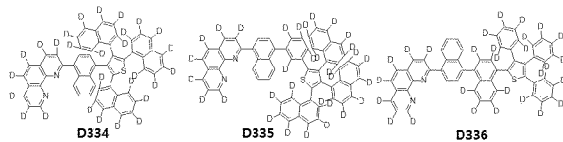


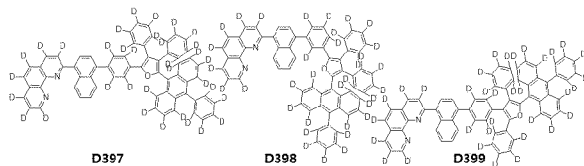
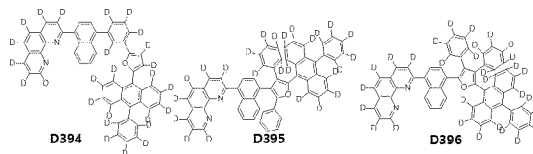
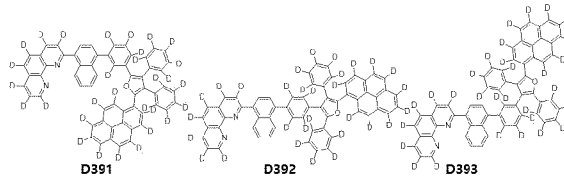
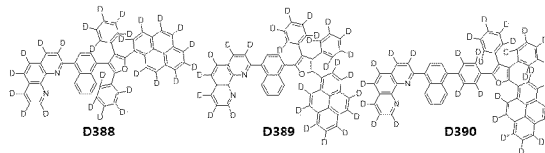
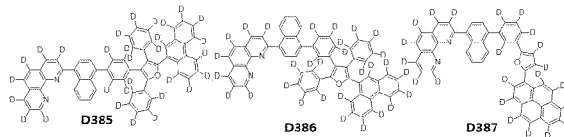
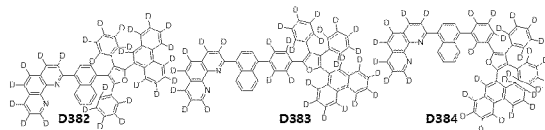
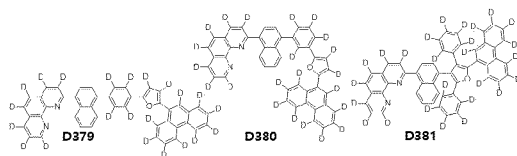
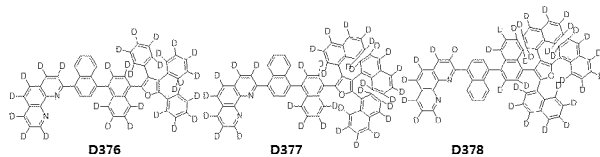
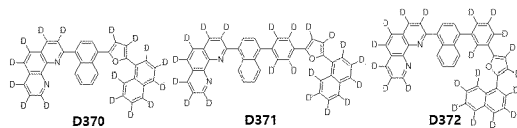
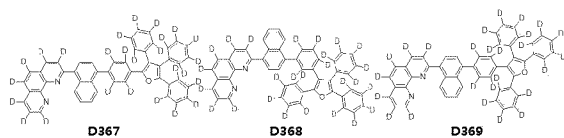


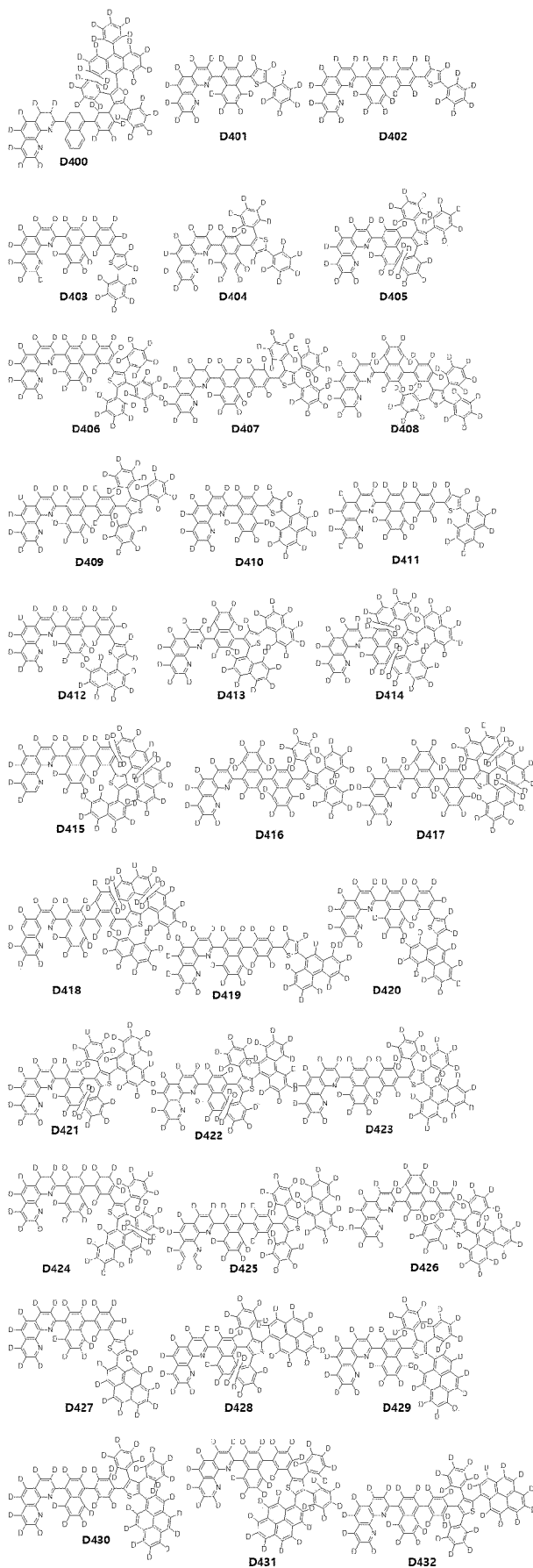


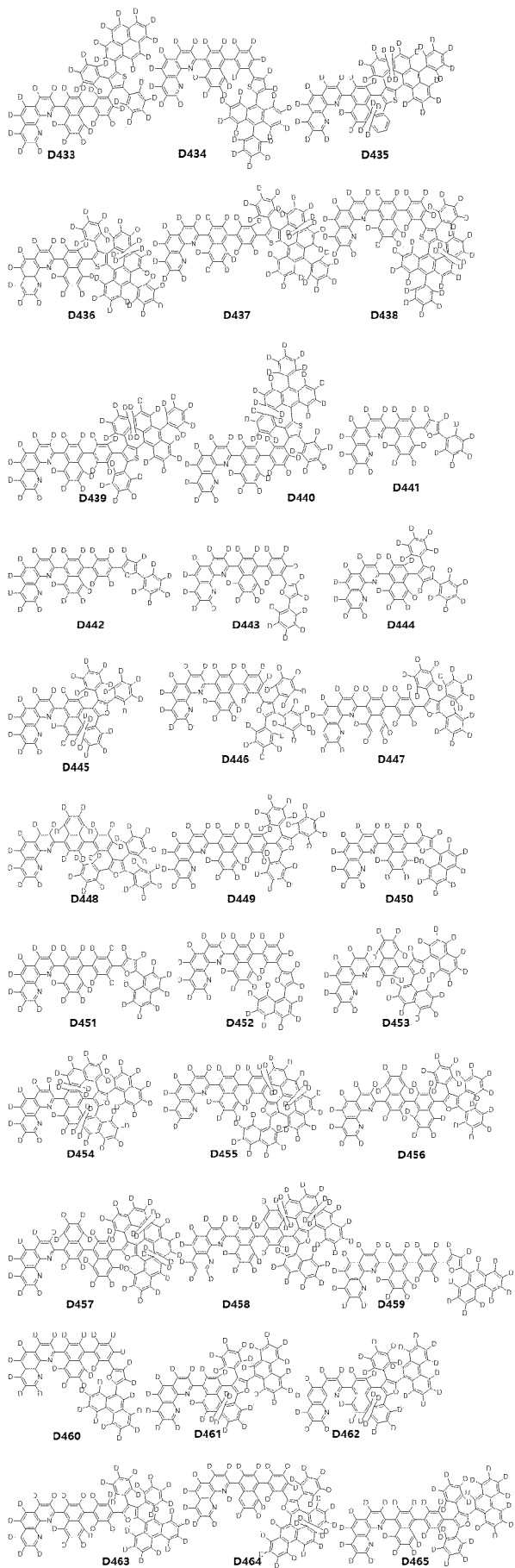


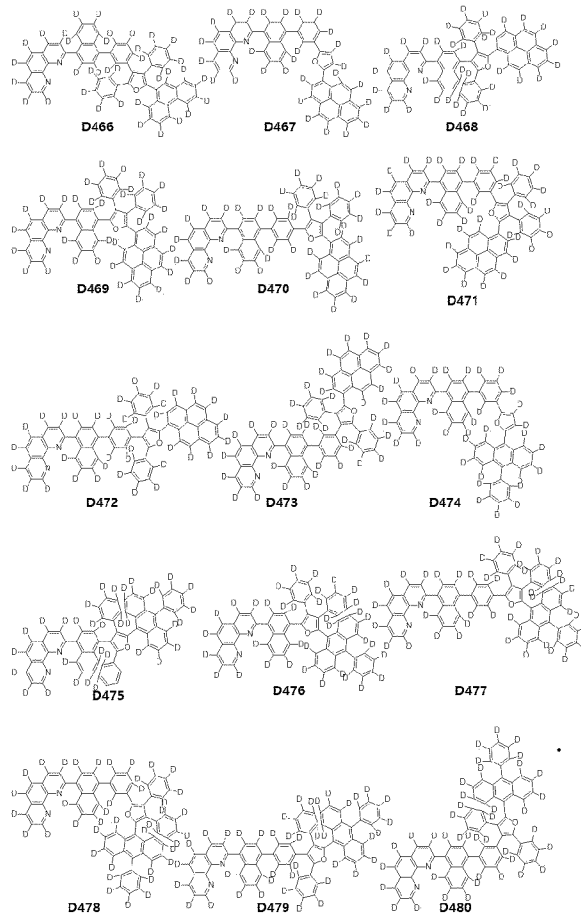












[Claim 3]

An organic light emitting diode, comprising:

a first electrode;

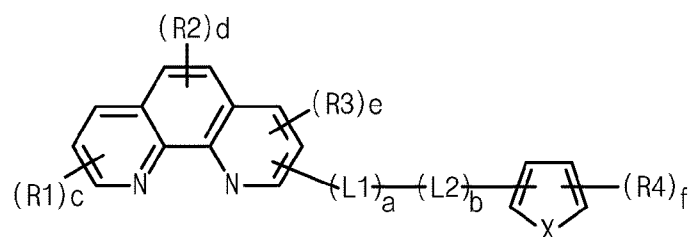
a second electrode facing the first electrode; and

a first emitting part including a first emitting material layer and a first electron transporting layer and positioned between the first and second electrodes,

wherein the first electron transporting layer includes a first electron transporting material and is positioned between the first emitting material layer and the second electrode,

wherein the first electron transporting material is an organic compound of Formula 1:

[Formula 1]



wherein X is oxygen (O) or sulfur (S), and each of R1 to R4 is independently selected from the group consisting of deuterium, halogen, cyano, C1 to C10 alkyl group, C1 to C10 alkoxy group, C3 to C30 cycloalkyl group, C6 to C30 aryl group, C6 to C30 arylamino group, and C5 to C30 heteroaryl group,

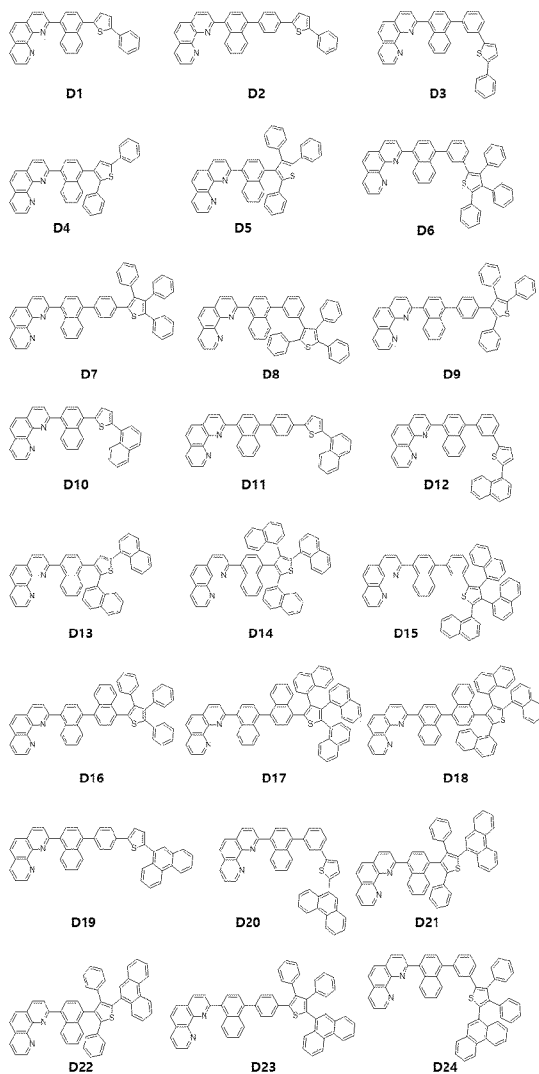
wherein each of L1 and L2 is independent selected from the group consisting of C6 to C30 arylene group and C5 to C30 heteroarylene group, and

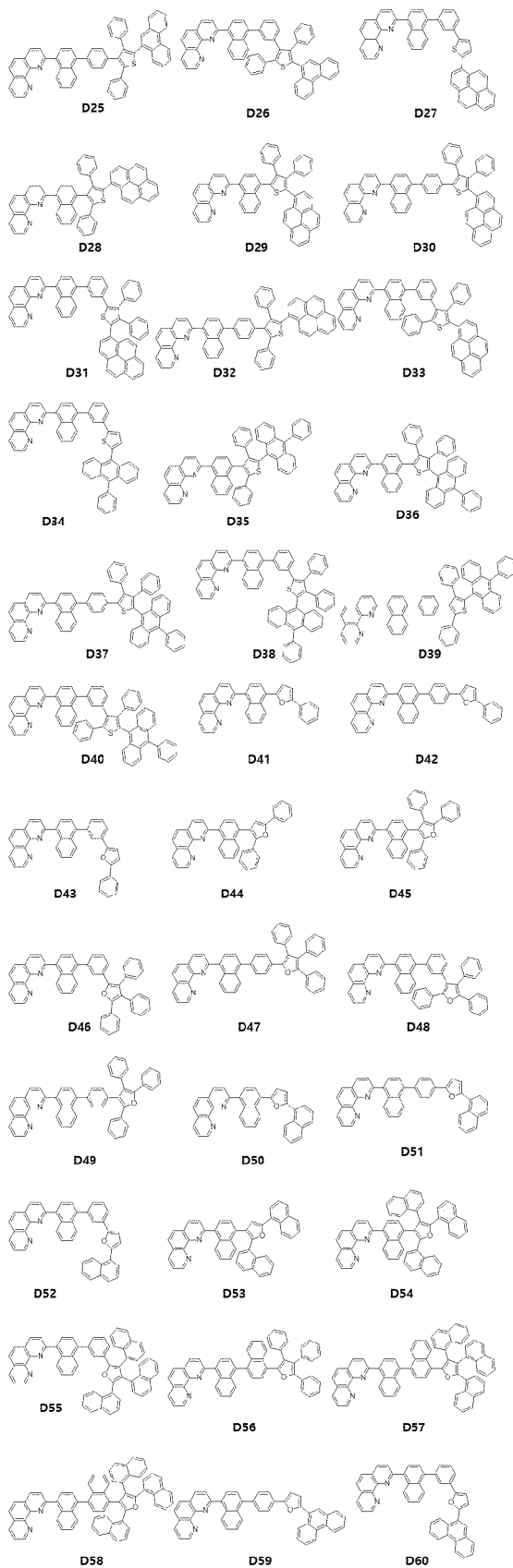
wherein each of a and b is independent 0 or 1, each of c and f is independently an integer of 0 to 3, and each of d and e is independently an integer of 0 to 2.

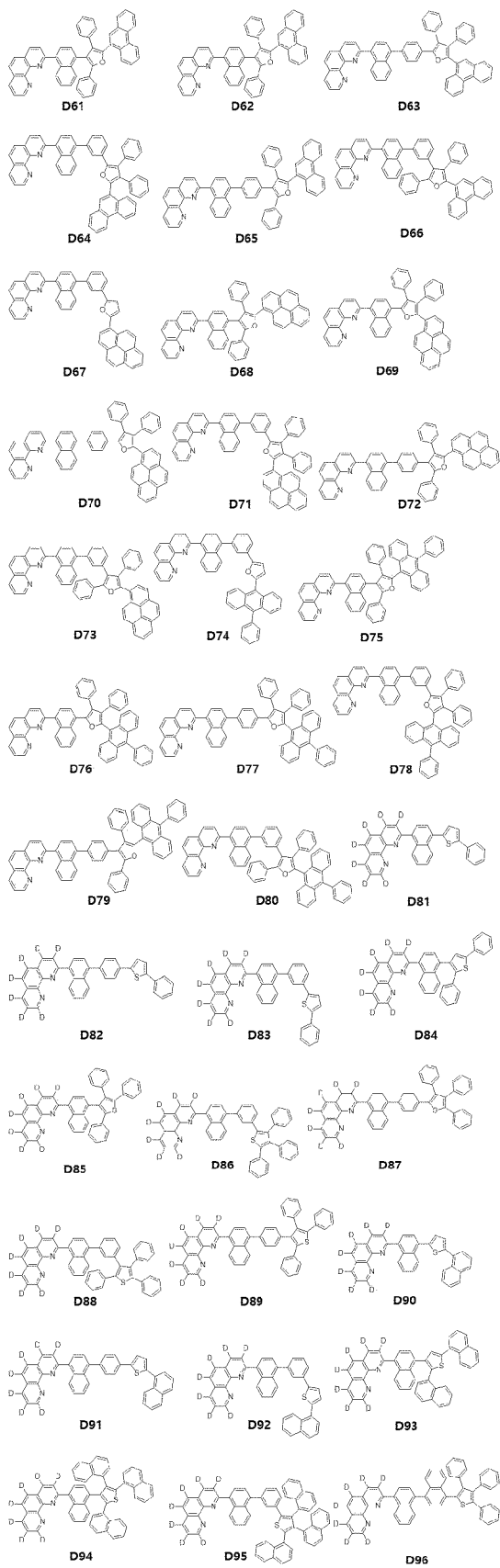
[Claim 4]

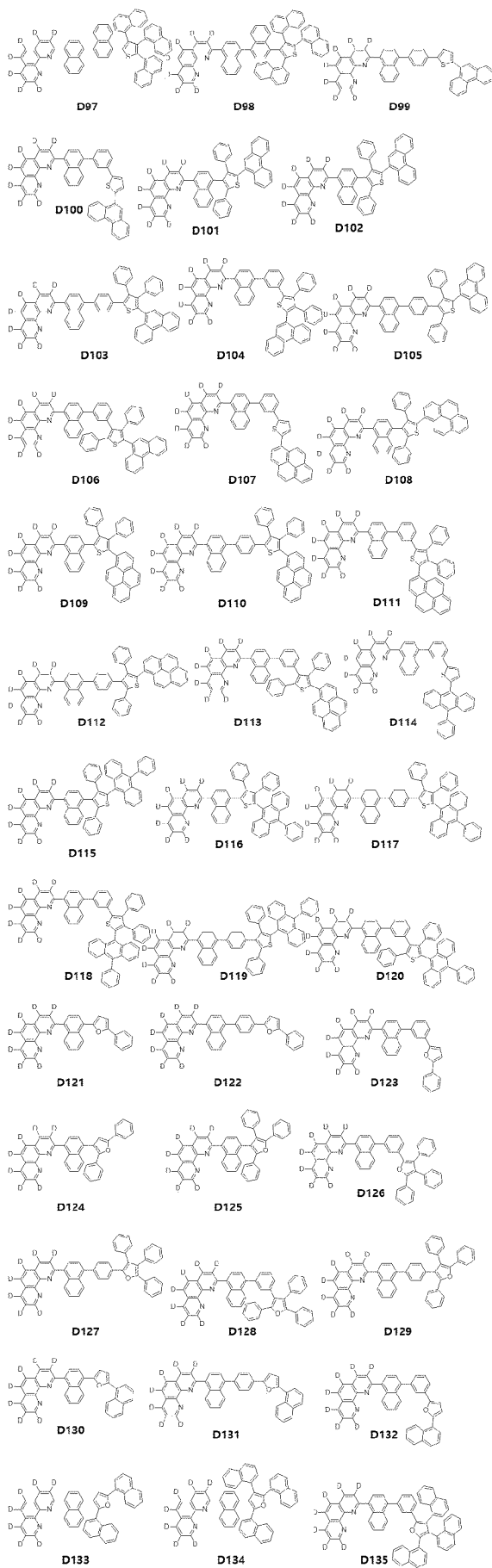
The organic light emitting diode according to claim 3, wherein the first compound is one of compounds in Formula 2:

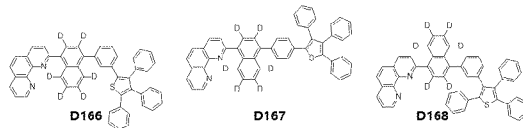
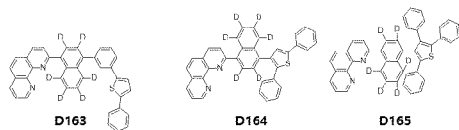
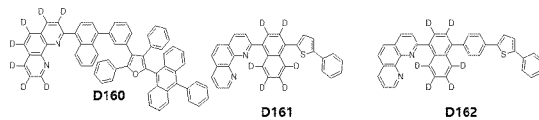
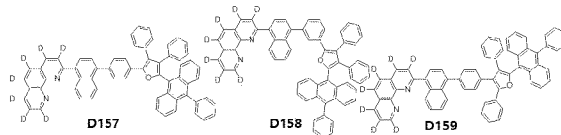
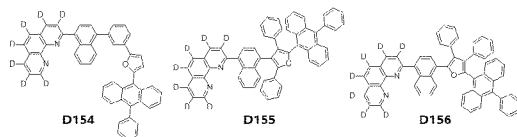
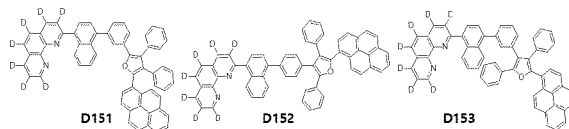
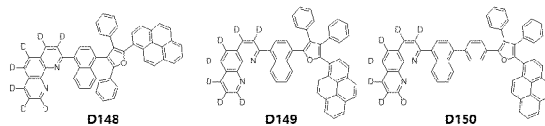
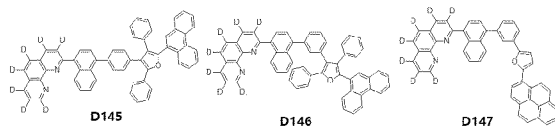
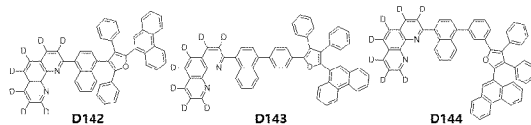
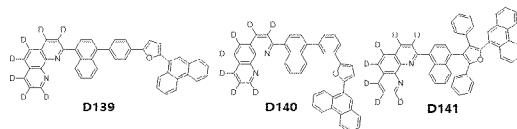
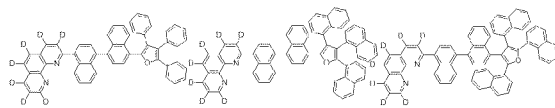
[Formula 2]

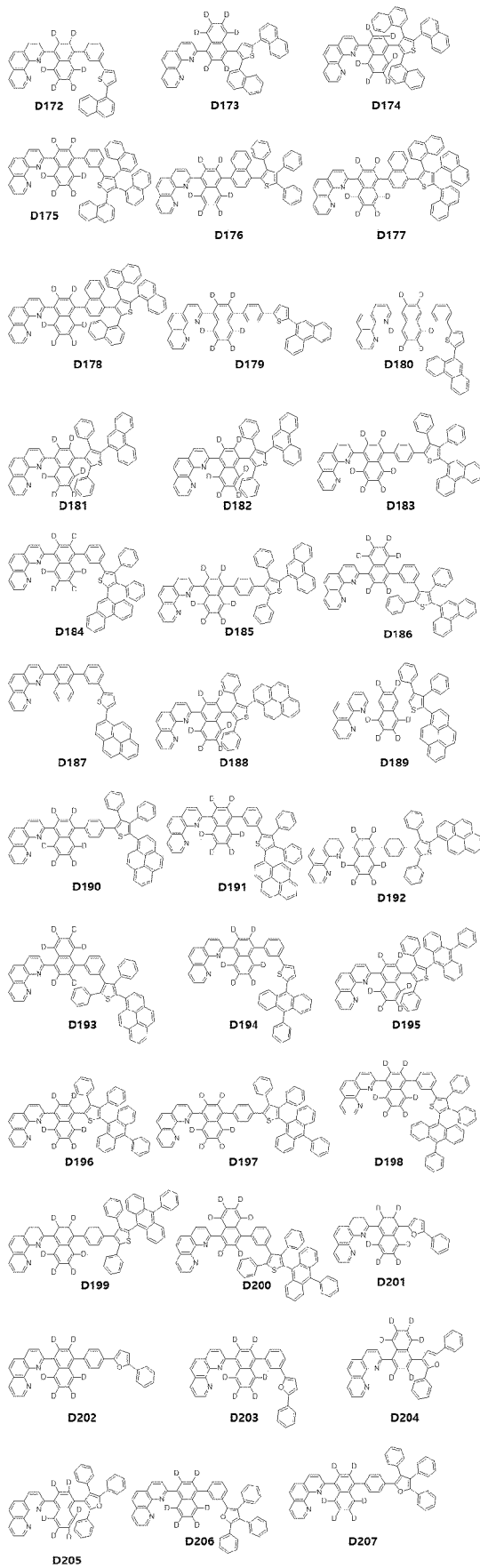


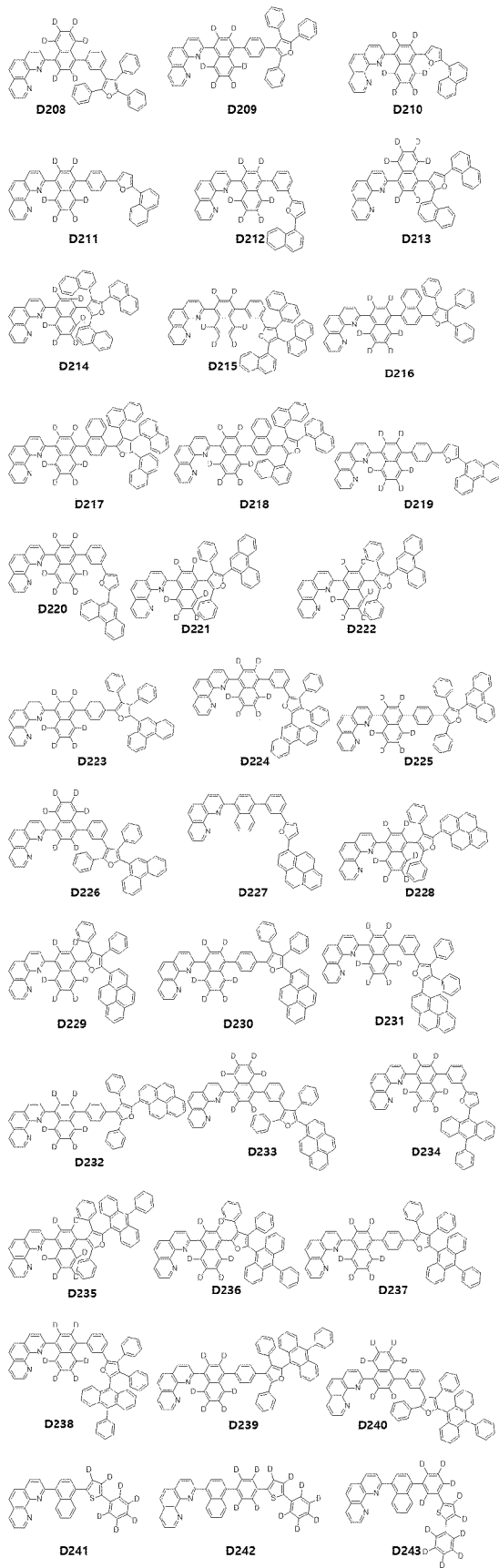


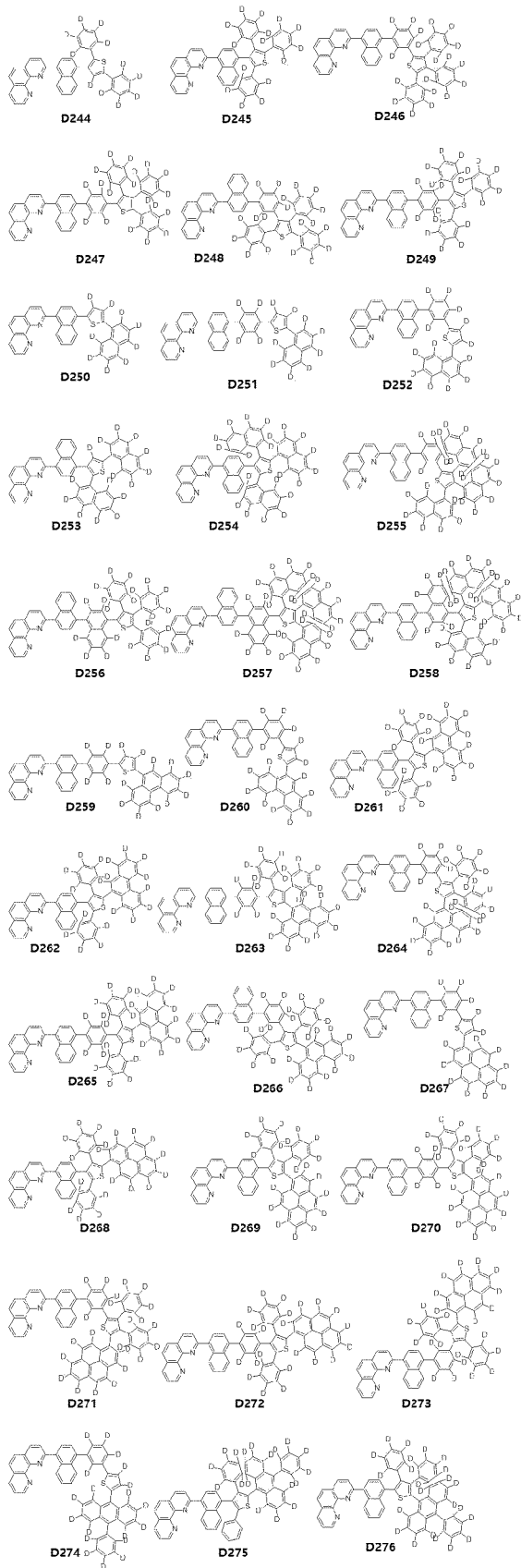


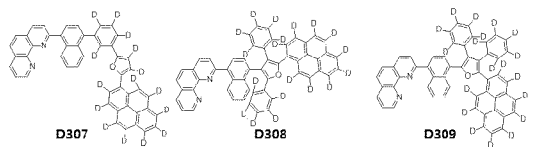
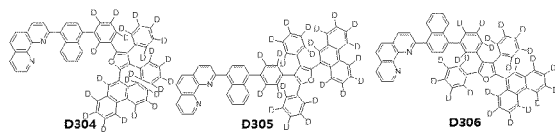
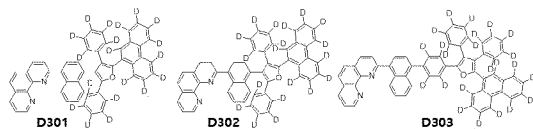
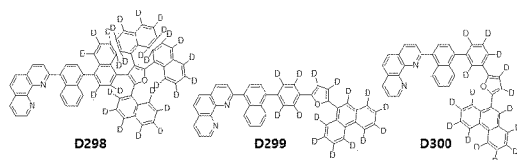
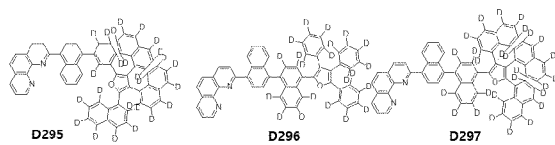
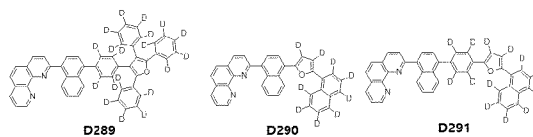
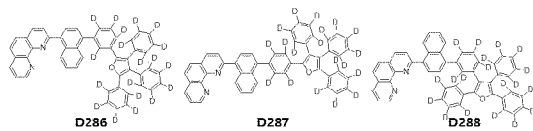
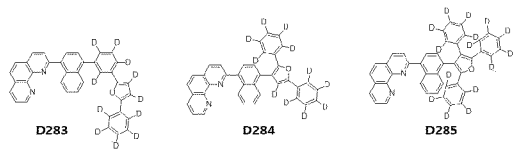
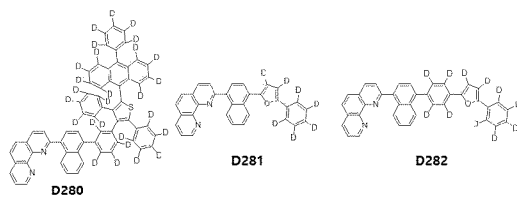
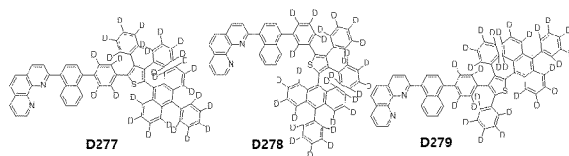


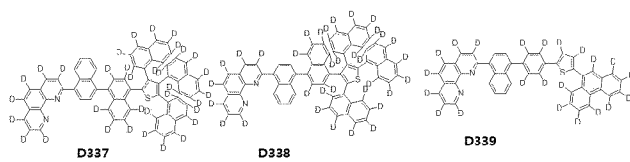
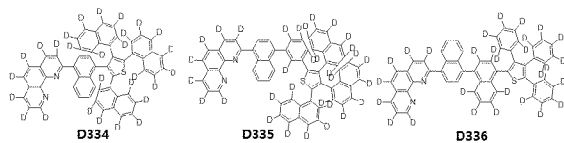
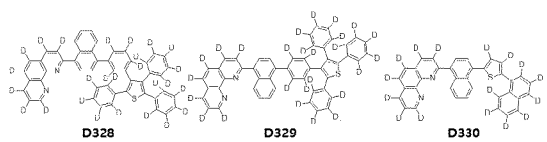
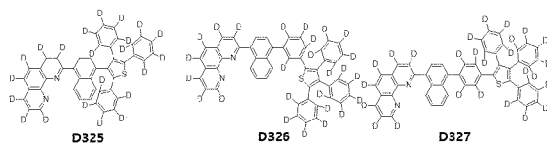
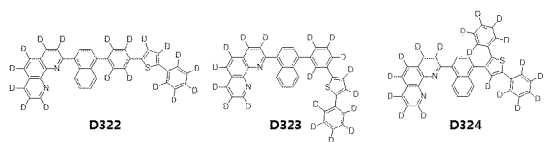
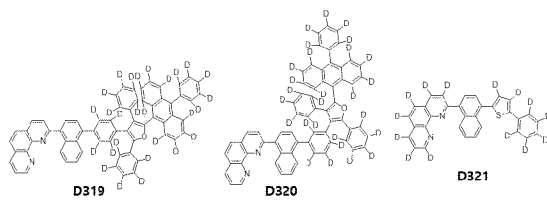
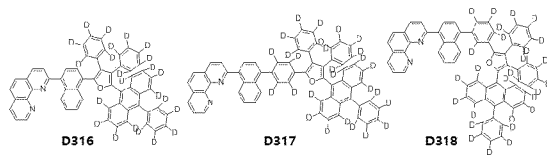
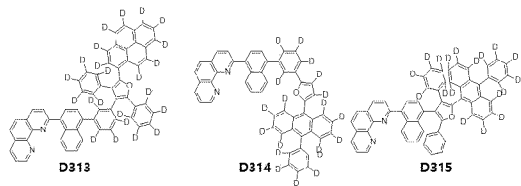
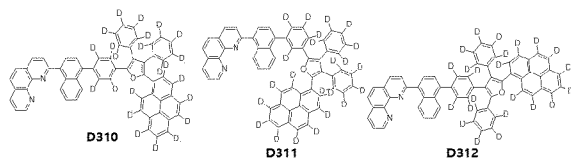


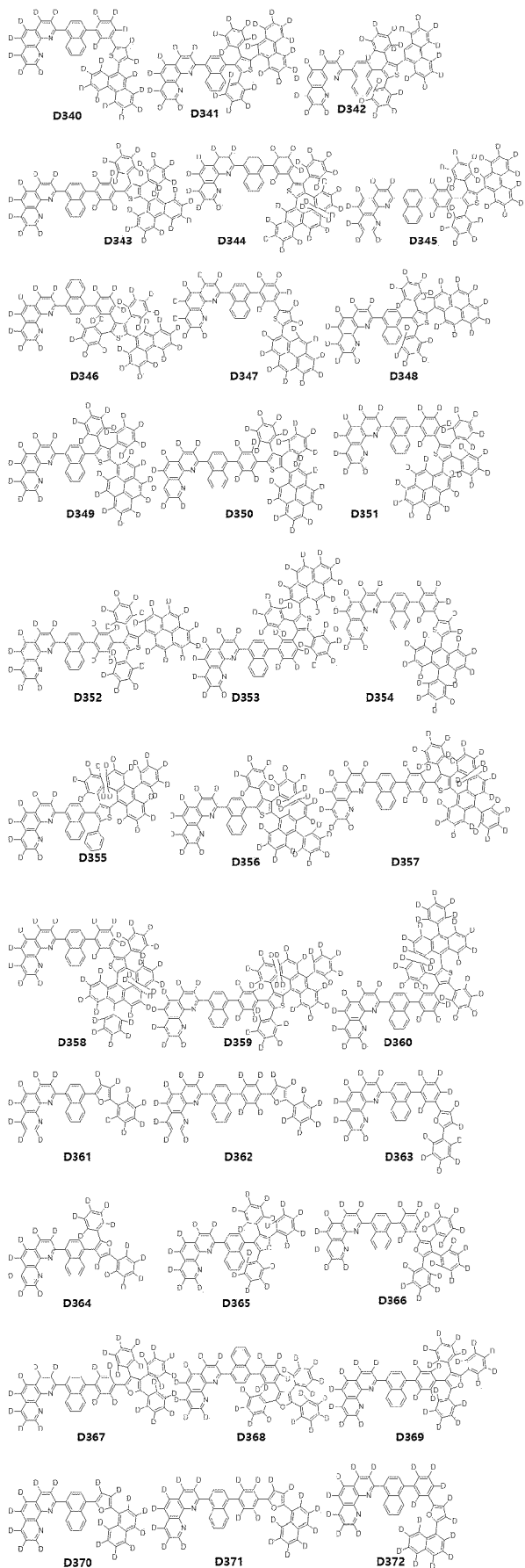


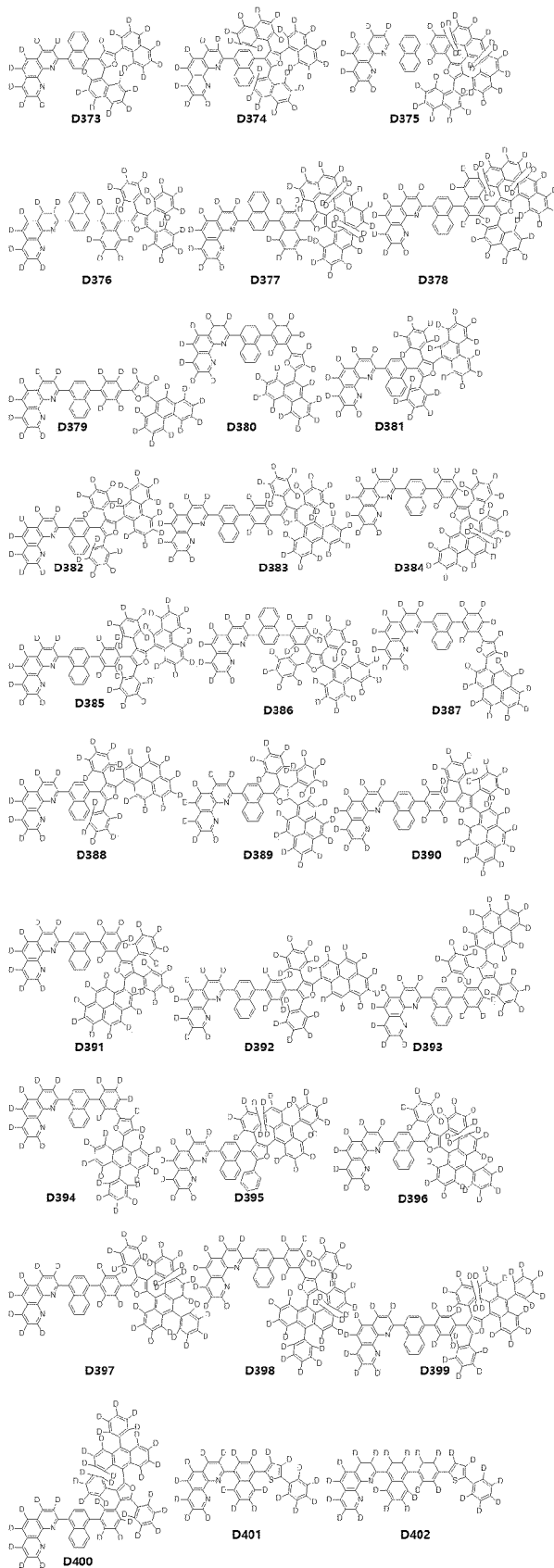


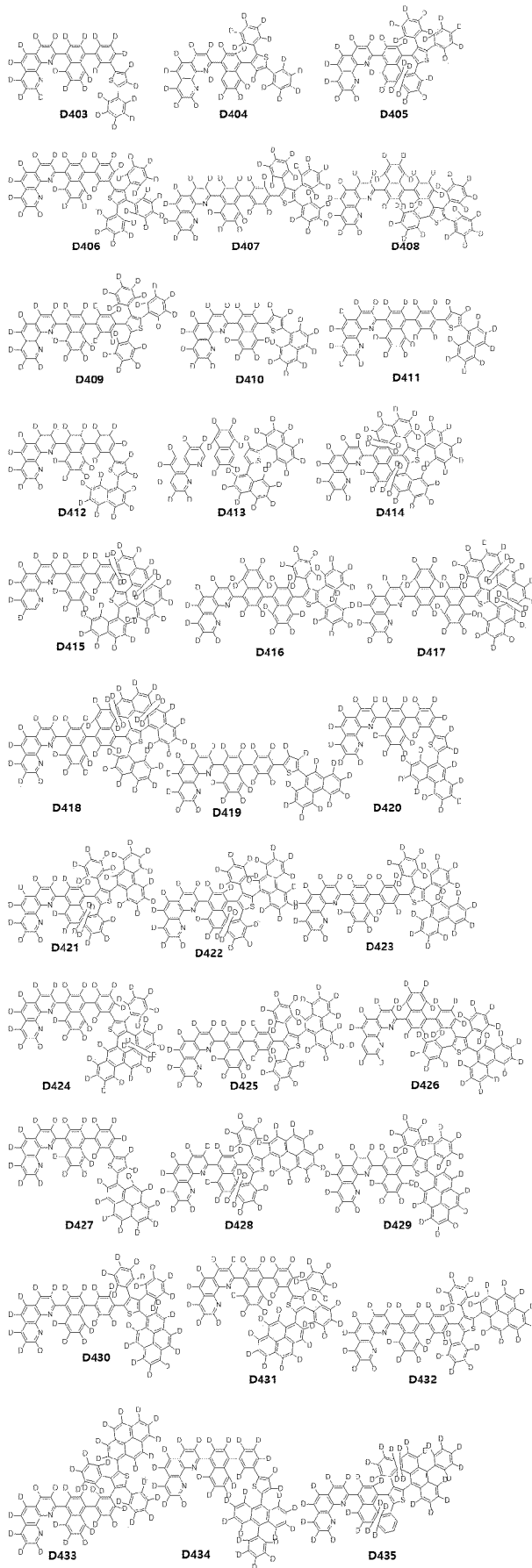


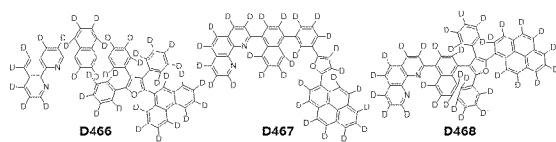
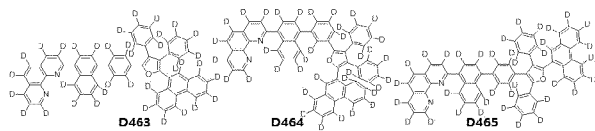
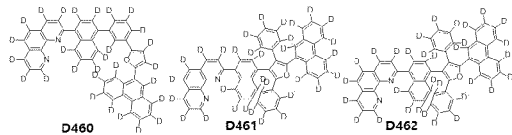
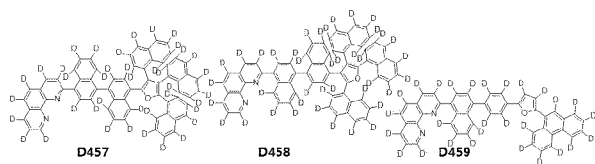
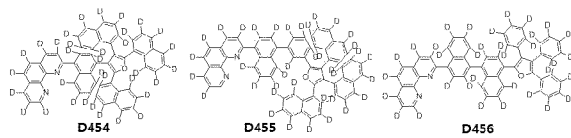
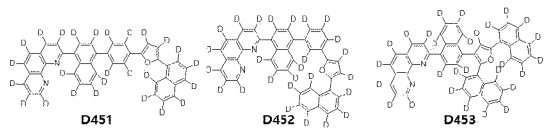
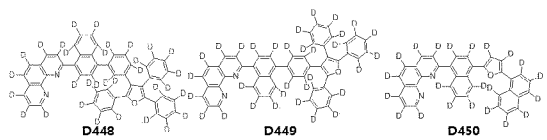
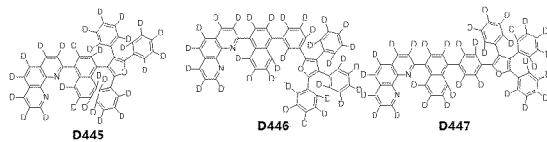
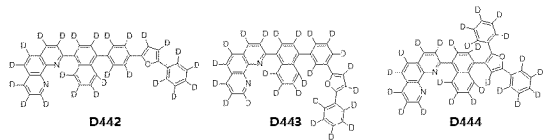
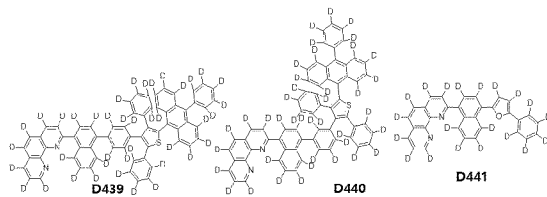
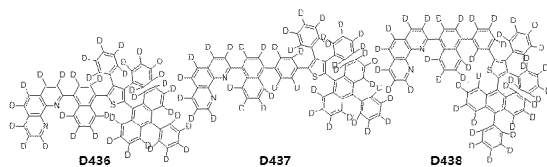


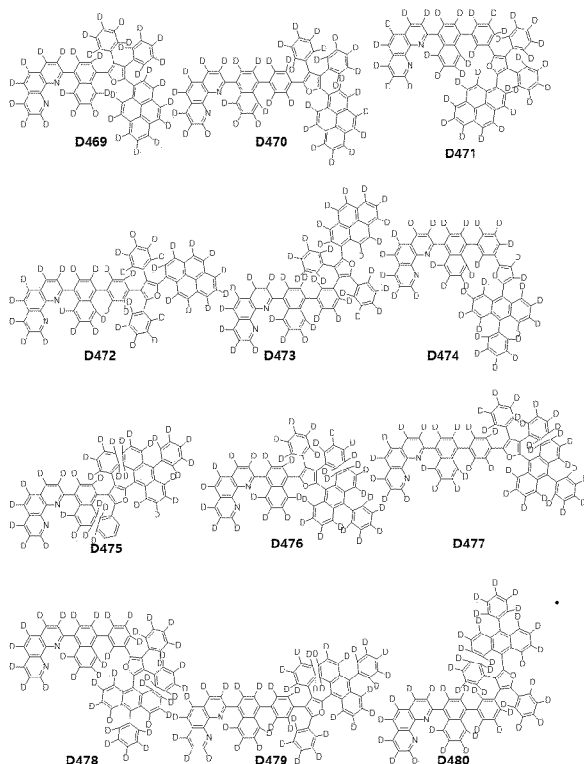












[Claim 5]

The organic light emitting diode according to claim 3, further comprising:

a second emitting part including a second emitting material layer and a second electron transporting layer and positioned between the first emitting part and the second electrode, the second electron transporting layer including a second electron transporting material and positioned between the second emitting material layer and the second electrode; and

a first n-type charge generation layer including a first n-type charge generation material and positioned between the first and second emitting parts.

[Claim 6]

The organic light emitting diode according to claim 5, wherein at least one of the second electron transporting material and the first n-type charge generation material is the organic compound of Formula 1.

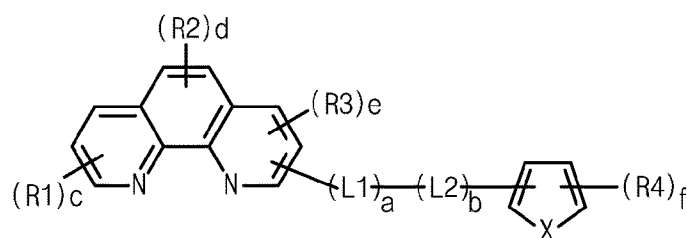
[Claim 7]

The organic light emitting diode according to claim 5, wherein the first emitting material layer emits a blue light, and the second emitting material layer emits a yellow-green light.

[Claim 8]

The organic light emitting diode according to claim 5, wherein the first emitting material layer emits a blue light, and the second emitting material layer includes a first layer emitting a red light and a second layer emitting a green light.

- [Claim 9] The organic light emitting diode according to claim 5, further comprising:
a third emitting part including a third emitting material layer and a third electron transporting layer and positioned between the second emitting part and the second electrode, the third electron transporting layer including a third electron transporting material and positioned between the third emitting material layer and the second electrode; and
a second n-type charge generation layer including a second n-type charge generation material and positioned between the second and third emitting parts.
- [Claim 10] The organic light emitting diode according to claim 9, wherein at least one of the second electron transporting material, the third electron transporting material, the first n-type charge generation material, and the second n-type charge generation material is the organic compound of Formula 1.
- [Claim 11] The organic light emitting diode according to claim 9, wherein each of the first and third emitting material layers emits a blue light, and the second emitting material layer emits a yellow-green light.
- [Claim 12] The organic light emitting diode according to claim 9, wherein each of the first and third emitting material layers emits a blue light, and the second emitting material layer includes a first layer emitting a red light and a second layer emitting a green light.
- [Claim 13] An organic light emitting diode, comprising:
a first electrode;
a second electrode facing the first electrode;
a first emitting part including a first emitting material layer and positioned between the first and second electrodes;
a second emitting part including a second emitting material layer and positioned between the first emitting part and the second electrode; and
a first n-type charge generation layer including a first n-type charge generation material and positioned between the first and second emitting parts,
wherein the first n-type charge generation material is an organic compound of Formula 1:
[Formula 1]



wherein X is oxygen (O) or sulfur (S), and each of R1 to R4 is independently selected from the group consisting of deuterium, halogen, cyano, C1 to C10 alkyl group, C1 to C10 alkoxy group, C3 to C30 cycloalkyl group, C6 to C30 aryl group, C6 to C30 arylamino group, and C5 to C30 heteroaryl group,

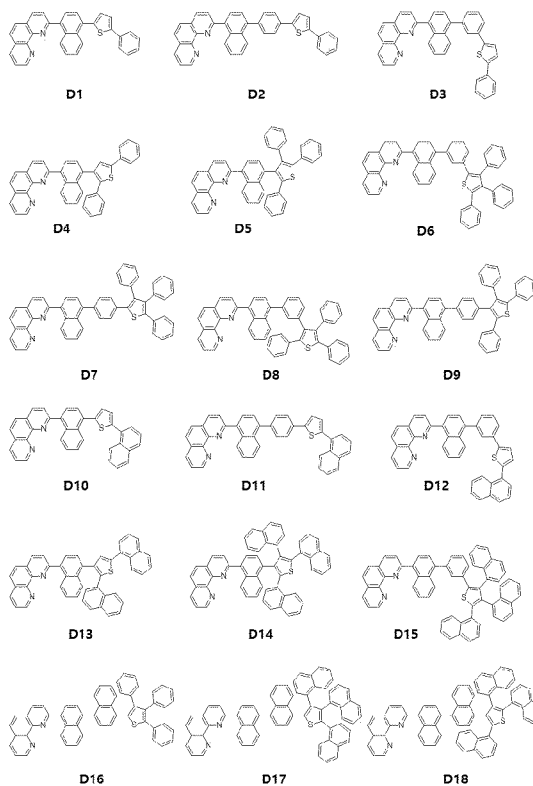
wherein each of L1 and L2 is independent selected from the group consisting of C6 to C30 arylene group and C5 to C30 heteroarylene group, and

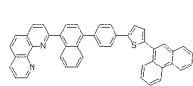
wherein each of a and b is independent 0 or 1, each of c and f is independently an integer of 0 to 3, and each of d and e is independently an integer of 0 to 2.

[Claim 14]

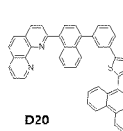
The organic light emitting diode according to claim 13, wherein the first compound is one of compounds in Formula 2:

[Formula 2]

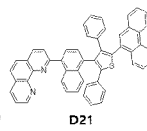




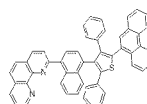
D19



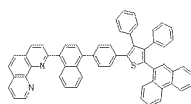
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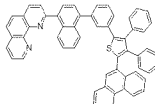
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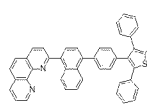
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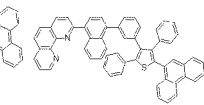
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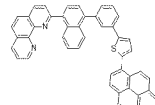
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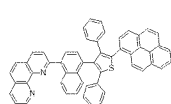
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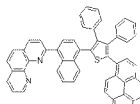
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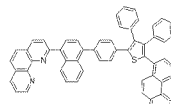
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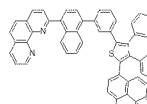
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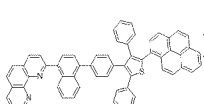
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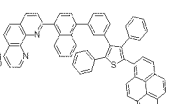
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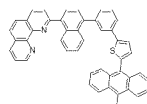
D31



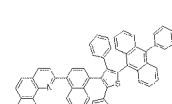
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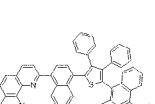
D33



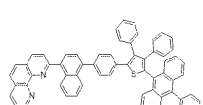
D34



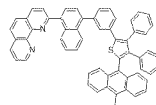
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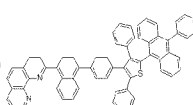
D36



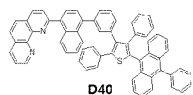
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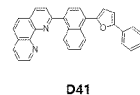
D38



D39



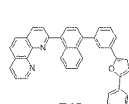
D40



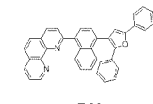
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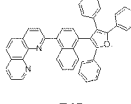
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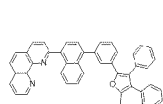
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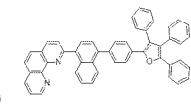
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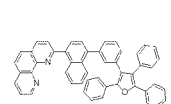
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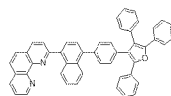
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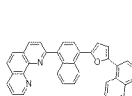
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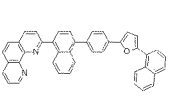
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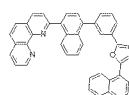
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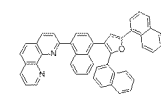
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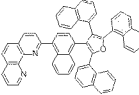
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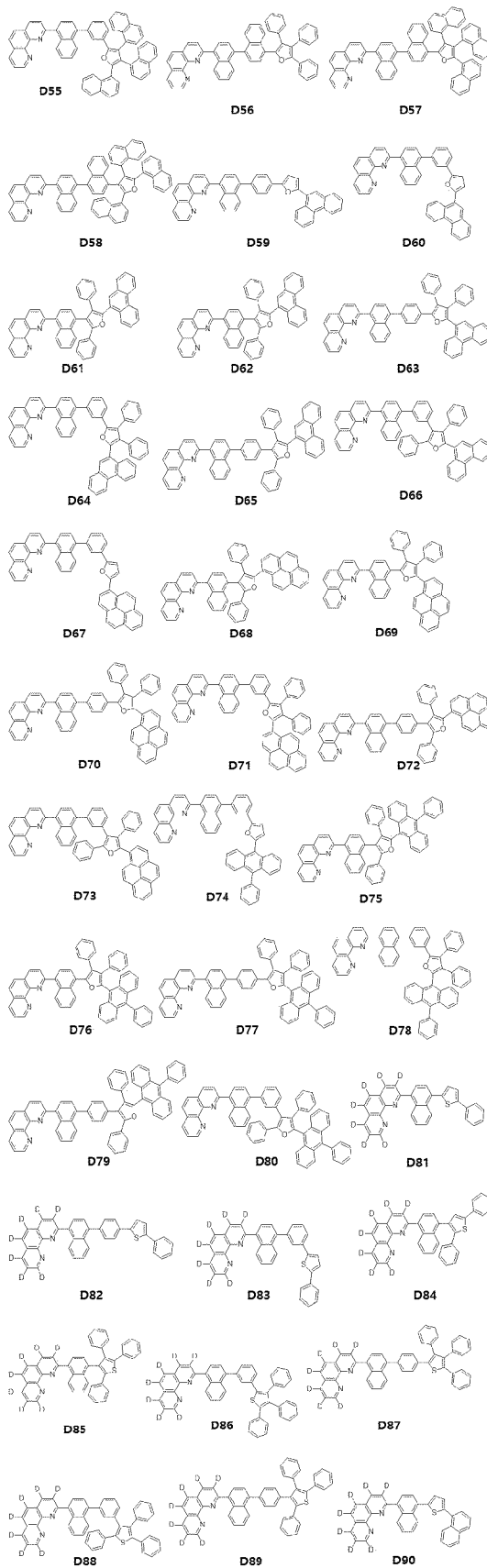
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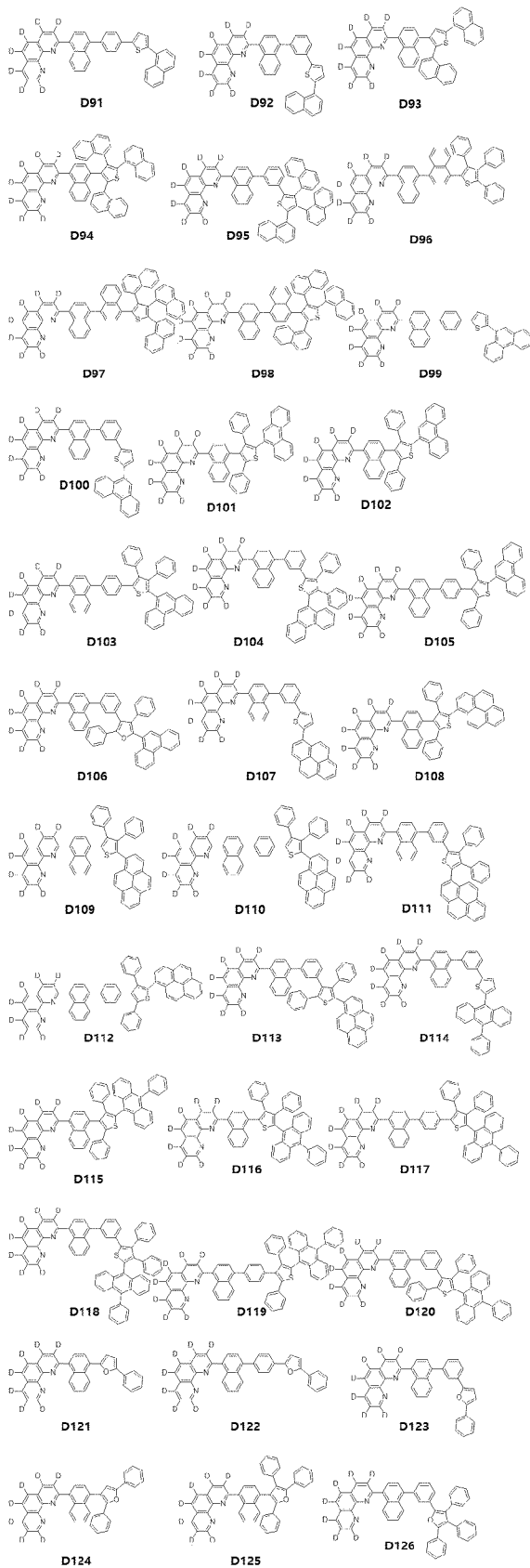


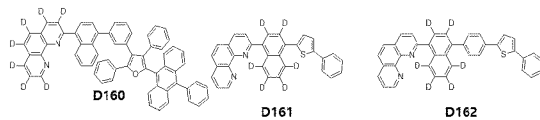
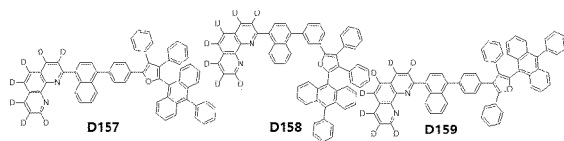
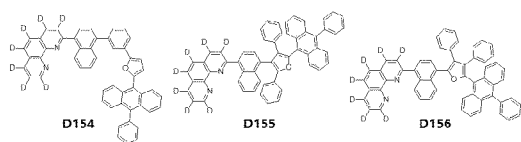
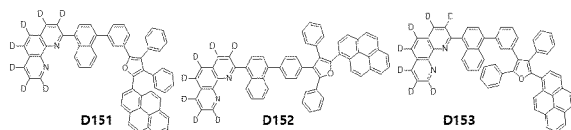
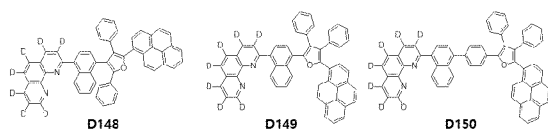
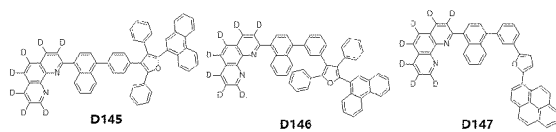
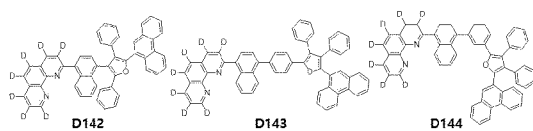
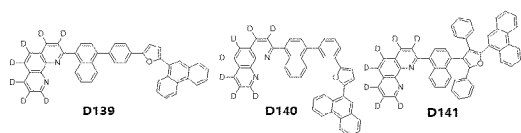
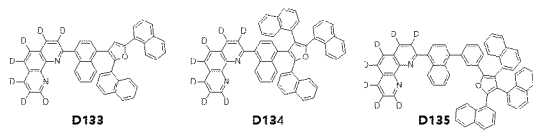
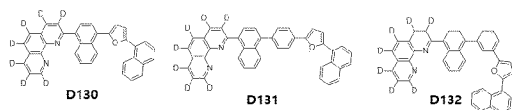
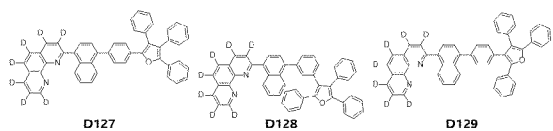
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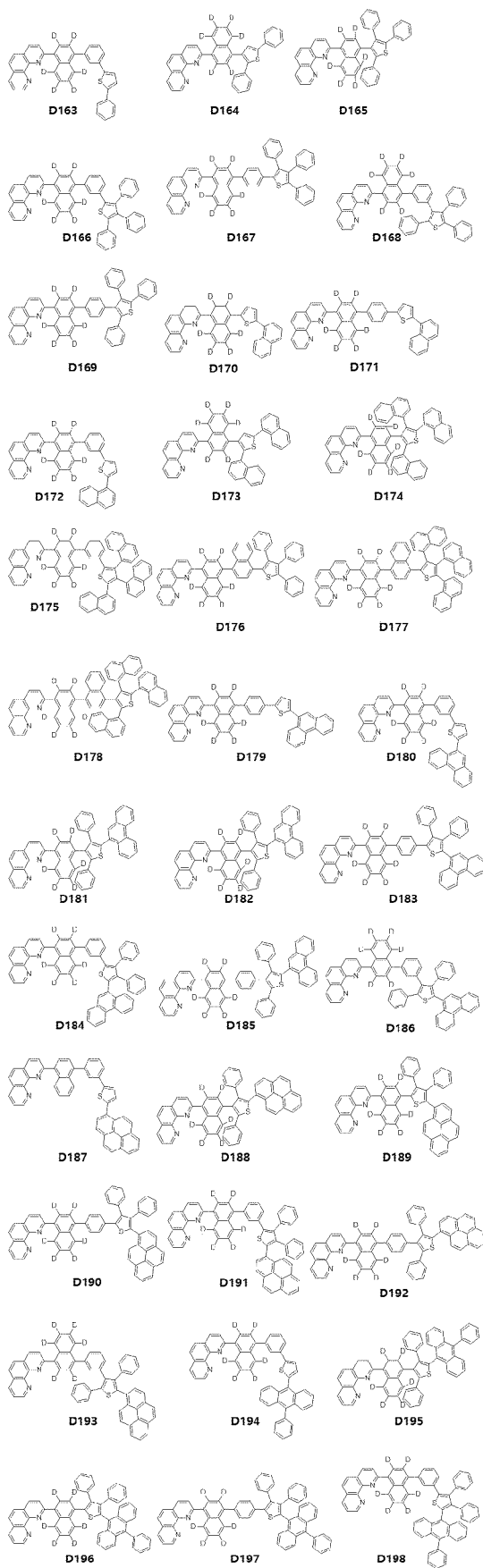


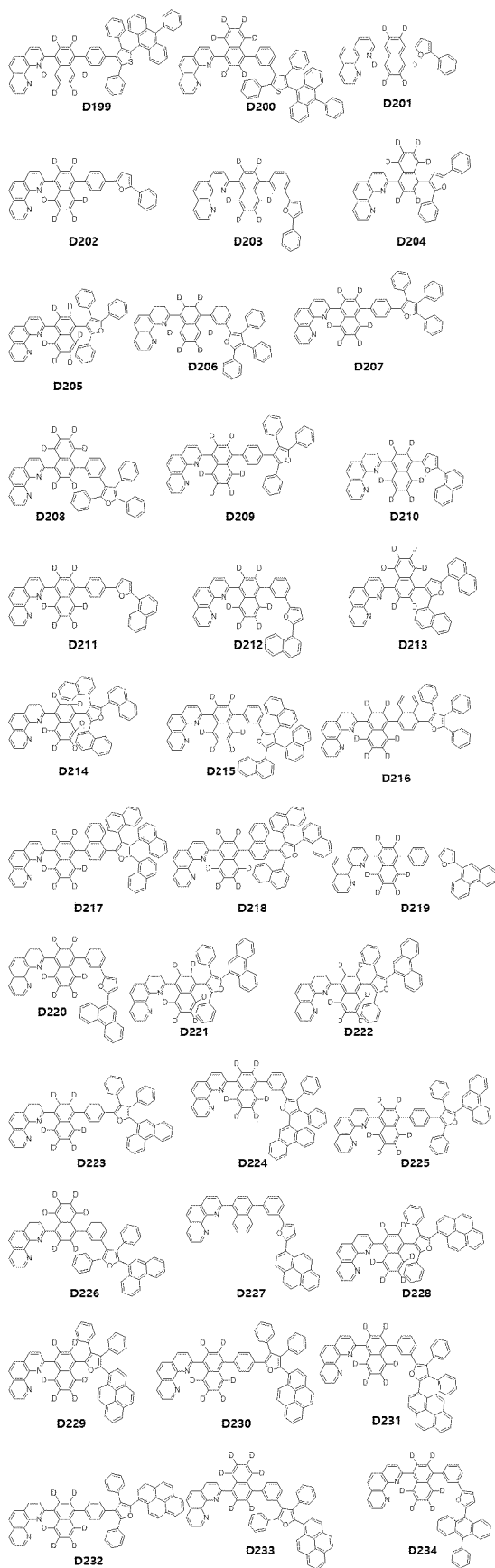
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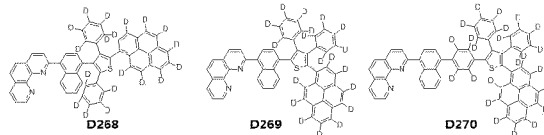


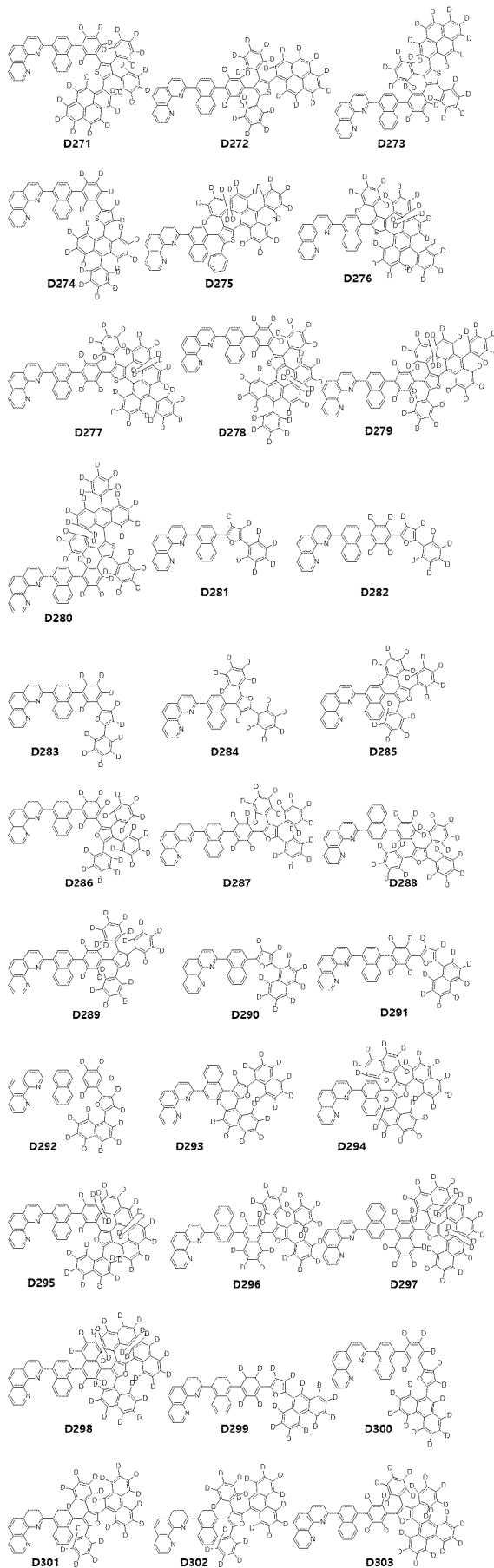


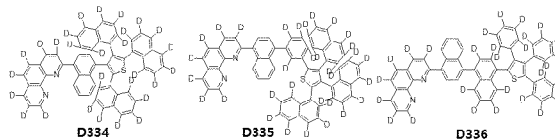
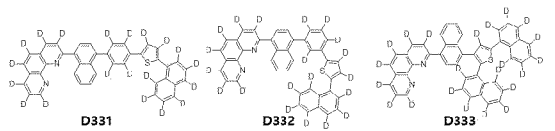
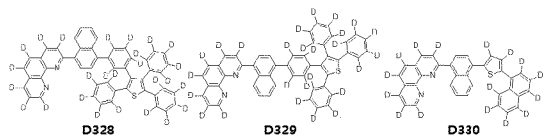
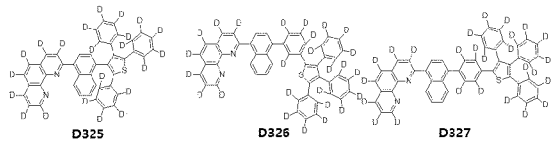
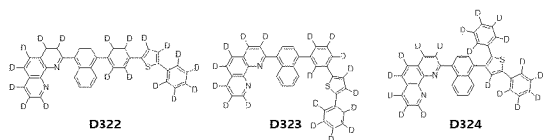
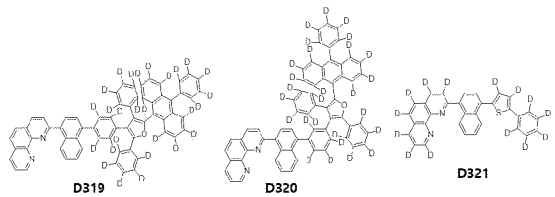
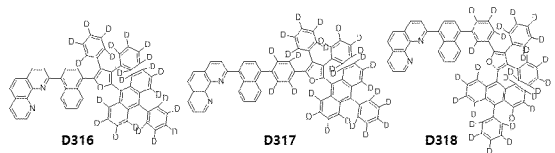
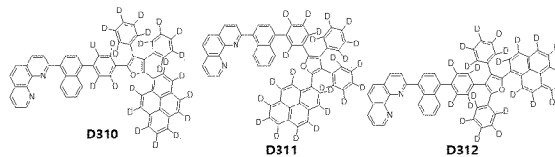
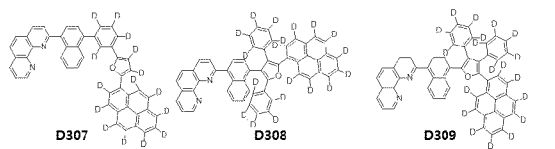
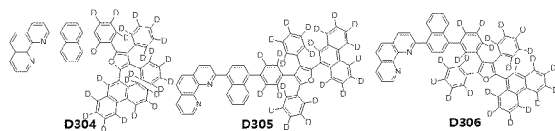


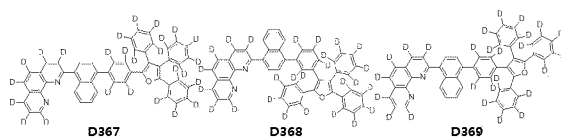
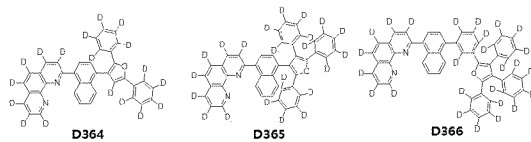
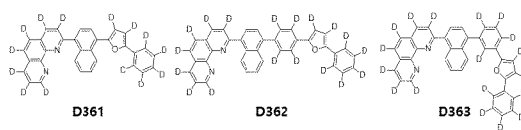
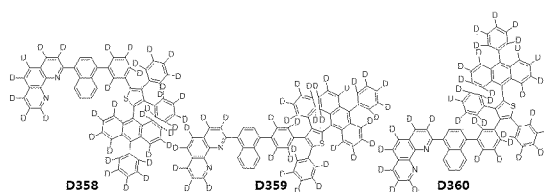
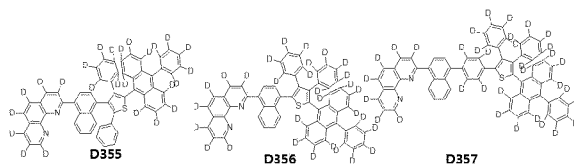
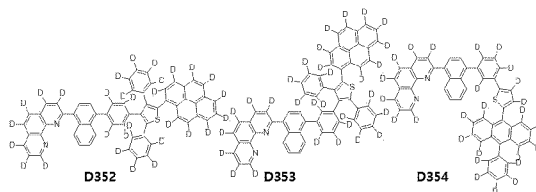
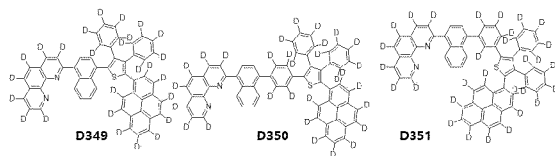
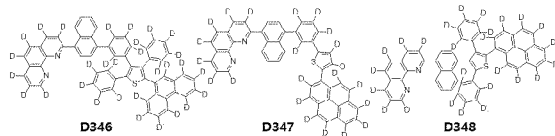
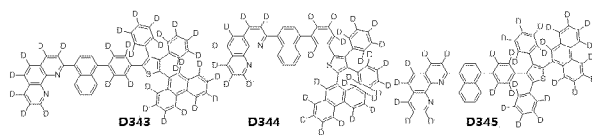
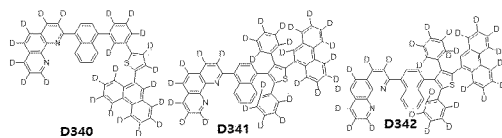
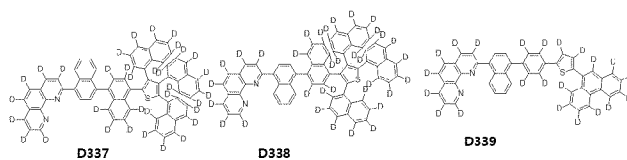


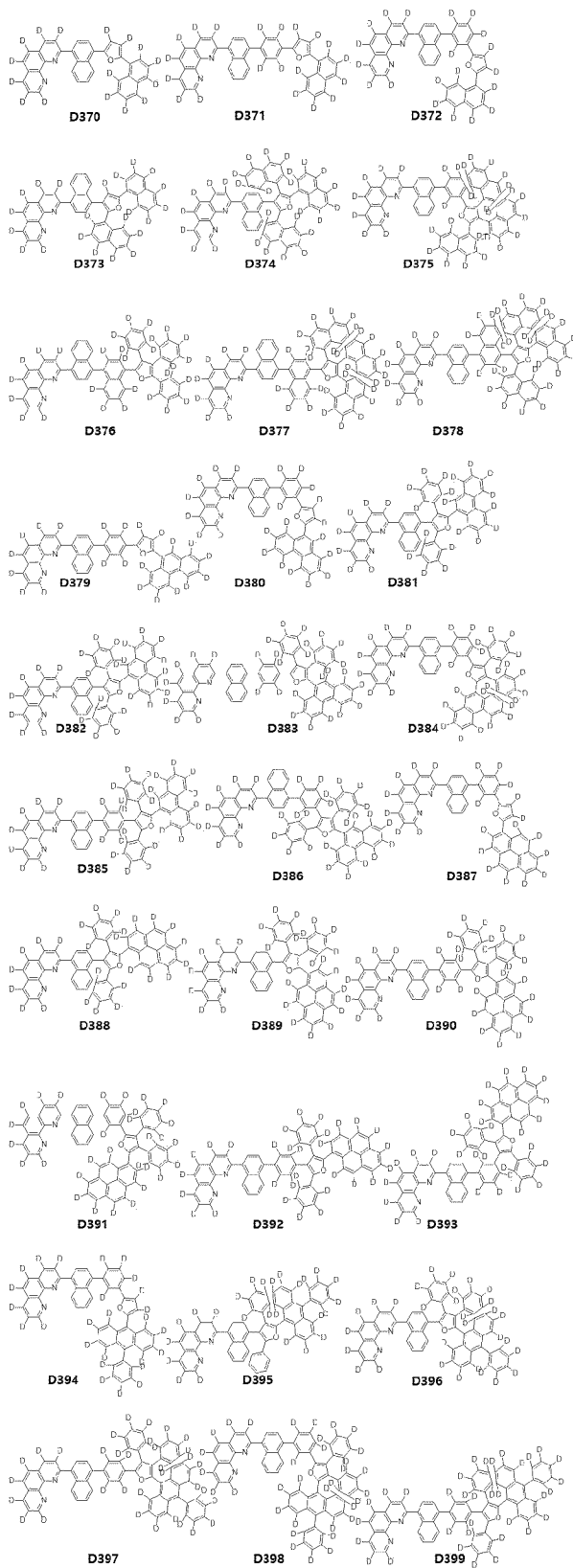


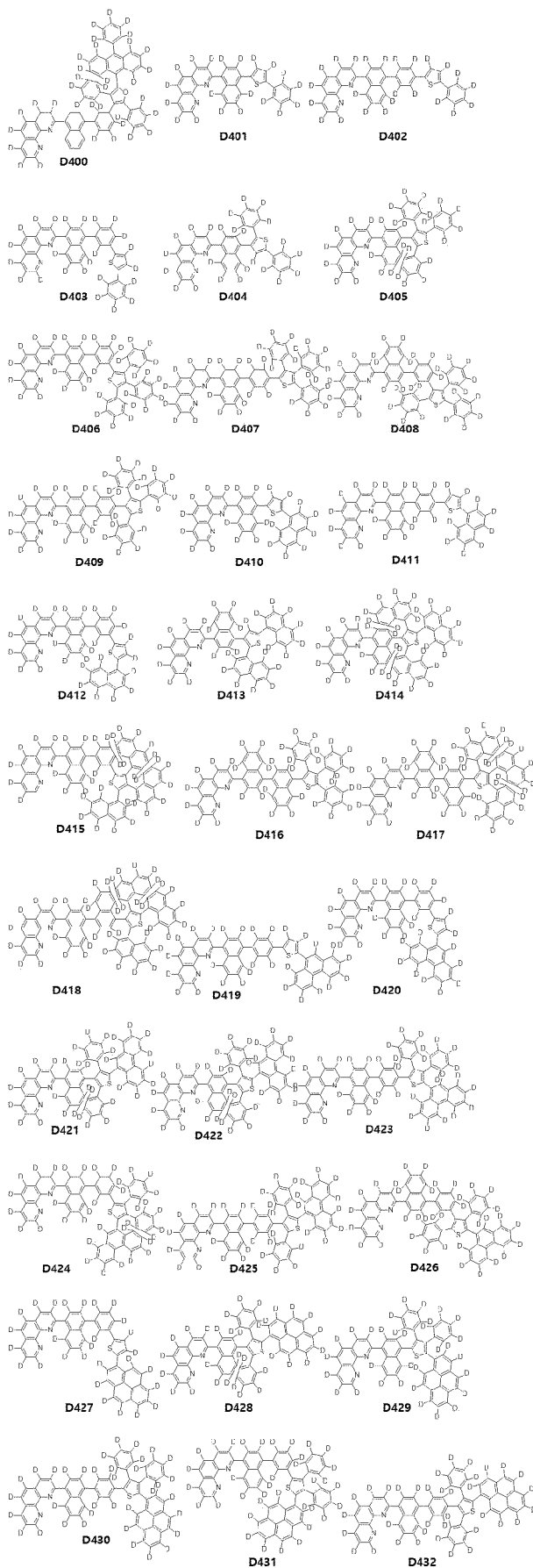


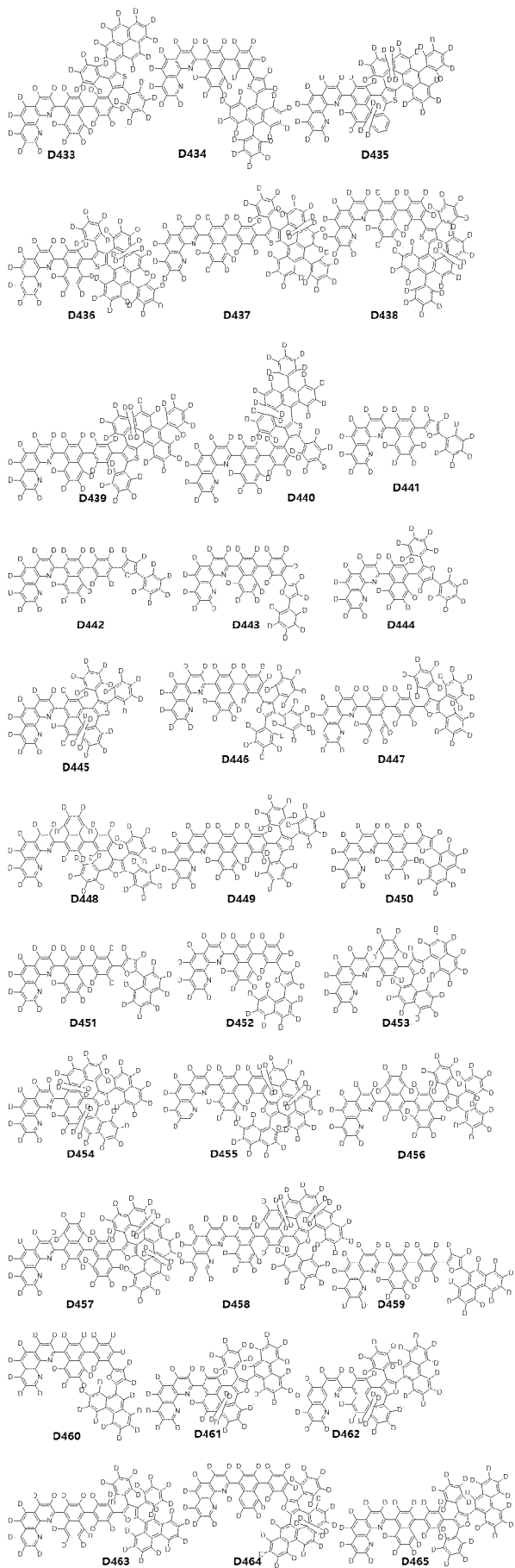


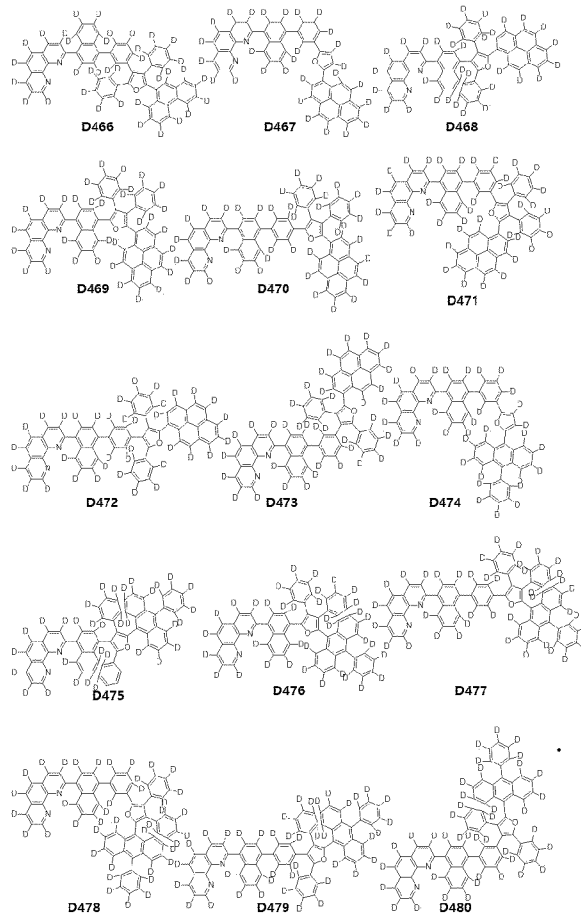












[Claim 15] The organic light emitting diode according to claim 14, wherein the first n-type charge generation layer further includes a metal or a p-type dopant.

[Claim 16] The organic light emitting diode according to claim 13, further comprising:
a third emitting part including a third emitting material layer and positioned between the second emitting part and the second electrode; and
a second n-type charge generation layer including a second n-type charge generation material and positioned between the second and third emitting parts.

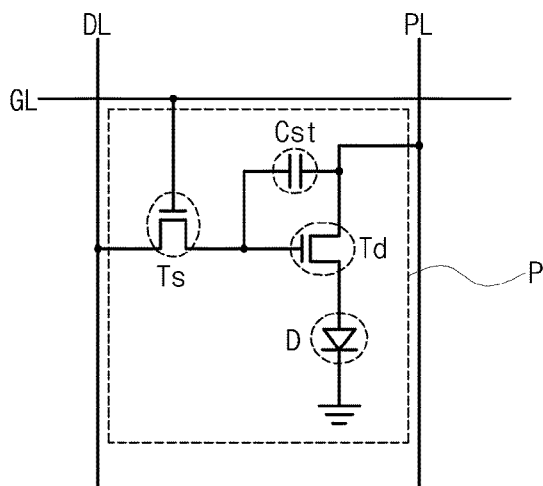
[Claim 17] The organic light emitting diode according to claim 16, wherein the second n-type charge generation material is the organic compound of Formula 1.

[Claim 18] An organic light emitting device, comprising:
a substrate;
an organic light emitting diode according to one of claims 3 to 17 over the substrate; and
an encapsulation film covering the organic light emitting diode.

[Claim 19]

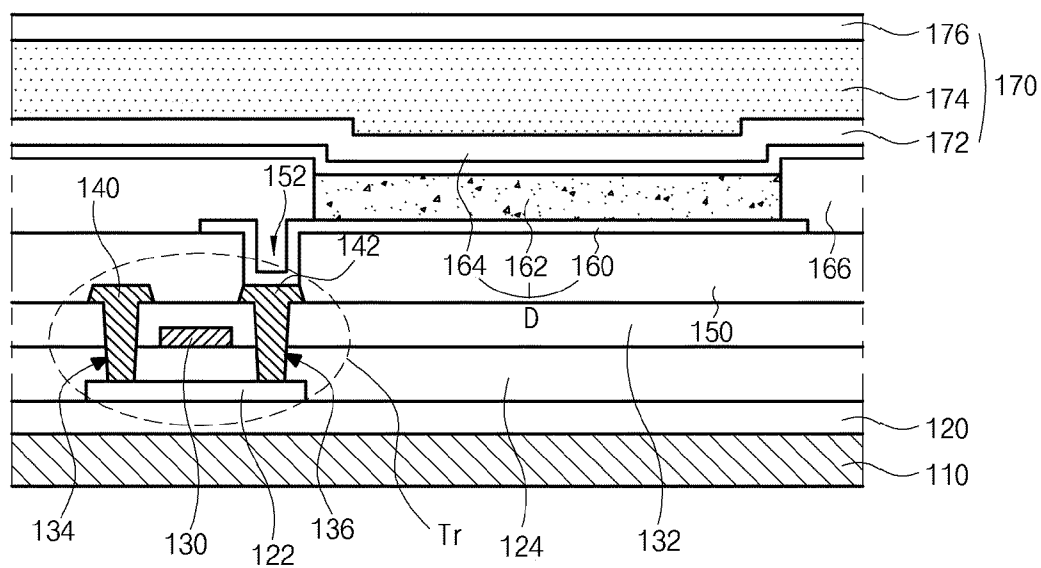
The organic light emitting device according to claim 18, wherein a red pixel region, a green pixel region and a blue pixel region are defined on the substrate, and the organic light emitting diode corresponds to each of the red, green and blue pixel regions, and
wherein the organic light emitting device further includes:
a color filter layer disposed between the substrate and the organic light emitting diode or on the organic light emitting diode and corresponding to the red, green and blue pixel regions.

[Fig. 1]



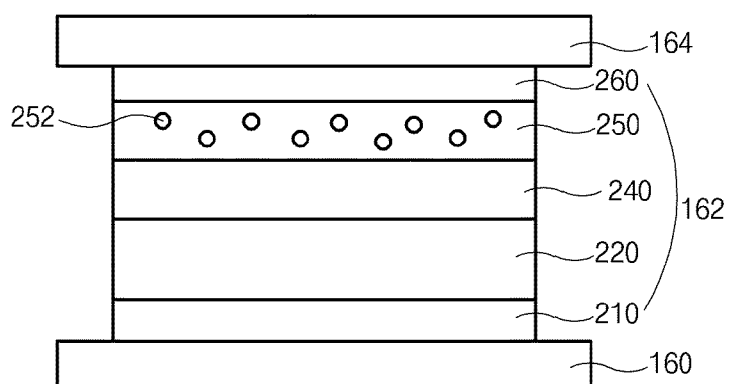
[Fig. 2]

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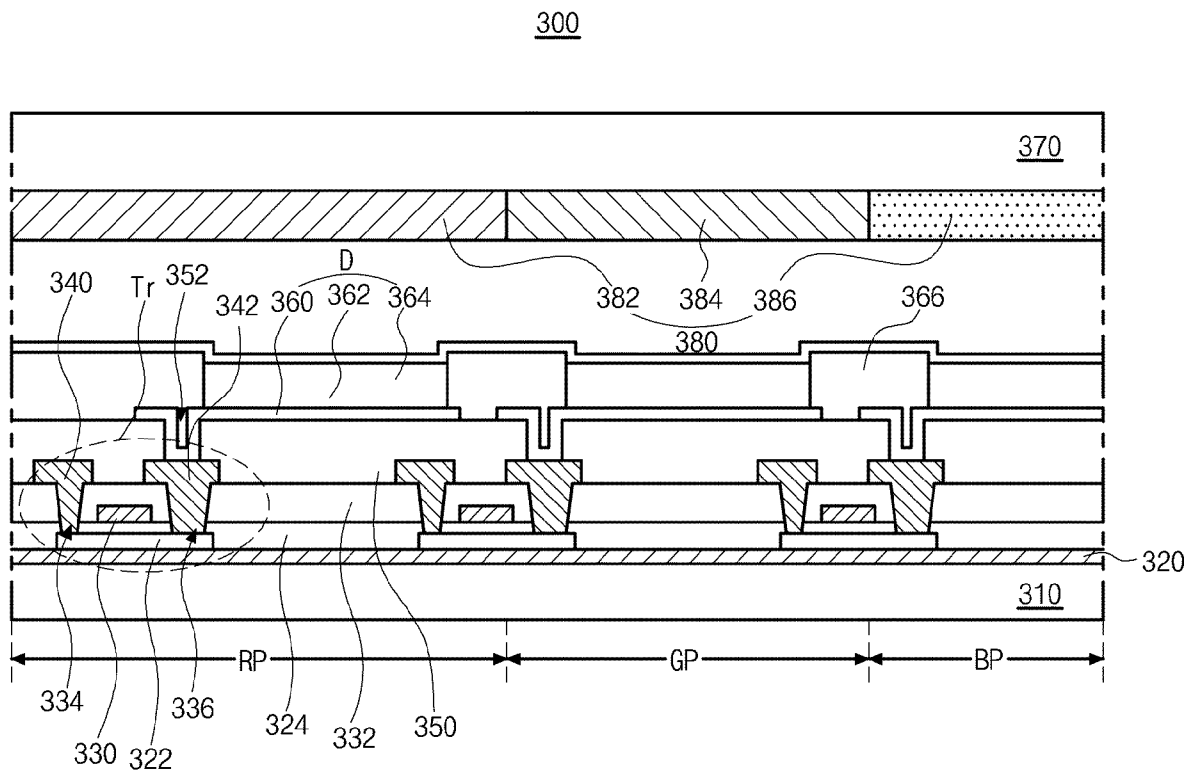


[Fig. 3]

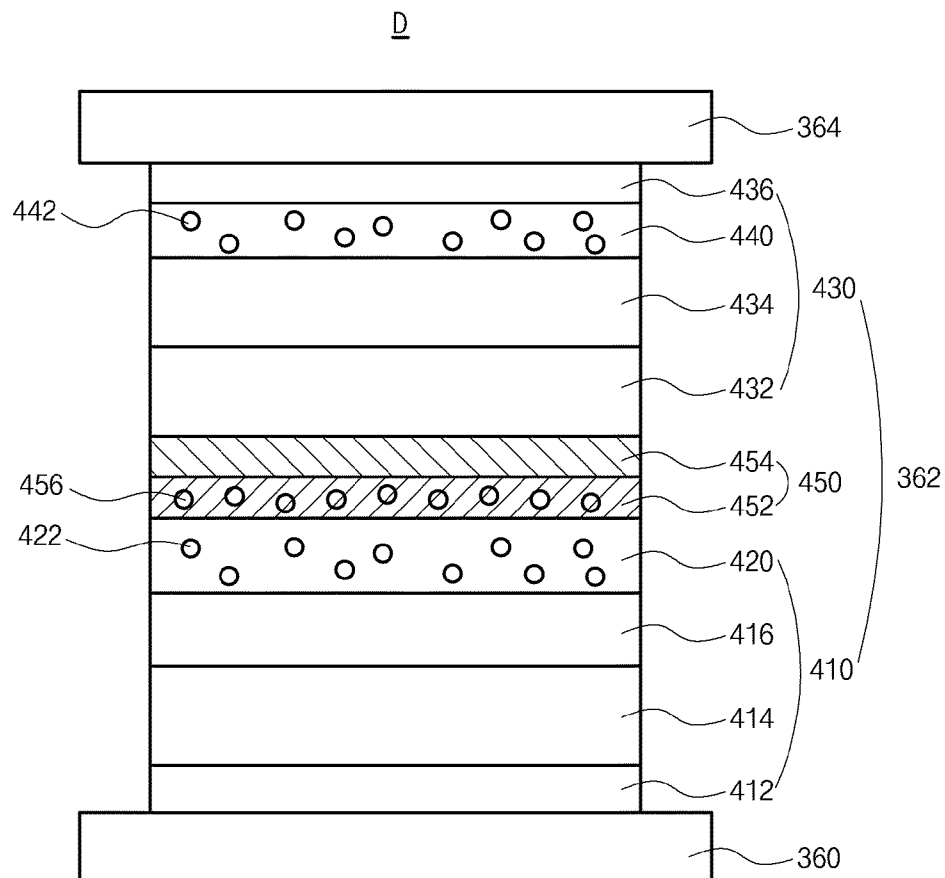
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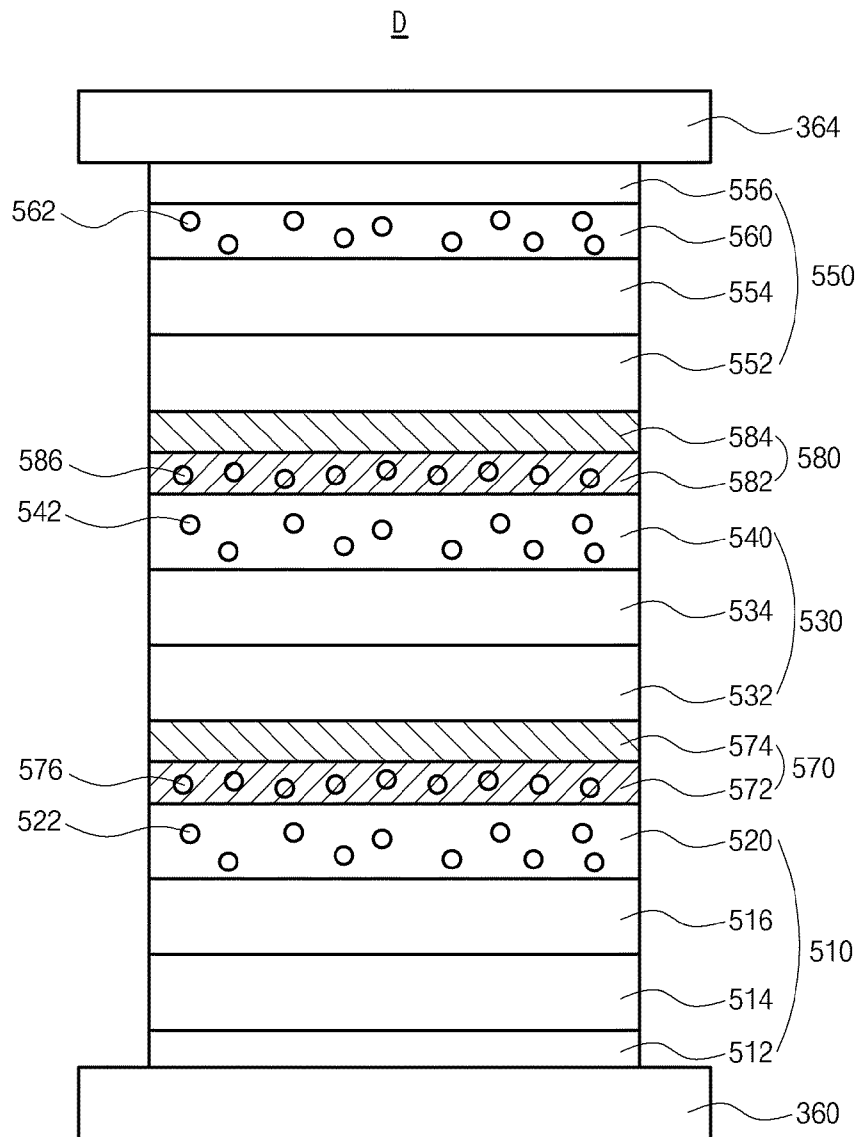
[Fig. 4]



[Fig. 5]



[Fig. 6]



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2021/010054

A. CLASSIFICATION OF SUBJECT MATTER**C07D 471/04**(2006.01)i; **H01L 51/00**(2006.01)i; **H01L 51/50**(2006.01)i; **H01L 51/52**(2006.01)i; **H01L 27/32**(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

C07D 471/04(2006.01); C07C 15/38(2006.01); C07D 519/00(2006.01); C09K 11/06(2006.01); H01L 51/00(2006.01); H01L 51/54(2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal), STN(Registry, CAplus) & Keywords: organic light emitting diode, organic light emitting device, phenanthroline, thiophene, furan

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2016-0018332 A (LG DISPLAY CO., LTD.) 17 February 2016 (2016-02-17) claims 1, 4, 11; paragraphs [0002], [0003], [0129], [0133], [0136], [0138]-[0143]; figure 2	1-19
X	KR 10-2017-0062629 A (LG DISPLAY CO., LTD.) 08 June 2017 (2017-06-08) claims 1, 8, 9 (page 7, 11th compound), 12; paragraphs [0161]-[0173]; figure 2	1-19
X	CN 102443003 A (SUZHOU NAKAI TECHNOLOGY CO., LTD.) 09 May 2012 (2012-05-09) abstract; claims 1 (compound 7), 8, 9	1-4, 18-19
X	US 2020-0203626 A1 (WUHAN TIANMA MICRO-ELECTRONICS CO., LTD.) 25 June 2020 (2020-06-25) claims 1, 10 (compound ET32), 12, 18	1-4, 18-19
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☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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“&” document member of the same patent family

Date of the actual completion of the international search

10 November 2021

Date of mailing of the international search report

10 November 2021

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2021/010054

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				CN	109608452	B	04 December 2020
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