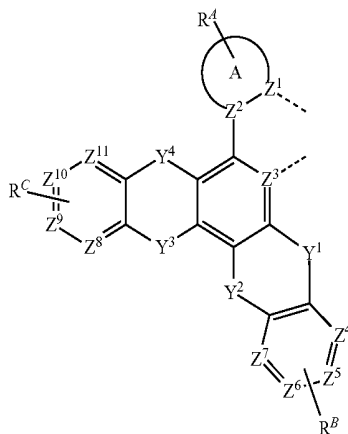




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(19) **United States**(12) **Patent Application Publication** (10) **Pub. No.: US 2018/0375035 A1**
Ji et al. (43) **Pub. Date: Dec. 27, 2018**(54) **ORGANIC ELECTROLUMINESCENT MATERIALS AND DEVICES**(57) **ABSTRACT**A compound comprising a first ligand L_A of Formula I(71) Applicant: **Universal Display Corporation**,
Ewing, NJ (US)

Formula I

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Jui-Yi Tsai, Newtown, PA (US)(73) Assignee: **Universal Display Corporation**,
Ewing, NJ (US)(21) Appl. No.: **16/009,455**(22) Filed: **Jun. 15, 2018****Related U.S. Application Data**

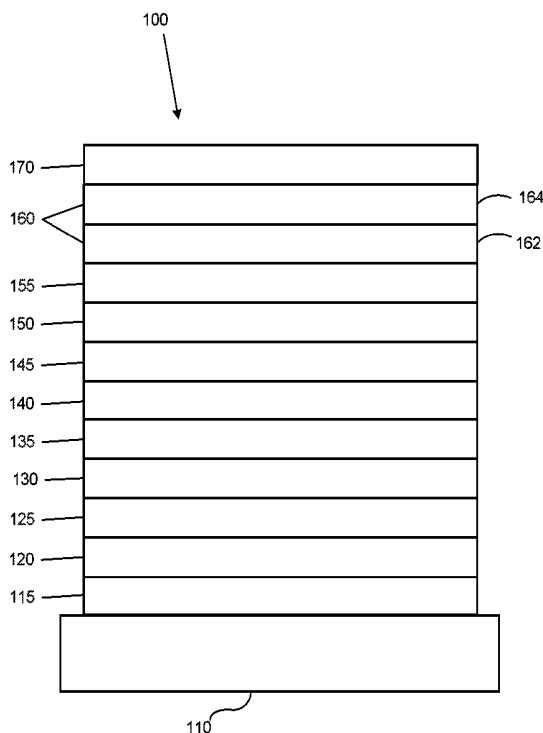
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is provided. In Formula I, A is a 5- or 6-membered aryl or heteroaryl ring; each of Z¹-Z¹¹ is either C or N; each of Y¹-Y⁴ is selected from a direct bond, BR, NR, PR, O, S, Se, C=O, S=O, SO₂, CRR', SiRR', and GeRR'; at least one of Y¹ and Y² is not a direct bond; at least one of Y³ and Y⁴ is not a direct bond; each R^A, R^B, R^C, R, and R' is independently hydrogen or a variety of substituents; any two adjacent substitutions in R^A, R^B and R^C can be joined or fused into a ring; ligand L_A is coordinated to a metal M; L_A is optionally linked with other ligands; and M is optionally coordinated to other ligands. Organic light emitting devices and consumer products containing the compounds are also disclosed.



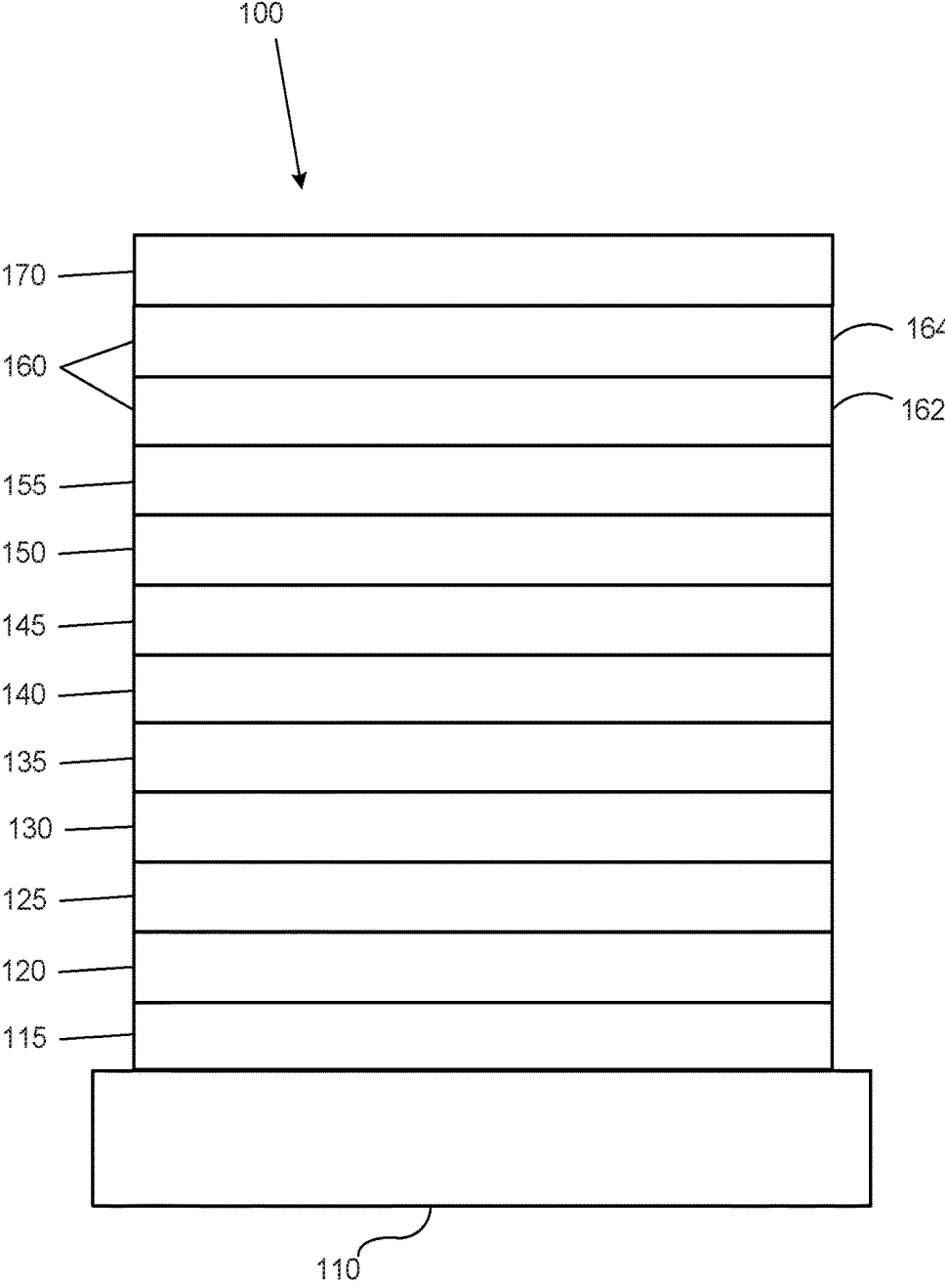


FIG. 1

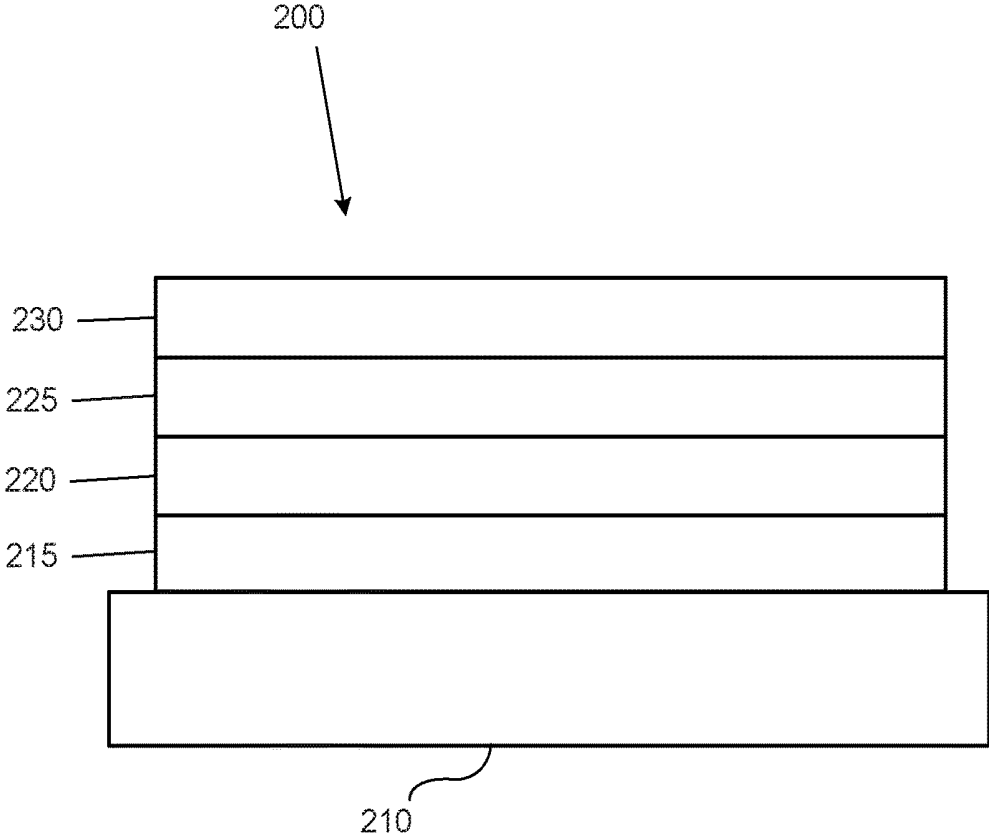
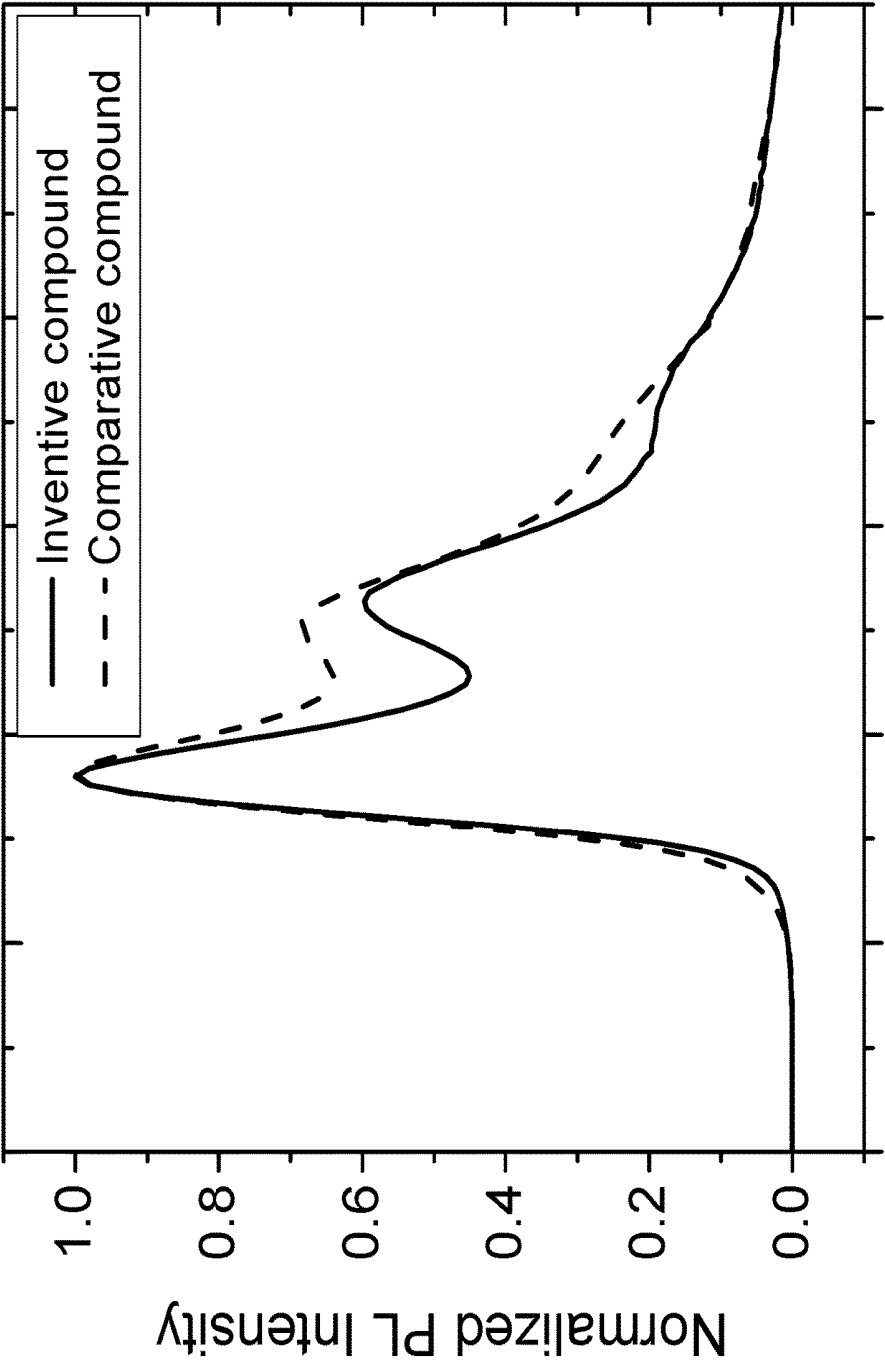


FIG. 2



Wavelength (nm)

FIG. 3

ORGANIC ELECTROLUMINESCENT MATERIALS AND DEVICES

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority under 35 U.S.C. § 119(e) to U.S. Provisional Application No. 62/524,071, filed Jun. 23, 2017, the entire contents of which are incorporated herein by reference.

FIELD

[0002] The present invention relates to compounds for use as emitters, and devices, such as organic light emitting diodes, including the same.

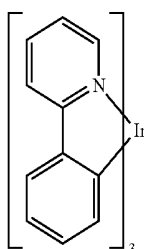
BACKGROUND

[0003] Opto-electronic devices that make use of organic materials are becoming increasingly desirable for a number of reasons. Many of the materials used to make such devices are relatively inexpensive, so organic opto-electronic devices have the potential for cost advantages over inorganic devices. In addition, the inherent properties of organic materials, such as their flexibility, may make them well suited for particular applications such as fabrication on a flexible substrate. Examples of organic opto-electronic devices include organic light emitting diodes/devices (OLEDs), organic phototransistors, organic photovoltaic cells, and organic photodetectors. For OLEDs, the organic materials may have performance advantages over conventional materials. For example, the wavelength at which an organic emissive layer emits light may generally be readily tuned with appropriate dopants.

[0004] OLEDs make use of thin organic films that emit light when voltage is applied across the device. OLEDs are becoming an increasingly interesting technology for use in applications such as flat panel displays, illumination, and backlighting. Several OLED materials and configurations are described in U.S. Pat. Nos. 5,844,363, 6,303,238, and 5,707,745, which are incorporated herein by reference in their entirety.

[0005] One application for phosphorescent emissive molecules is a full color display. Industry standards for such a display call for pixels adapted to emit particular colors, referred to as “saturated” colors. In particular, these standards call for saturated red, green, and blue pixels. Alternatively the OLED can be designed to emit white light. In conventional liquid crystal displays emission from a white backlight is filtered using absorption filters to produce red, green and blue emission. The same technique can also be used with OLEDs. The white OLED can be either a single EML device or a stack structure. Color may be measured using CIE coordinates, which are well known to the art.

[0006] One example of a green emissive molecule is tris(2-phenylpyridine) iridium, denoted Ir(ppy)₃, which has the following structure:



[0007] In this, and later figures herein, we depict the dative bond from nitrogen to metal (here, Ir) as a straight line.

[0008] As used herein, the term “organic” includes polymeric materials as well as small molecule organic materials that may be used to fabricate organic opto-electronic devices. “Small molecule” refers to any organic material that is not a polymer, and “small molecules” may actually be quite large. Small molecules may include repeat units in some circumstances. For example, using a long chain alkyl group as a substituent does not remove a molecule from the “small molecule” class. Small molecules may also be incorporated into polymers, for example as a pendant group on a polymer backbone or as a part of the backbone. Small molecules may also serve as the core moiety of a dendrimer, which consists of a series of chemical shells built on the core moiety. The core moiety of a dendrimer may be a fluorescent or phosphorescent small molecule emitter. A dendrimer may be a “small molecule,” and it is believed that all dendrimers currently used in the field of OLEDs are small molecules.

[0009] As used herein, “top” means furthest away from the substrate, while “bottom” means closest to the substrate. Where a first layer is described as “disposed over” a second layer, the first layer is disposed further away from substrate. There may be other layers between the first and second layer, unless it is specified that the first layer is “in contact with” the second layer. For example, a cathode may be described as “disposed over” an anode, even though there are various organic layers in between.

[0010] As used herein, “solution processible” means capable of being dissolved, dispersed, or transported in and/or deposited from a liquid medium, either in solution or suspension form.

[0011] A ligand may be referred to as “photoactive” when it is believed that the ligand directly contributes to the photoactive properties of an emissive material. A ligand may be referred to as “ancillary” when it is believed that the ligand does not contribute to the photoactive properties of an emissive material, although an ancillary ligand may alter the properties of a photoactive ligand.

[0012] As used herein, and as would be generally understood by one skilled in the art, a first “Highest Occupied Molecular Orbital” (HOMO) or “Lowest Unoccupied Molecular Orbital” (LUMO) energy level is “greater than” or “higher than” a second HOMO or LUMO energy level if the first energy level is closer to the vacuum energy level. Since ionization potentials (IP) are measured as a negative energy relative to a vacuum level, a higher HOMO energy level corresponds to an IP having a smaller absolute value (an IP that is less negative). Similarly, a higher LUMO energy level corresponds to an electron affinity (EA) having a smaller absolute value (an EA that is less negative). On a conventional energy level diagram, with the vacuum level at the top, the LUMO energy level of a material is higher than the HOMO energy level of the same material. A “higher” HOMO or LUMO energy level appears closer to the top of such a diagram than a “lower” HOMO or LUMO energy level.

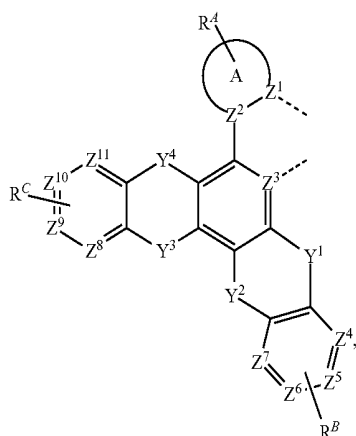
[0013] As used herein, and as would be generally understood by one skilled in the art, a first work function is “greater than” or “higher than” a second work function if the first work function has a higher absolute value. Because work functions are generally measured as negative numbers relative to vacuum level, this means that a “higher” work function is more negative. On a conventional energy level

diagram, with the vacuum level at the top, a “higher” work function is illustrated as further away from the vacuum level in the downward direction. Thus, the definitions of HOMO and LUMO energy levels follow a different convention than work functions.

[0014] More details on OLEDs, and the definitions described above, can be found in U.S. Pat. No. 7,279,704, which is incorporated herein by reference in its entirety.

SUMMARY

[0015] According to an aspect of the present disclosure, a metal-containing compound comprising a first ligand L_A of Formula I



Formula I

is provided. In these structures:

[0016] A is a 5- or 6-membered aryl or heteroaryl ring;

[0017] R^A , R^B , and R^C each represent mono to a maximum possible number of substitutions, or no substitution;

[0018] Z^1 - Z^{11} are each independently selected from the group consisting of C and N;

[0019] Y^1 , Y^2 , Y^3 , and Y^4 are each independently selected from the group consisting of a direct bond, BR, NR, PR, O, S, Se, C=O, S=O, SO₂, CRR', SiRR', and GeRR';

[0020] at least one of Y^1 and Y^2 is not a direct bond;

[0021] at least one of Y^3 and Y^4 is not a direct bond;

[0022] R^A , R^B , R^C , R, and R' are each independently selected from the group consisting of hydrogen, deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof;

[0023] any two adjacent substitutions in R^A , R^B and R^C are optionally joined or fused into a ring;

[0024] the ligand L_A is coordinated to a metal M;

[0025] L_A is optionally linked with other ligands to comprise a tridentate, tetradentate, pentadentate, or hexadentate ligand; and

[0026] M is optionally coordinated to other ligands.

[0027] According to another aspect of the present disclosure, an organic light emitting device (OLED) is provided. The OLED can include an anode; a cathode; and an organic layer, disposed between the anode and the cathode, where

the organic layer includes a compound comprising a first ligand L_A having the structure of Formula I as described herein.

[0028] A consumer product comprising the OLED is also disclosed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] FIG. 1 shows an organic light emitting device.

[0030] FIG. 2 shows an inverted organic light emitting device that does not have a separate electron transport layer.

[0031] FIG. 3 shows a normalized PL spectra of the a compound as disclosed herein and a comparative compound.

DETAILED DESCRIPTION

[0032] Generally, an OLED comprises at least one organic layer disposed between and electrically connected to an anode and a cathode. When a current is applied, the anode injects holes and the cathode injects electrons into the organic layer(s). The injected holes and electrons each migrate toward the oppositely charged electrode. When an electron and hole localize on the same molecule, an “exciton,” which is a localized electron-hole pair having an excited energy state, is formed. Light is emitted when the exciton relaxes via a photoemissive mechanism. In some cases, the exciton may be localized on an excimer or an exciplex. Non-radiative mechanisms, such as thermal relaxation, may also occur, but are generally considered undesirable.

[0033] The initial OLEDs used emissive molecules that emitted light from their singlet states (“fluorescence”) as disclosed, for example, in U.S. Pat. No. 4,769,292, which is incorporated by reference in its entirety. Fluorescent emission generally occurs in a time frame of less than 10 nanoseconds.

[0034] More recently, OLEDs having emissive materials that emit light from triplet states (“phosphorescence”) have been demonstrated. Baldo et al., “Highly Efficient Phosphorescent Emission from Organic Electroluminescent Devices,” Nature, vol. 395, 151-154, 1998; (“Baldo-I”) and Baldo et al., “Very high-efficiency green organic light-emitting devices based on electrophosphorescence,” Appl. Phys. Lett., vol. 75, No. 3, 4-6 (1999) (“Baldo-II”), are incorporated by reference in their entireties. Phosphorescence is described in more detail in U.S. Pat. No. 7,279,704 at cols. 5-6, which are incorporated by reference.

[0035] FIG. 1 shows an organic light emitting device 100. The figures are not necessarily drawn to scale. Device 100 may include a substrate 110, an anode 115, a hole injection layer 120, a hole transport layer 125, an electron blocking layer 130, an emissive layer 135, a hole blocking layer 140, an electron transport layer 145, an electron injection layer 150, a protective layer 155, a cathode 160, and a barrier layer 170. Cathode 160 is a compound cathode having a first conductive layer 162 and a second conductive layer 164. Device 100 may be fabricated by depositing the layers described, in order. The properties and functions of these various layers, as well as example materials, are described in more detail in U.S. Pat. No. 7,279,704 at cols. 6-10, which are incorporated by reference.

[0036] More examples for each of these layers are available. For example, a flexible and transparent substrate-anode combination is disclosed in U.S. Pat. No. 5,844,363, which is incorporated by reference in its entirety. An example of a

p-doped hole transport layer is m-MTDATA doped with F₄-TCNQ at a molar ratio of 50:1, as disclosed in U.S. Patent Application Publication No. 2003/0230980, which is incorporated by reference in its entirety. Examples of emissive and host materials are disclosed in U.S. Pat. No. 6,303,238 to Thompson et al., which is incorporated by reference in its entirety. An example of an n-doped electron transport layer is BPhen doped with Li at a molar ratio of 1:1, as disclosed in U.S. Patent Application Publication No. 2003/0230980, which is incorporated by reference in its entirety. U.S. Pat. Nos. 5,703,436 and 5,707,745, which are incorporated by reference in their entireties, disclose examples of cathodes including compound cathodes having a thin layer of metal such as Mg:Ag with an overlying transparent, electrically-conductive, sputter-deposited ITO layer. The theory and use of blocking layers is described in more detail in U.S. Pat. No. 6,097,147 and U.S. Patent Application Publication No. 2003/0230980, which are incorporated by reference in their entireties. Examples of injection layers are provided in U.S. Patent Application Publication No. 2004/0174116, which is incorporated by reference in its entirety. A description of protective layers may be found in U.S. Patent Application Publication No. 2004/0174116, which is incorporated by reference in its entirety.

[0037] FIG. 2 shows an inverted OLED 200. The device includes a substrate 210, a cathode 215, an emissive layer 220, a hole transport layer 225, and an anode 230. Device 200 may be fabricated by depositing the layers described, in order. Because the most common OLED configuration has a cathode disposed over the anode, and device 200 has cathode 215 disposed under anode 230, device 200 may be referred to as an "inverted" OLED. Materials similar to those described with respect to device 100 may be used in the corresponding layers of device 200. FIG. 2 provides one example of how some layers may be omitted from the structure of device 100.

[0038] The simple layered structure illustrated in FIGS. 1 and 2 is provided by way of non-limiting example, and it is understood that embodiments of the invention may be used in connection with a wide variety of other structures. The specific materials and structures described are exemplary in nature, and other materials and structures may be used. Functional OLEDs may be achieved by combining the various layers described in different ways, or layers may be omitted entirely, based on design, performance, and cost factors. Other layers not specifically described may also be included. Materials other than those specifically described may be used. Although many of the examples provided herein describe various layers as comprising a single material, it is understood that combinations of materials, such as a mixture of host and dopant, or more generally a mixture, may be used. Also, the layers may have various sublayers. The names given to the various layers herein are not intended to be strictly limiting. For example, in device 200, hole transport layer 225 transports holes and injects holes into emissive layer 220, and may be described as a hole transport layer or a hole injection layer. In one embodiment, an OLED may be described as having an "organic layer" disposed between a cathode and an anode. This organic layer may comprise a single layer, or may further comprise multiple layers of different organic materials as described, for example, with respect to FIGS. 1 and 2.

[0039] Structures and materials not specifically described may also be used, such as OLEDs comprised of polymeric

materials (PLEDs) such as disclosed in U.S. Pat. No. 5,247,190 to Friend et al., which is incorporated by reference in its entirety. By way of further example, OLEDs having a single organic layer may be used. OLEDs may be stacked, for example as described in U.S. Pat. No. 5,707,745 to Forrest et al, which is incorporated by reference in its entirety. The OLED structure may deviate from the simple layered structure illustrated in FIGS. 1 and 2. For example, the substrate may include an angled reflective surface to improve out-coupling, such as a mesa structure as described in U.S. Pat. No. 6,091,195 to Forrest et al., and/or a pit structure as described in U.S. Pat. No. 5,834,893 to Bulovic et al., which are incorporated by reference in their entireties.

[0040] Unless otherwise specified, any of the layers of the various embodiments may be deposited by any suitable method. For the organic layers, preferred methods include thermal evaporation, ink-jet, such as described in U.S. Pat. Nos. 6,013,982 and 6,087,196, which are incorporated by reference in their entireties, organic vapor phase deposition (OVDP), such as described in U.S. Pat. No. 6,337,102 to Forrest et al., which is incorporated by reference in its entirety, and deposition by organic vapor jet printing (OVJP), such as described in U.S. Pat. No. 7,431,968, which is incorporated by reference in its entirety. Other suitable deposition methods include spin coating and other solution based processes. Solution based processes are preferably carried out in nitrogen or an inert atmosphere. For the other layers, preferred methods include thermal evaporation. Preferred patterning methods include deposition through a mask, cold welding such as described in U.S. Pat. Nos. 6,294,398 and 6,468,819, which are incorporated by reference in their entireties, and patterning associated with some of the deposition methods such as ink-jet and organic vapor jet printing (OVJP). Other methods may also be used. The materials to be deposited may be modified to make them compatible with a particular deposition method. For example, substituents such as alkyl and aryl groups, branched or unbranched, and preferably containing at least 3 carbons, may be used in small molecules to enhance their ability to undergo solution processing. Substituents having 20 carbons or more may be used, and 3-20 carbons is a preferred range. Materials with asymmetric structures may have better solution processibility than those having symmetric structures, because asymmetric materials may have a lower tendency to recrystallize. Dendrimer substituents may be used to enhance the ability of small molecules to undergo solution processing.

[0041] Devices fabricated in accordance with embodiments of the present invention may further optionally comprise a barrier layer. One purpose of the barrier layer is to protect the electrodes and organic layers from damaging exposure to harmful species in the environment including moisture, vapor and/or gases, etc. The barrier layer may be deposited over, under or next to a substrate, an electrode, or over any other parts of a device including an edge. The barrier layer may comprise a single layer, or multiple layers. The barrier layer may be formed by various known chemical vapor deposition techniques and may include compositions having a single phase as well as compositions having multiple phases. Any suitable material or combination of materials may be used for the barrier layer. The barrier layer may incorporate an inorganic or an organic compound or both. The preferred barrier layer comprises a mixture of a polymeric material and a non-polymeric material as

described in U.S. Pat. No. 7,968,146, PCT Pat. Application Nos. PCT/US2007/023098 and PCT/US2009/042829, which are herein incorporated by reference in their entireties. To be considered a “mixture”, the aforesaid polymeric and non-polymeric materials comprising the barrier layer should be deposited under the same reaction conditions and/or at the same time. The weight ratio of polymeric to non-polymeric material may be in the range of 95:5 to 5:95. The polymeric material and the non-polymeric material may be created from the same precursor material. In one example, the mixture of a polymeric material and a non-polymeric material consists essentially of polymeric silicon and inorganic silicon.

[0042] Devices fabricated in accordance with embodiments of the invention can be incorporated into a wide variety of electronic component modules (or units) that can be incorporated into a variety of electronic products or intermediate components. Examples of such electronic products or intermediate components include display screens, lighting devices such as discrete light source devices or lighting panels, etc. that can be utilized by the end-user product manufacturers. Such electronic component modules can optionally include the driving electronics and/or power source(s). Devices fabricated in accordance with embodiments of the invention can be incorporated into a wide variety of consumer products that have one or more of the electronic component modules (or units) incorporated therein. A consumer product comprising an OLED that includes the compound of the present disclosure in the organic layer in the OLED is disclosed. Such consumer products would include any kind of products that include one or more light source(s) and/or one or more of some type of visual displays. Some examples of such consumer products include flat panel displays, curved displays, computer monitors, medical monitors, televisions, billboards, lights for interior or exterior illumination and/or signaling, heads-up displays, fully or partially transparent displays, flexible displays, rollable displays, foldable displays, stretchable displays, laser printers, telephones, mobile phones, tablets, phablets, personal digital assistants (PDAs), wearable devices, laptop computers, digital cameras, camcorders, viewfinders, micro-displays (displays that are less than 2 inches diagonal), 3-D displays, virtual reality or augmented reality displays, vehicles, video walls comprising multiple displays tiled together, theater or stadium screen, and a sign. Various control mechanisms may be used to control devices fabricated in accordance with the present invention, including passive matrix and active matrix. Many of the devices are intended for use in a temperature range comfortable to humans, such as 18 degrees C. to 30 degrees C., and more preferably at room temperature (20-25 degrees C.), but could be used outside this temperature range, for example, from -40 degree C. to +80 degree C.

[0043] The materials and structures described herein may have applications in devices other than OLEDs. For example, other optoelectronic devices such as organic solar cells and organic photodetectors may employ the materials and structures. More generally, organic devices, such as organic transistors, may employ the materials and structures.

[0044] The terms “halo,” “halogen,” and “halide” are used interchangeably and refer to fluorine, chlorine, bromine, and iodine.

[0045] The term “acyl” refers to a substituted carbonyl radical ($C(O)-R_s$).

[0046] The term “ester” refers to a substituted oxycarbonyl ($-O-C(O)-R_s$ or $-C(O)-O-R_s$) radical.

[0047] The term “ether” refers to an $-OR_s$ radical.

[0048] The terms “sulfanyl” or “thio-ether” are used interchangeably and refer to a $-SR_s$ radical.

[0049] The term “sulfinyl” refers to a $-S(O)-R_s$ radical.

[0050] The term “sulfonyl” refers to a $-SO_2-R_s$ radical.

[0051] The term “phosphino” refers to a $-P(R_s)_3$ radical, wherein each R_s can be same or different.

[0052] The term “silyl” refers to a $-Si(R_s)_3$ radical, wherein each R_s can be same or different.

[0053] In each of the above, R_s can be hydrogen or a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, and combination thereof. Preferred R_s is selected from the group consisting of alkyl, cycloalkyl, aryl, heteroaryl, and combination thereof.

[0054] The term “alkyl” refers to and includes both straight and branched chain alkyl radicals. Preferred alkyl groups are those containing from one to fifteen carbon atoms and includes methyl, ethyl, propyl, 1-methylethyl, butyl, 1-methylpropyl, 2-methylpropyl, pentyl, 1-methylbutyl, 2-methylbutyl, 3-methylbutyl, 1,1-dimethylpropyl, 1,2-dimethylpropyl, 2,2-dimethylpropyl, and the like. Additionally, the alkyl group is optionally substituted.

[0055] The term “cycloalkyl” refers to and includes monocyclic, polycyclic, and spiro alkyl radicals. Preferred cycloalkyl groups are those containing 3 to 12 ring carbon atoms and includes cyclopropyl, cyclopentyl, cyclohexyl, bicyclo[3.1.1]heptyl, spiro[4.5]decyl, spiro[5.5]undecyl, adamantyl, and the like. Additionally, the cycloalkyl group is optionally substituted.

[0056] The terms “heteroalkyl” or “heterocycloalkyl” refer to an alkyl or a cycloalkyl radical, respectively, having at least one carbon atom replaced by a heteroatom. Optionally the at least one heteroatom is selected from O, S, N, P, B, Si and Se, preferably, O, S or N. Additionally, the heteroalkyl or heterocycloalkyl group is optionally substituted.

[0057] The term “alkenyl” refers to and includes both straight and branched chain alkene radicals. Alkenyl groups are essentially alkyl groups that include at least one carbon-carbon double bond in the alkyl chain. Cycloalkenyl groups are essentially cycloalkyl groups that include at least one carbon-carbon double bond in the cycloalkyl ring. The term “heteroalkenyl” as used herein refers to an alkenyl radical having at least one carbon atom replaced by a heteroatom. Optionally the at least one heteroatom is selected from O, S, N, P, B, Si, and Se, preferably, O, S, or N. Preferred alkenyl, cycloalkenyl, or heteroalkenyl groups are those containing two to fifteen carbon atoms. Additionally, the alkenyl, cycloalkenyl, or heteroalkenyl group is optionally substituted.

[0058] The term “alkynyl” refers to and includes both straight and branched chain alkyne radicals. Preferred alkynyl groups are those containing two to fifteen carbon atoms. Additionally, the alkynyl group is optionally substituted.

[0059] The terms “aralkyl” or “arylalkyl” are used interchangeably and refer to an alkyl group that is substituted with an aryl group. Additionally, the aralkyl group is optionally substituted.

[0060] The term “heterocyclic group” refers to and includes aromatic and non-aromatic cyclic radicals containing at least one heteroatom. Optionally the at least one heteroatom is selected from O, S, N, P, B, Si, and Se, preferably, O, S, or N. Hetero-aromatic cyclic radicals may be used interchangeably with heteroaryl. Preferred hetero-non-aromatic cyclic groups are those containing 3 to 7 ring atoms which includes at least one hetero atom, and includes cyclic amines such as morpholino, piperidino, pyrrolidino, and the like, and cyclic ethers/thio-ethers, such as tetrahydrofuran, tetrahydropyran, tetrahydrothiophene, and the like. Additionally, the heterocyclic group may be optionally substituted.

[0061] The term “aryl” refers to and includes both single-ring aromatic hydrocarbyl groups and polycyclic aromatic ring systems. The polycyclic rings may have two or more rings in which two carbons are common to two adjoining rings (the rings are “fused”) wherein at least one of the rings is an aromatic hydrocarbyl group, e.g., the other rings can be cycloalkyls, cycloalkenyls, aryl, heterocycles, and/or heteroaryls. Preferred aryl groups are those containing six to thirty carbon atoms, preferably six to twenty carbon atoms, more preferably six to twelve carbon atoms. Especially preferred is an aryl group having six carbons, ten carbons or twelve carbons. Suitable aryl groups include phenyl, biphenyl, triphenyl, triphenylene, tetraphenylene, naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, and azulene, preferably phenyl, biphenyl, triphenyl, triphenylene, fluorene, and naphthalene. Additionally, the aryl group is optionally substituted.

[0062] The term “heteroaryl” refers to and includes both single-ring aromatic groups and polycyclic aromatic ring systems that include at least one heteroatom. The heteroatoms include, but are not limited to O, S, N, P, B, Si, and Se. In many instances, O, S, or N are the preferred heteroatoms. Hetero-single ring aromatic systems are preferably single rings with 5 or 6 ring atoms, and the ring can have from one to six heteroatoms. The hetero-polycyclic ring systems can have two or more rings in which two atoms are common to two adjoining rings (the rings are “fused”) wherein at least one of the rings is a heteroaryl, e.g., the other rings can be cycloalkyls, cycloalkenyls, aryl, heterocycles, and/or heteroaryls. The hetero-polycyclic aromatic ring systems can have from one to six heteroatoms per ring of the polycyclic aromatic ring system. Preferred heteroaryl groups are those containing three to thirty carbon atoms, preferably three to twenty carbon atoms, more preferably three to twelve carbon atoms. Suitable heteroaryl groups include dibenzothiophene, dibenzofuran, dibenzoselenophene, furan, thiophene, benzofuran, benzothiophene, benzoselenophene, carbazole, indolocarbazole, pyridylindole, pyrrolodipyrindine, pyrazole, imidazole, triazole, oxazole, thiazole, oxadiazole, oxatriazole, dioxazole, thiadiazole, pyridine, pyridazine, pyrimidine, pyrazine, triazine, oxazine, oxathiazine, oxadiazine, indole, benzimidazole, indazole, indoxazine, benzoxazole, benzisoxazole, benzothiazole, quinoline, isoquinoline, cinnoline, quinazoline, quinoxaline, naphthyridine, phthalazine, pteridine, xanthene, acridine, phenazine, phenothiazine, phenoxazine, benzofuopyridine, furodipyrindine, benzothienopyridine, thienodipyrindine, benzoselenophenopyridine, and selenophenodipyrindine, preferably dibenzothiophene, dibenzofuran, dibenzoselenophene, carbazole, indolocarbazole, imidazole, pyridine, triazine, benzimidazole, 1,2-aza-

borine, 1,3-azaborine, 1,4-azaborine, borazine, and aza-analogs thereof. Additionally, the heteroaryl group is optionally substituted.

[0063] Of the aryl and heteroaryl groups listed above, the groups of triphenylene, naphthalene, anthracene, dibenzothiophene, dibenzofuran, dibenzoselenophene, carbazole, indolocarbazole, imidazole, pyridine, pyrazine, pyrimidine, triazine, and benzimidazole, and the respective aza-analogs of each thereof are of particular interest.

[0064] The terms alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aralkyl, heterocyclic group, aryl, and heteroaryl, as used herein, are independently unsubstituted, or independently substituted, with one or more general substituents.

[0065] In many instances, the general substituents are selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof.

[0066] In some instances, the preferred general substituents are selected from the group consisting of deuterium, fluorine, alkyl, cycloalkyl, heteroalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, aryl, heteroaryl, nitrile, isonitrile, sulfanyl, and combinations thereof.

[0067] In some instances, the preferred general substituents are selected from the group consisting of deuterium, fluorine, alkyl, cycloalkyl, alkoxy, aryloxy, amino, silyl, aryl, heteroaryl, sulfanyl, and combinations thereof.

[0068] In yet other instances, the more preferred general substituents are selected from the group consisting of deuterium, fluorine, alkyl, cycloalkyl, aryl, heteroaryl, and combinations thereof.

[0069] The term “substituted” refers to a substituent other than H that is bonded to the relevant position, e.g., a carbon. For example, where R^1 represents mono-substituted, then one R^1 must be other than H. Similarly, where R^1 represents di-substituted, then two of R^1 must be other than H. Similarly, where R^1 is unsubstituted, R^1 is hydrogen for all available positions. The maximum number of substitutions possible in a structure (for example, a particular ring or fused ring system) will depend on the number of atoms with available valencies.

[0070] As used herein, “combinations thereof” indicates that one or more members of the applicable list are combined to form a known or chemically stable arrangement that one of ordinary skill in the art can envision from the applicable list. For example, an alkyl and deuterium can be combined to form a partial or fully deuterated alkyl group; a halogen and alkyl can be combined to form a halogenated alkyl substituent; and a halogen, alkyl, and aryl can be combined to form a halogenated arylalkyl. In one instance, the term substitution includes a combination of two to four of the listed groups. In another instance, the term substitution includes a combination of two to three groups. In yet another instance, the term substitution includes a combination of two groups. Preferred combinations of substituent groups are those that contain up to fifty atoms that are not hydrogen or deuterium, or those which include up to forty atoms that are not hydrogen or deuterium, or those that include up to thirty atoms that are not hydrogen or deute-

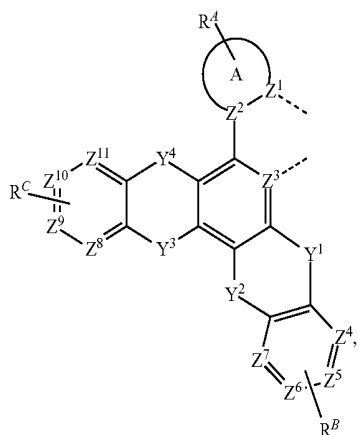
rium. In many instances, a preferred combination of substituent groups will include up to twenty atoms that are not hydrogen or deuterium.

[0071] The “aza” designation in the fragments described herein, i.e. aza-dibenzofuran, aza-dibenzothiophene, etc. means that one or more of the C—H groups in the respective fragment can be replaced by a nitrogen atom, for example, and without any limitation, azatriphenylene encompasses both dibenzo[f,h]quinoxaline and dibenzo[f,h]quinoline. One of ordinary skill in the art can readily envision other nitrogen analogs of the aza-derivatives described above, and all such analogs are intended to be encompassed by the terms as set forth herein.

[0072] As used herein, “deuterium” refers to an isotope of hydrogen. Deuterated compounds can be readily prepared using methods known in the art. For example, U.S. Pat. No. 8,557,400, Patent Pub. No. WO 2006/095951, and U.S. Pat. Application Pub. No. US 2011/0037057, which are hereby incorporated by reference in their entireties, describe the making of deuterium-substituted organometallic complexes. Further reference is made to Ming Yan, et al., *Tetrahedron* 2015, 71, 1425-30 and Atzrodt et al., *Angew. Chem. Int. Ed. (Reviews)* 2007, 46, 7744-65, which are incorporated by reference in their entireties, describe the deuteration of the methylene hydrogens in benzyl amines and efficient pathways to replace aromatic ring hydrogens with deuterium, respectively.

[0073] It is to be understood that when a molecular fragment is described as being a substituent or otherwise attached to another moiety, its name may be written as if it were a fragment (e.g. phenyl, phenylene, naphthyl, dibenzofuryl) or as if it were the whole molecule (e.g. benzene, naphthalene, dibenzofuran). As used herein, these different ways of designating a substituent or attached fragment are considered to be equivalent.

[0074] According to an aspect of the present disclosure, a metal-containing compound comprising a first ligand L_A of Formula I



Formula I

is described. In these structures:

[0075] A is a 5- or 6-membered aryl or heteroaryl ring;

[0076] R^A , R^B , and R^C each represent mono to a maximum possible number of substitutions, or no substitution;

[0077] Z^1 - Z^{11} are each independently selected from the group consisting of C and N;

[0078] Y^1 , Y^2 , Y^3 , and Y^4 are each independently selected from the group consisting of a direct bond, BR, NR, PR, O, S, Se, C=O, S=O, SO₂, CRR', SiRR', and GeRR';

[0079] at least one of Y^1 and Y^2 is not a direct bond;

[0080] at least one of Y^3 and Y^4 is not a direct bond;

[0081] R^A , R^B , R^C , R, and R' are each independently selected from the group consisting of hydrogen, deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof;

[0082] any two adjacent substitutions in R^A , R^B and R^C are optionally joined or fused into a ring;

[0083] the ligand L_A is coordinated to a metal M;

[0084] L_A is optionally linked with other ligands to comprise a tridentate, tetradentate, pentadentate, or hexadentate ligand; and

[0085] M is optionally coordinated to other ligands.

[0086] In some embodiments, the compound is neutral.

[0087] In some embodiments, one of Y^1 and Y^2 is O and the other one of Y^1 and Y^2 is a direct bond, and one of Y^3 and Y^4 is O and the other one of Y^3 and Y^4 is a direct bond. In some embodiments, one of Y^1 and Y^2 is S and the other one of Y^1 and Y^2 is a direct bond, and one of Y^3 and Y^4 is S and the other one of Y^3 and Y^4 is a direct bond.

[0088] In some embodiments, each of Y^1 , Y^2 , Y^3 , and Y^4 is O. In some embodiments, each of Y^1 , Y^2 , Y^3 , and Y^4 is S.

[0089] In some embodiments, Z^1 is N, Z^2 is C, and Z^3 is C. In some embodiments, one of Z^1 , Z^2 , and Z^3 is N. In some embodiments, Z^1 is C, Z^2 is N, and Z^3 is C. In some embodiments, Z^1 is N, Z^2 is C, and Z^3 is N.

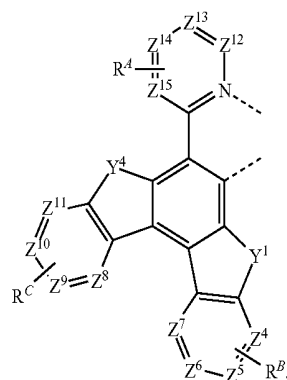
[0090] In some embodiments, each one of Z^4 through Z^{11} is C. In some embodiments, at least one of Z^4 through Z^{11} is N. In some embodiments, exactly one of Z^4 - Z^{11} is N.

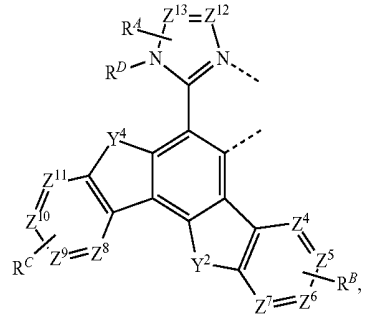
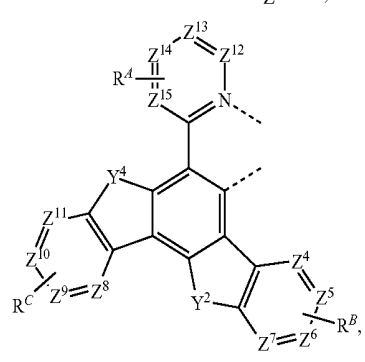
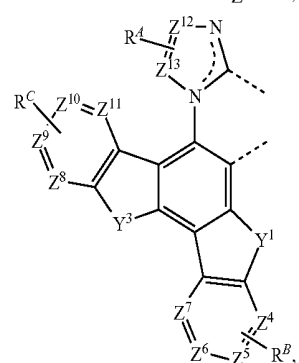
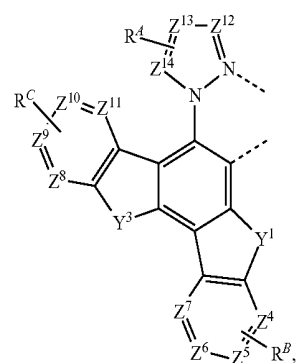
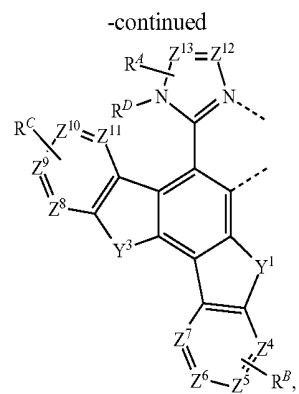
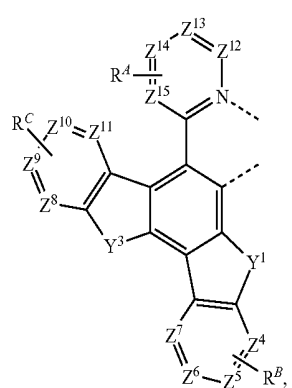
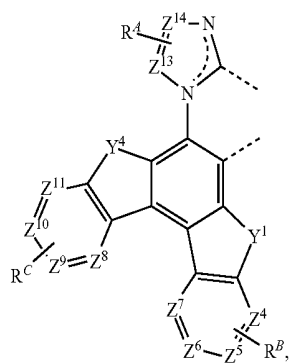
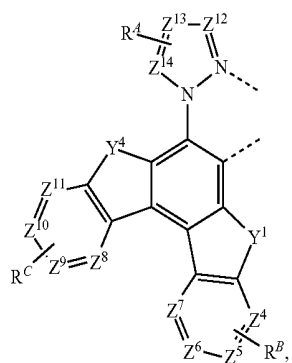
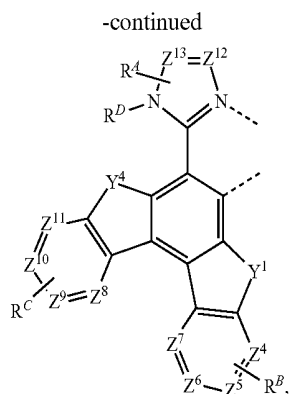
[0091] In some embodiments, M is selected from the group consisting of Ir, Rh, Re, Ru, Os, Pt, Au, and Cu. In some embodiments, M is Ir or Pt.

[0092] In some embodiments, ring A is a 6-membered aryl or heteroaryl ring. In some embodiments, ring A is a 5-membered heteroaryl ring. In some embodiments, ring A is selected from the group consisting of pyridine, pyrimidine, imidazole, pyrazole, and imidazole derived carbene. In some embodiments, ring A comprises a carbene carbon. In some embodiments, Z^1 is a carbene carbon.

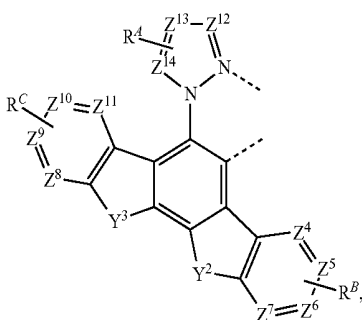
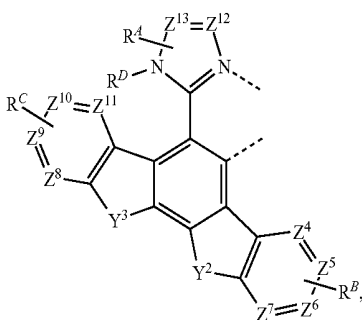
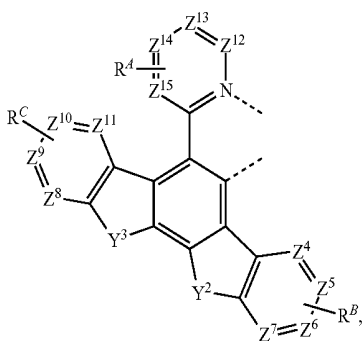
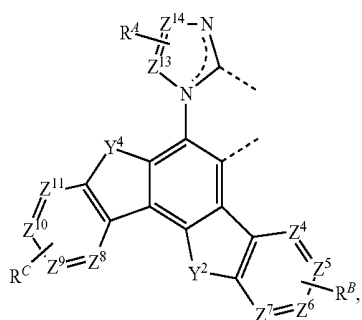
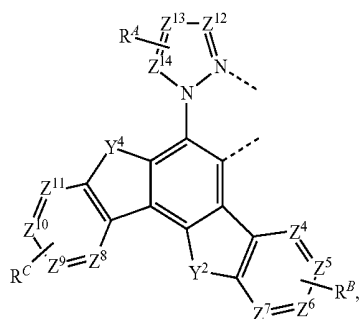
[0093] In some embodiments, the compound is homoleptic. In some embodiments, the compound is heteroleptic.

[0094] In some embodiments, the first ligand L_A is selected from the group consisting of:

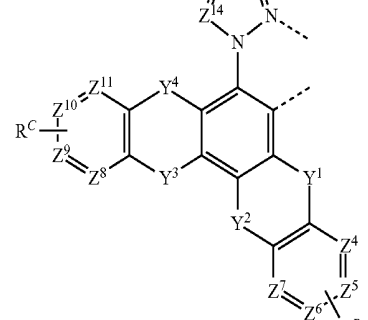
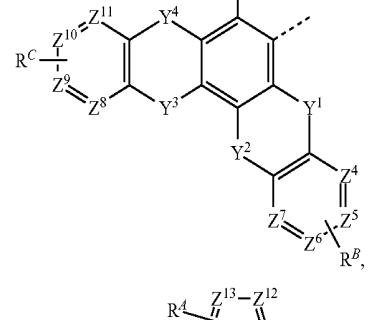
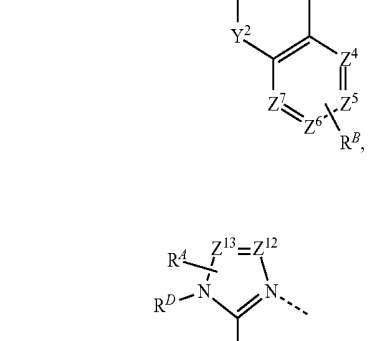
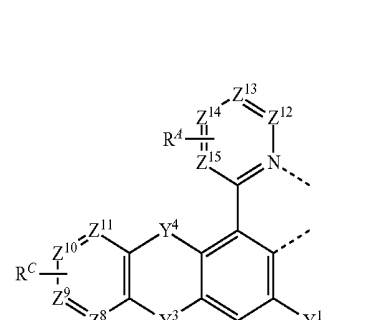
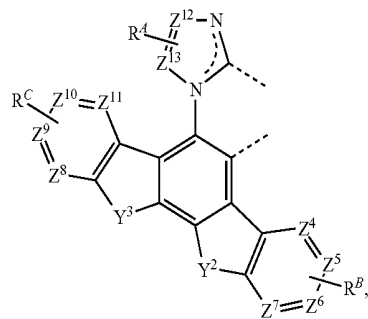




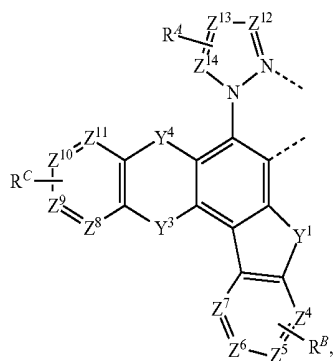
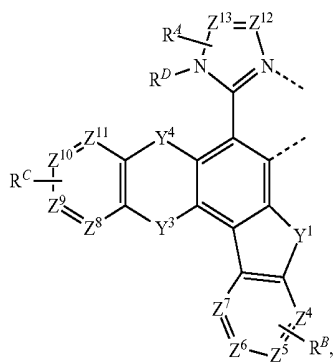
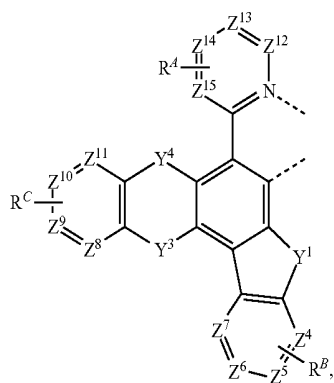
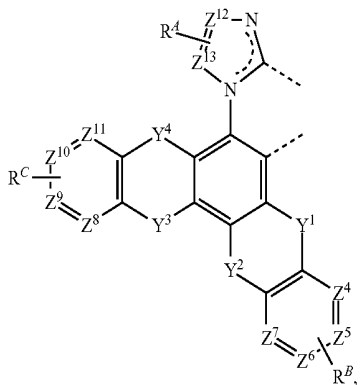
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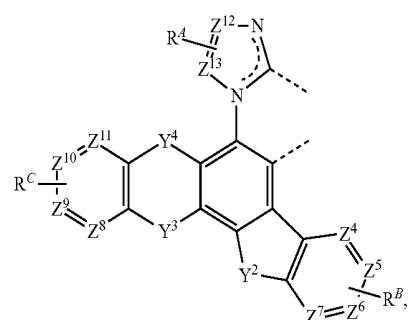
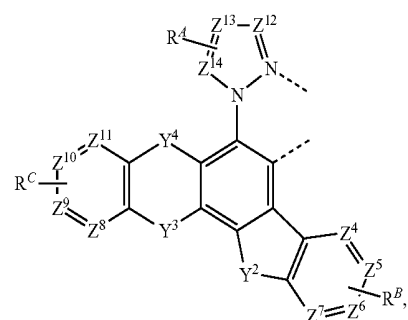
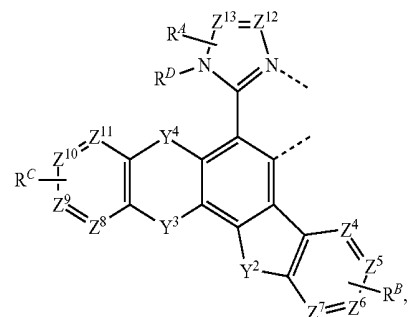
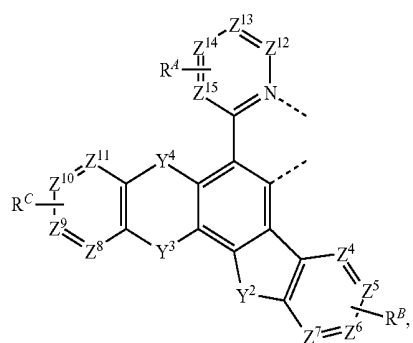
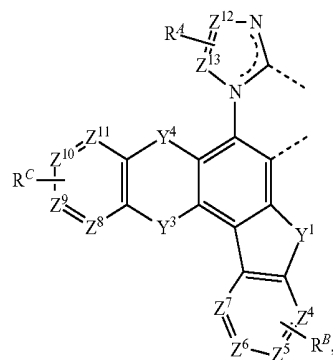
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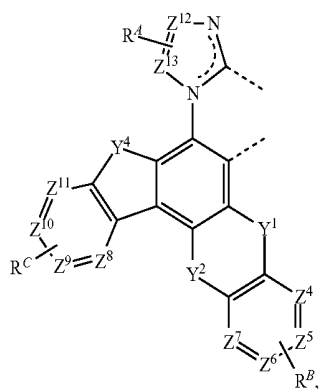
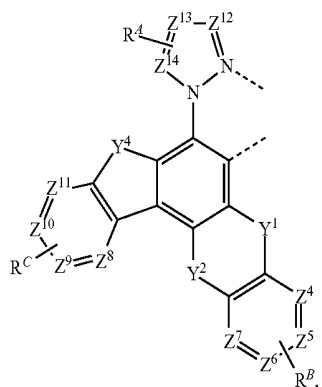
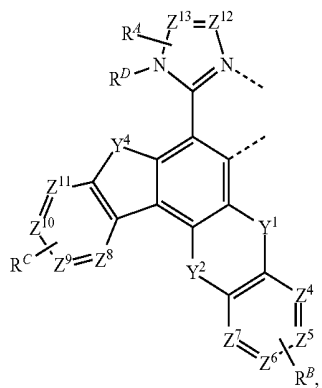
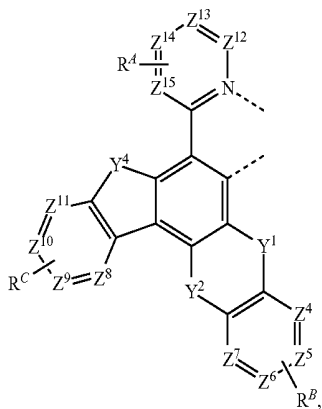
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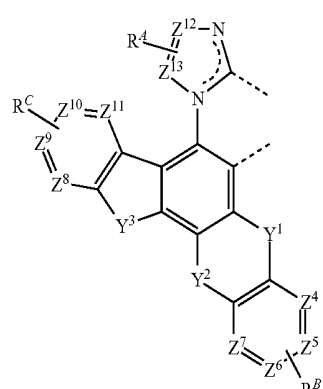
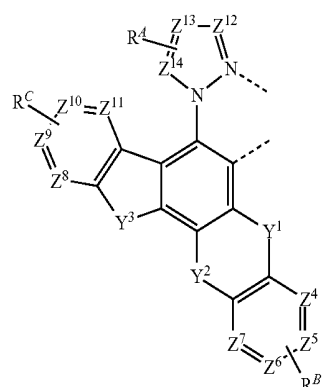
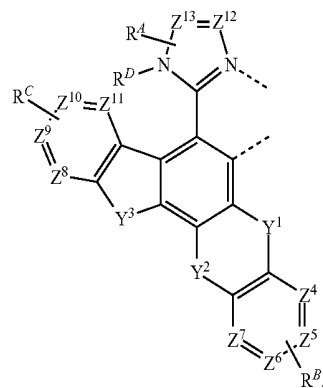
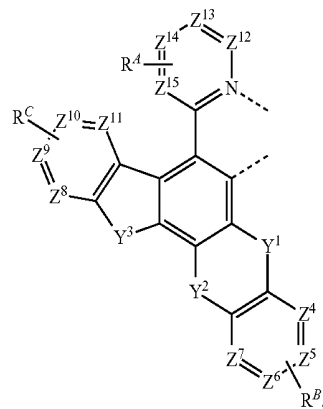
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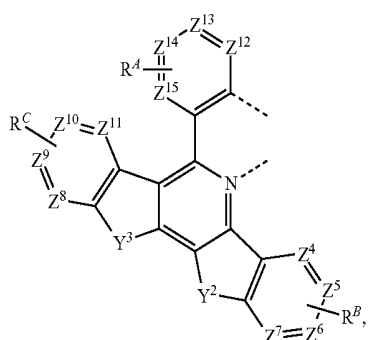
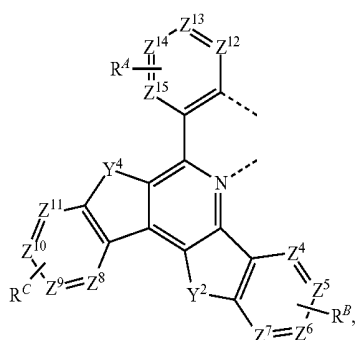
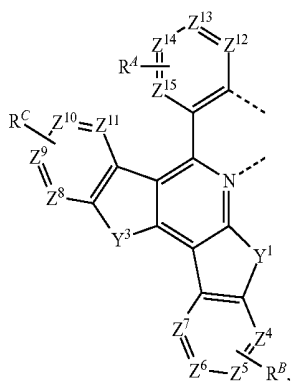
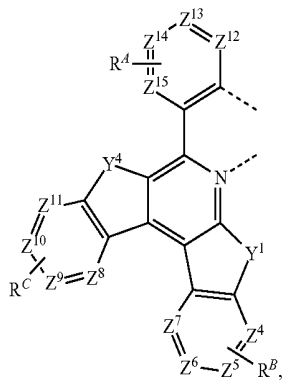
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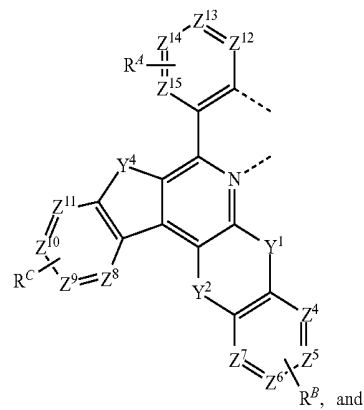
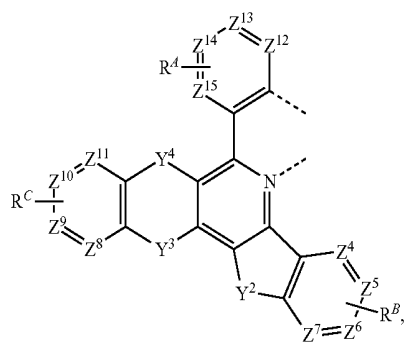
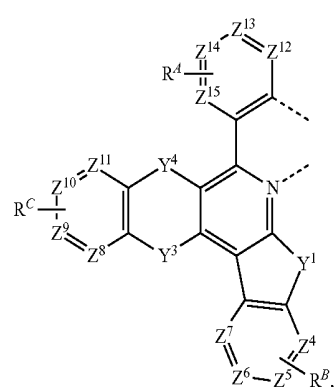
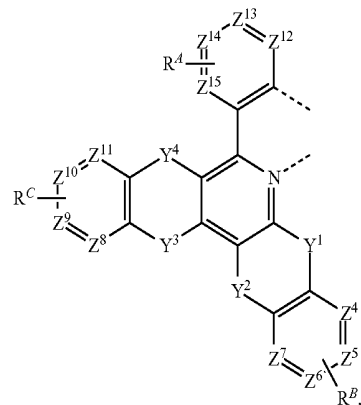
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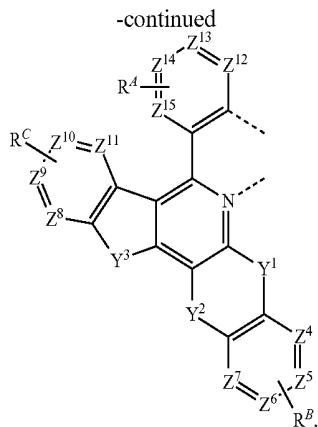
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, and



where:

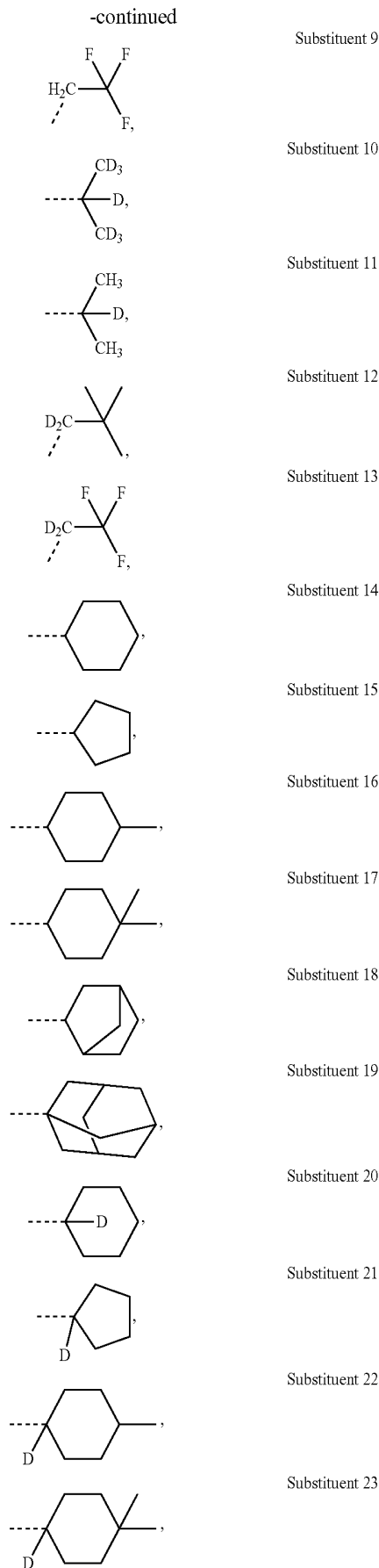
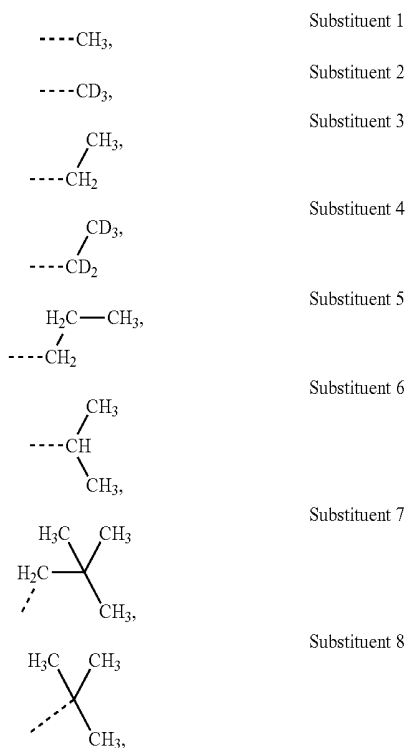
[0095] each of Z^{12} through Z^{14} is independently selected from the group consisting of C and N;

[0096] R^D is independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof; and

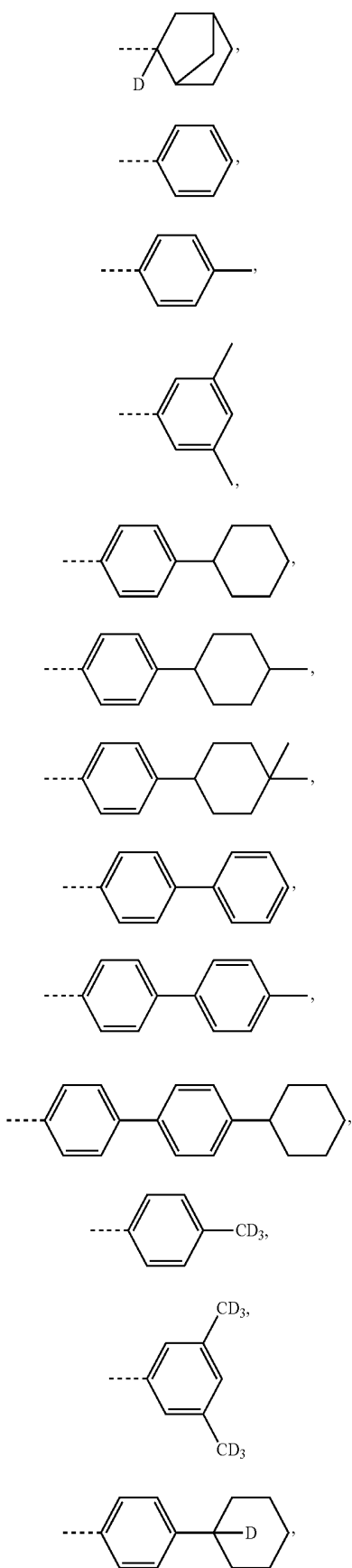
[0097] any two adjacent substitutions of R^A , R^B , R^C , and R^D are optionally joined or fused into a ring.

[0098] In some embodiments, ring A is pyridine, Z^1 is nitrogen, and R^A para to Z^1 is not hydrogen or deuterium.

[0099] In some embodiments, R^A is at least a monosubstitution and at least one of R^A substituent is selected from the group consisting of:



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Substituent 24

Substituent 25

Substituent 26

Substituent 27

Substituent 28

Substituent 29

Substituent 30

Substituent 31

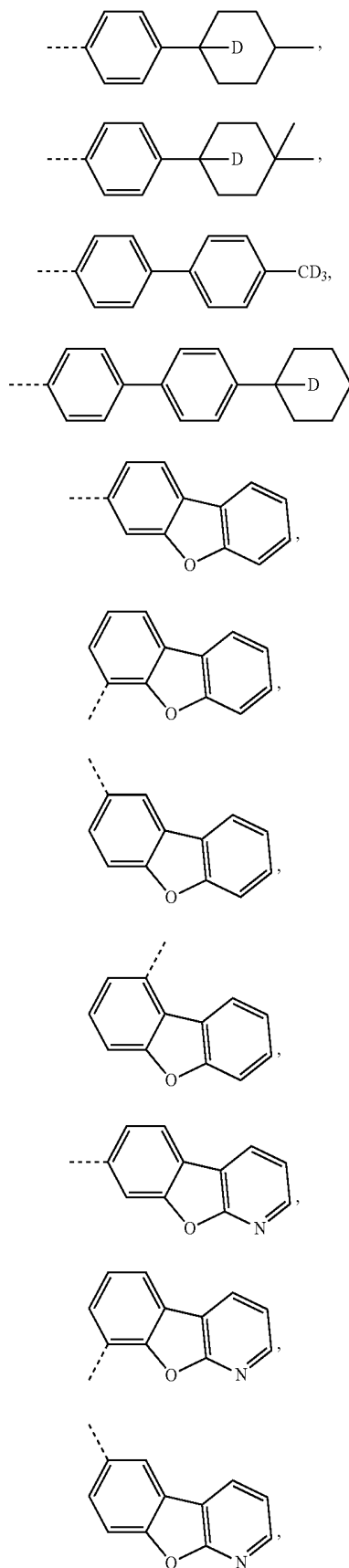
Substituent 32

Substituent 33

Substituent 34

Substituent 35

Substituent 36



Substituent 37

Substituent 38

Substituent 39

Substituent 40

Substituent 41

Substituent 42

Substituent 43

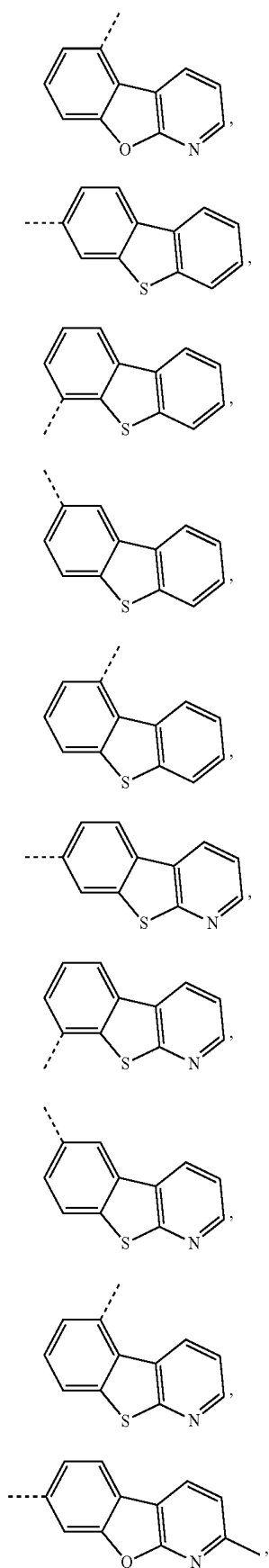
Substituent 44

Substituent 45

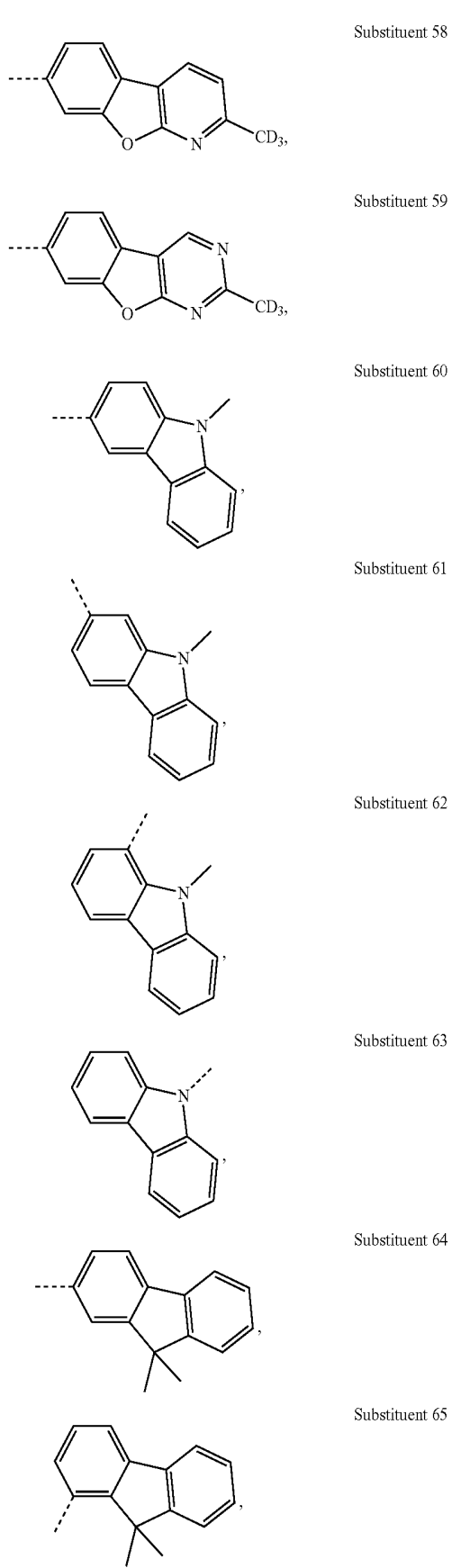
Substituent 46

Substituent 47

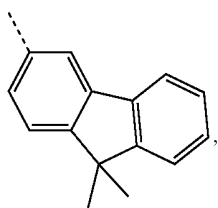
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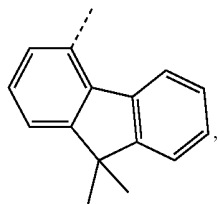
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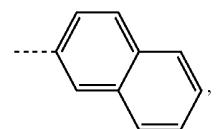
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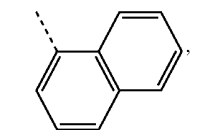
Substituent 66



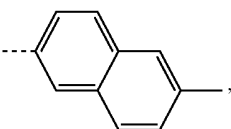
Substituent 67



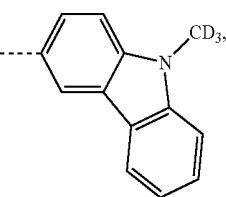
Substituent 68



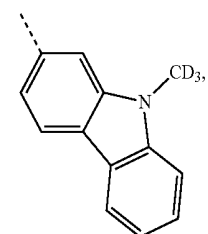
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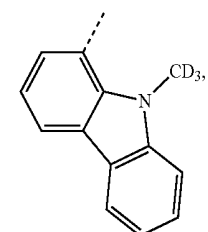
Substituent 70



Substituent 71

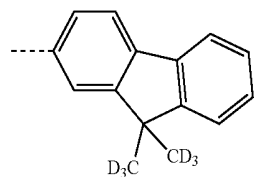


Substituent 72

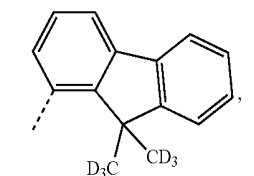


Substituent 73

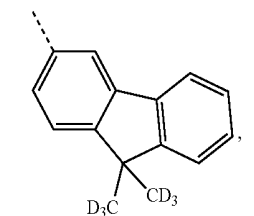
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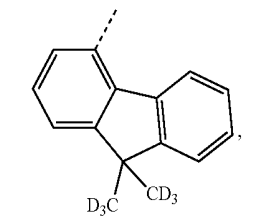
Substituent 74



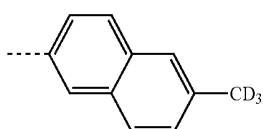
Substituent 75



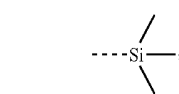
Substituent 76



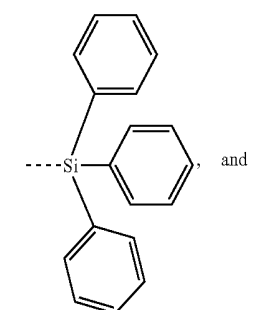
Substituent 77



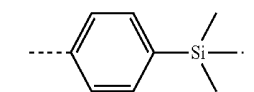
Substituent 78



Substituent 79



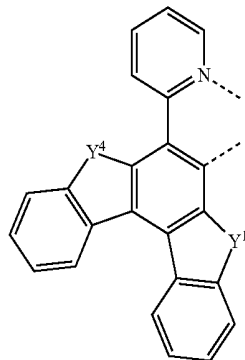
Substituent 80



Substituent 81

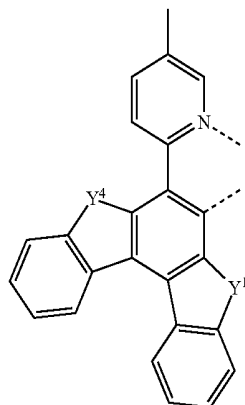
[0100] In some embodiments, L_{A} is selected from the group consisting of L_{A1} to L_{A544} , which are defined as follows:

Ligand L_{A11} through L_{A45}, each represented by the formula



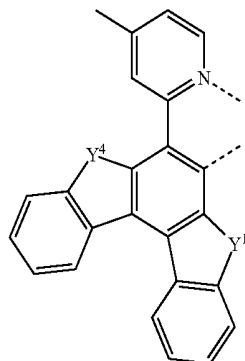
wherein in ligand L_{A11}, Y¹ = O, Y⁴ = O;
 in ligand L_{A12}, Y¹ = S, Y⁴ = S;
 in ligand L_{A13}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A14}, Y¹ = O, Y⁴ = S;
 in ligand L_{A15}, Y¹ = S, Y⁴ = O;

Ligand L_{A46} through L_{A110}, each represented by the formula



wherein in ligand L_{A46}, Y¹ = O, Y⁴ = O;
 in ligand L_{A47}, Y¹ = S, Y⁴ = S;
 in ligand L_{A48}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A49}, Y¹ = O, Y⁴ = S;
 in ligand L_{A110}, Y¹ = S, Y⁴ = O;

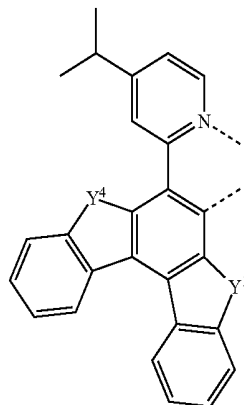
Ligand L_{A111} through L_{A115}, each represented by the formula



wherein in ligand L_{A111}, Y¹ = O, Y⁴ = O;
 in ligand L_{A112}, Y¹ = S, Y⁴ = S;
 in ligand L_{A113}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A114}, Y¹ = O, Y⁴ = S;
 in ligand L_{A115}, Y¹ = S, Y⁴ = O;

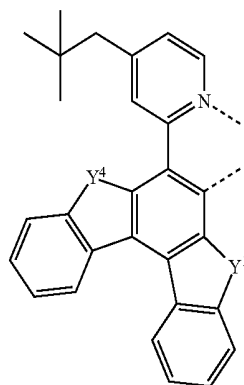
-continued

Ligand L_{A116} through L_{A20}, each represented by the formula



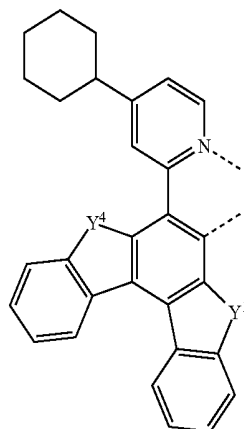
wherein in ligand L_{A116}, Y¹ = O, Y⁴ = O;
 in ligand L_{A117}, Y¹ = S, Y⁴ = S;
 in ligand L_{A118}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A119}, Y¹ = O, Y⁴ = S;
 in ligand L_{A120}, Y¹ = S, Y⁴ = O;

Ligand L_{A21} through L_{A25}, each represented by the formula



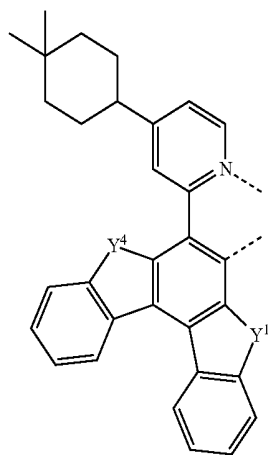
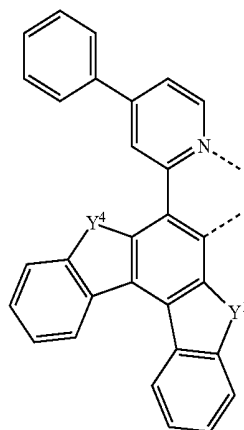
wherein in ligand L_{A21}, Y¹ = O, Y⁴ = O;
 in ligand L_{A22}, Y¹ = S, Y⁴ = S;
 in ligand L_{A23}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A24}, Y¹ = O, Y⁴ = S;
 in ligand L_{A25}, Y¹ = S, Y⁴ = O;

Ligand L_{A26} through L_{A30}, each represented by the formula

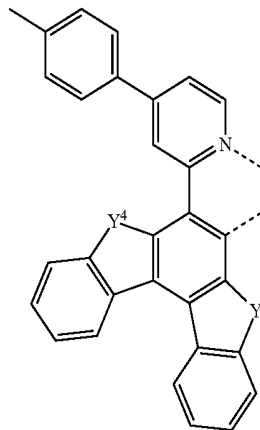
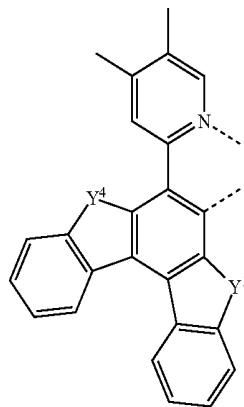
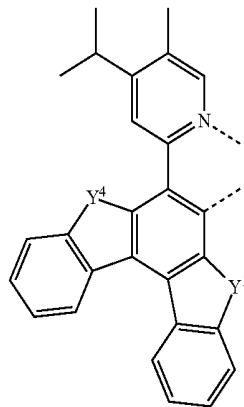


wherein in ligand L_{A26}, Y¹ = O, Y⁴ = O;
 in ligand L_{A27}, Y¹ = S, Y⁴ = S;

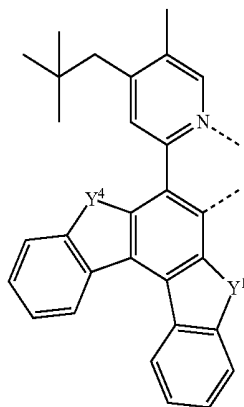
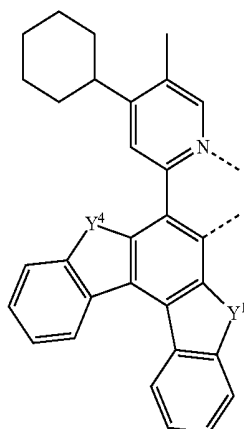
-continued

in ligand L₄₂₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₂₉, Y¹ = O, Y⁴ = S;in ligand L₄₃₀, Y¹ = S, Y⁴ = O;Ligand L₄₃₁ through L₄₃₅, each represented by the formulawherein in ligand L₄₃₁, Y¹ = O, Y⁴ = O;in ligand L₄₃₂, Y¹ = S, Y⁴ = S;in ligand L₄₃₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₃₄, Y¹ = O, Y⁴ = S;in ligand L₄₃₅, Y¹ = S, Y⁴ = O;Ligand L₄₃₆ through L₄₄₀, each represented by the formulawherein in ligand L₄₃₆, Y¹ = O, Y⁴ = O;in ligand L₄₃₇, Y¹ = S, Y⁴ = S;in ligand L₄₃₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₃₉, Y¹ = O, Y⁴ = S;in ligand L₄₄₀, Y¹ = S, Y⁴ = O;

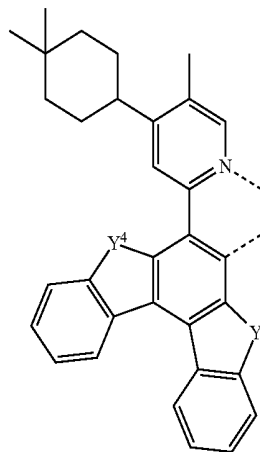
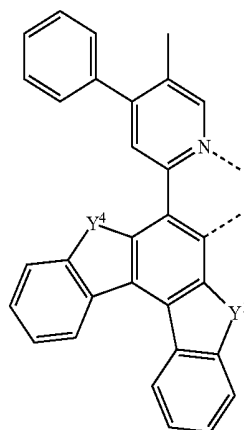
-continued

Ligand L₄₄₁ through L₄₄₅, each represented by the formulawherein in ligand L₄₄₁, Y¹ = O, Y⁴ = O;in ligand L₄₄₂, Y¹ = S, Y⁴ = S;in ligand L₄₄₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₄₄, Y¹ = O, Y⁴ = S;in ligand L₄₄₅, Y¹ = S, Y⁴ = O;Ligand L₄₄₆ through L₄₅₀, each represented by the formulawherein in ligand L₄₄₆, Y¹ = O, Y⁴ = O;in ligand L₄₄₇, Y¹ = S, Y⁴ = S;in ligand L₄₄₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₄₉, Y¹ = O, Y⁴ = S;in ligand L₄₅₀, Y¹ = S, Y⁴ = O;Ligand L₄₅₁ through L₄₅₅, each represented by the formulawherein in ligand L₄₅₁, Y¹ = O, Y⁴ = O;in ligand L₄₅₂, Y¹ = S, Y⁴ = S;

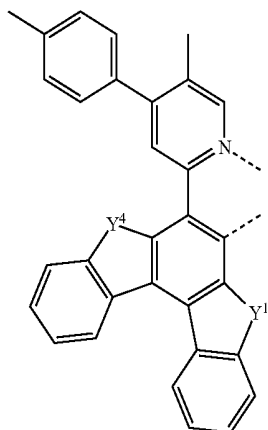
-continued

in ligand L_{453} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{454} , $Y^1 = O$, $Y^4 = S$;in ligand L_{455} , $Y^1 = S$, $Y^4 = O$;Ligand L_{456} through L_{460} , each represented by the formulawherein in ligand L_{456} , $Y^1 = O$, $Y^4 = O$;in ligand L_{457} , $Y^1 = S$, $Y^4 = S$;in ligand L_{458} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{459} , $Y^1 = O$, $Y^4 = S$;in ligand L_{460} , $Y^1 = S$, $Y^4 = O$;Ligand L_{461} through L_{465} , each represented by the formulawherein in ligand L_{461} , $Y^1 = O$, $Y^4 = O$;in ligand L_{462} , $Y^1 = S$, $Y^4 = S$;in ligand L_{463} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{464} , $Y^1 = O$, $Y^4 = S$;in ligand L_{465} , $Y^1 = S$, $Y^4 = O$;

-continued

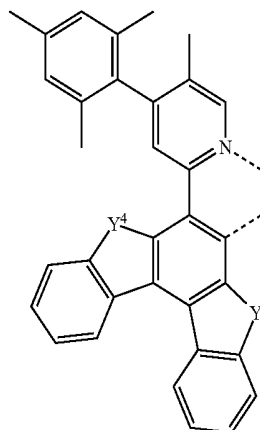
Ligand L_{466} through L_{470} , each represented by the formulawherein in ligand L_{466} , $Y^1 = O$, $Y^4 = O$;in ligand L_{467} , $Y^1 = S$, $Y^4 = S$;in ligand L_{468} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{469} , $Y^1 = O$, $Y^4 = S$;in ligand L_{470} , $Y^1 = S$, $Y^4 = O$;Ligand L_{471} through L_{475} , each represented by the formulawherein in ligand L_{471} , $Y^1 = O$, $Y^4 = O$;in ligand L_{472} , $Y^1 = S$, $Y^4 = S$;in ligand L_{473} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{474} , $Y^1 = O$, $Y^4 = S$;in ligand L_{475} , $Y^1 = S$, $Y^4 = O$;

-continued

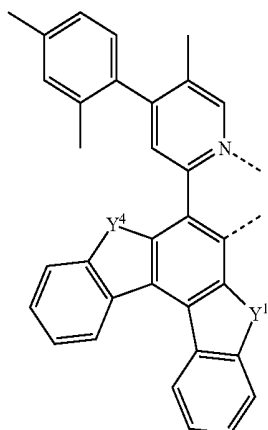
Ligand L₄₇₆ through L₄₈₀, each represented by the formula

wherein in ligand L₄₇₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₇₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₇₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₇₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₈₀, Y¹ = S, Y⁴ = O;

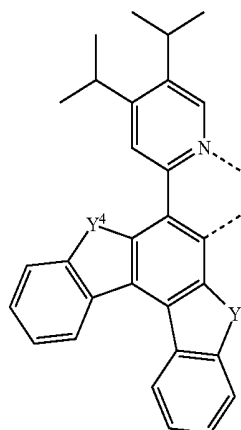
-continued

Ligand L₄₈₆ through L₄₉₀, each represented by the formula

wherein in ligand L₄₈₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₈₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₈₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₈₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₉₀, Y¹ = S, Y⁴ = O;

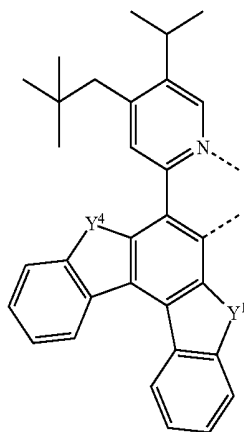
Ligand L₄₈₁ through L₄₈₅, each represented by the formula

wherein in ligand L₄₈₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₈₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₈₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₈₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₈₅, Y¹ = S, Y⁴ = O;

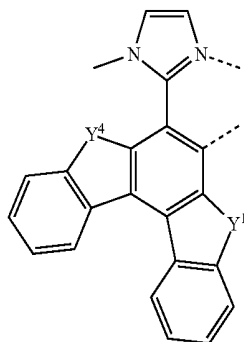
Ligand L₄₉₁ through L₄₉₅, each represented by the formula

wherein in ligand L₄₉₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₉₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₉₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₉₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₉₅, Y¹ = S, Y⁴ = O;

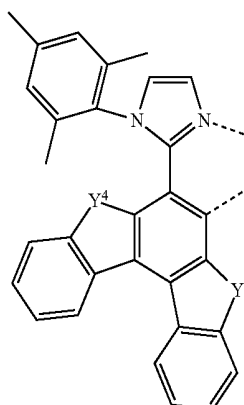
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Ligand L_{496} through L_{4100} , each represented by the formula

wherein in ligand L_{496} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{497} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{498} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{499} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4100} , $Y^1 = S$, $Y^4 = O$;

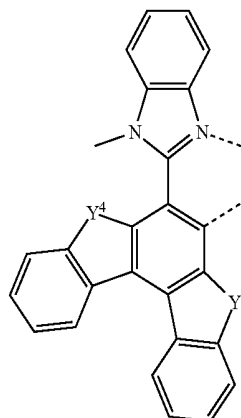
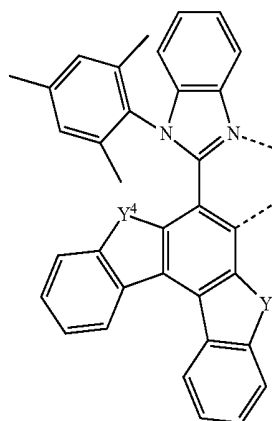
Ligand L_{4101} through L_{4105} , each represented by the formula

wherein in ligand L_{4101} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4102} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4103} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4104} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4105} , $Y^1 = S$, $Y^4 = O$;

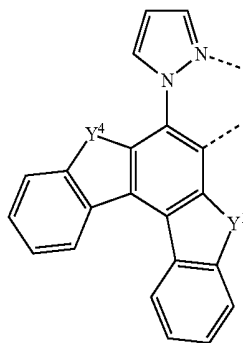
Ligand L_{4106} through L_{4110} , each represented by the formula

wherein in ligand L_{4106} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4107} , $Y^1 = S$, $Y^4 = S$;

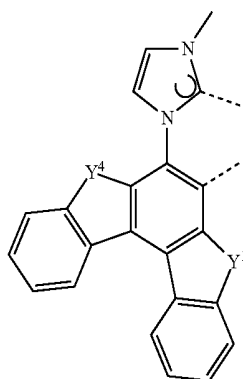
-continued

in ligand L_{4108} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{4109} , $Y^1 = O$, $Y^4 = S$;in ligand L_{4110} , $Y^1 = S$, $Y^4 = O$;Ligand L_{4111} through L_{4115} , each represented by the formulawherein in ligand L_{4111} , $Y^1 = O$, $Y^4 = O$;in ligand L_{4112} , $Y^1 = S$, $Y^4 = S$;in ligand L_{4113} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{4114} , $Y^1 = O$, $Y^4 = S$;in ligand L_{4115} , $Y^1 = S$, $Y^4 = O$;Ligand L_{4116} through L_{4120} , each represented by the formulawherein in ligand L_{4116} , $Y^1 = O$, $Y^4 = O$;in ligand L_{4117} , $Y^1 = S$, $Y^4 = S$;in ligand L_{4118} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{4119} , $Y^1 = O$, $Y^4 = S$;in ligand L_{4120} , $Y^1 = S$, $Y^4 = O$;

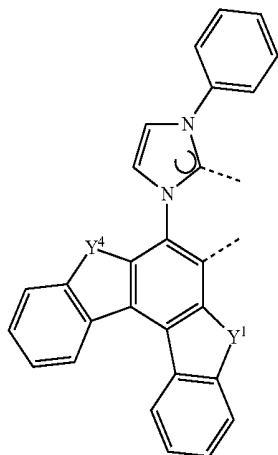
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Ligand L₄₁₂₁ through L₄₁₂₅, each represented by the formula

wherein in ligand L₄₁₂₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₂₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₂₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₂₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₂₅, Y¹ = S, Y⁴ = O;

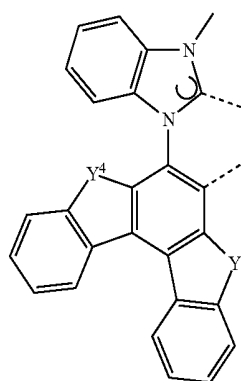
Ligand L₄₁₂₆ through L₄₁₃₀, each represented by the formula

wherein in ligand L₄₁₂₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₂₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₂₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₂₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₃₀, Y¹ = S, Y⁴ = O;

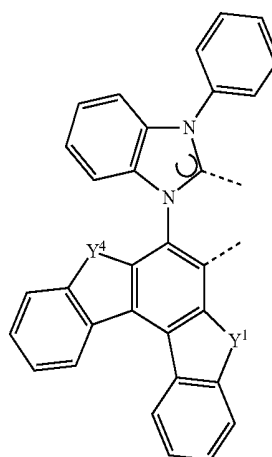
Ligand L₄₁₃₁ through L₄₁₃₅, each represented by the formula

wherein in ligand L₄₁₃₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₃₂, Y¹ = S, Y⁴ = S;

-continued

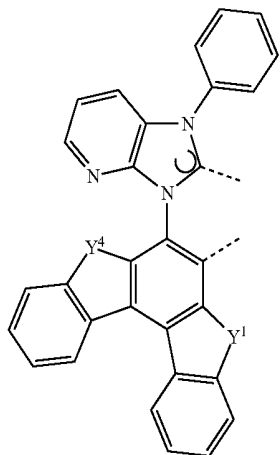
in ligand L₄₁₃₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₁₃₄, Y¹ = O, Y⁴ = S;in ligand L₄₁₃₅, Y¹ = S, Y⁴ = O;Ligand L₄₁₃₆ through L₄₁₄₀, each represented by the formula

wherein in ligand L₄₁₃₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₃₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₃₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₃₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₄₀, Y¹ = S, Y⁴ = O;

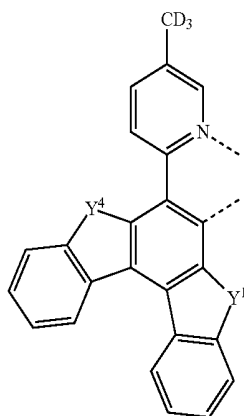
Ligand L₄₁₄₁ through L₄₁₄₅, each represented by the formula

wherein in ligand L₄₁₄₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₄₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₄₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₄₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₄₅, Y¹ = S, Y⁴ = O;

-continued

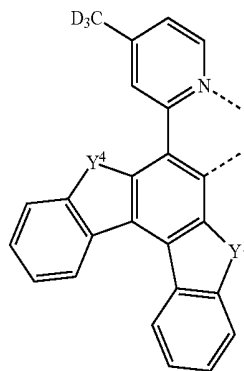
Ligand L_{A146} through L_{A150}, each represented by the formula

wherein in ligand L_{A146}, Y¹ = O, Y⁴ = O;
 in ligand L_{A147}, Y¹ = S, Y⁴ = S;
 in ligand L_{A148}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A149}, Y¹ = O, Y⁴ = S;
 in ligand L_{A150}, Y¹ = S, Y⁴ = O;

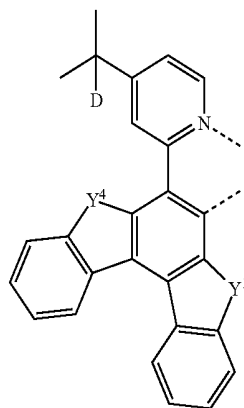
Ligand L_{A151} through L_{A155}, each represented by the formula

wherein in ligand L_{A151}, Y¹ = O, Y⁴ = O;
 in ligand L_{A152}, Y¹ = S, Y⁴ = S;
 in ligand L_{A153}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A154}, Y¹ = O, Y⁴ = S;
 in ligand L_{A155}, Y¹ = S, Y⁴ = O;

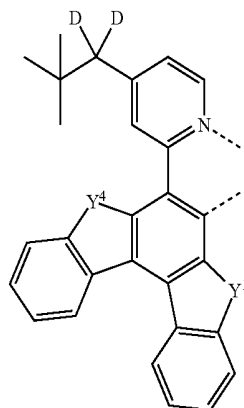
-continued

Ligand L_{A156} through L_{A160}, each represented by the formula

wherein in ligand L_{A156}, Y¹ = O, Y⁴ = O;
 in ligand L_{A157}, Y¹ = S, Y⁴ = S;
 in ligand L_{A158}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A159}, Y¹ = O, Y⁴ = S;
 in ligand L_{A160}, Y¹ = S, Y⁴ = O;

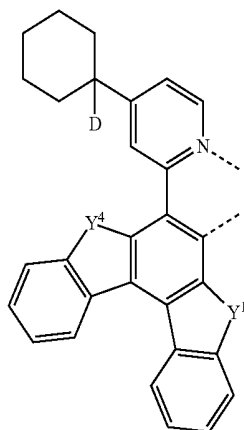
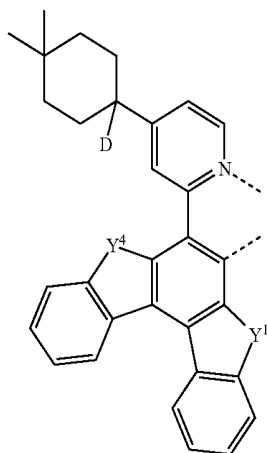
Ligand L_{A161} through L_{A165}, each represented by the formula

wherein in ligand L_{A161}, Y¹ = O, Y⁴ = O;
 in ligand L_{A162}, Y¹ = S, Y⁴ = S;
 in ligand L_{A163}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A164}, Y¹ = O, Y⁴ = S;
 in ligand L_{A165}, Y¹ = S, Y⁴ = O;

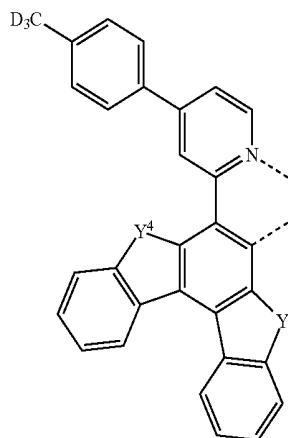
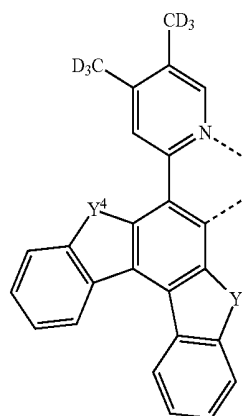
Ligand L_{A166} through L_{A170}, each represented by the formula

wherein in ligand L_{A166}, Y¹ = O, Y⁴ = O;
 in ligand L_{A167}, Y¹ = S, Y⁴ = S;

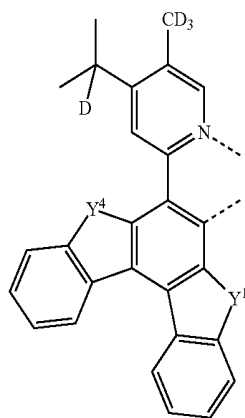
-continued

in ligand L_{A168} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A169} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A170} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A171} through L_{A175} , each represented by the formulawherein in ligand L_{A171} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A172} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A173} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A174} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A175} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A176} through L_{A180} , each represented by the formulawherein in ligand L_{A176} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A177} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A178} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A179} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A180} , $Y^1 = S$, $Y^4 = O$;

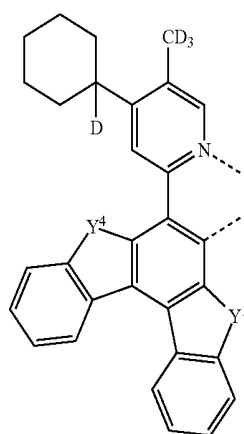
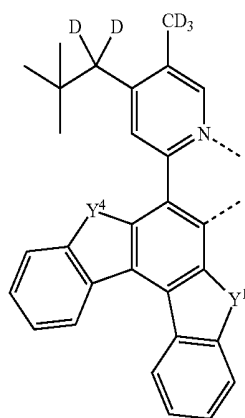
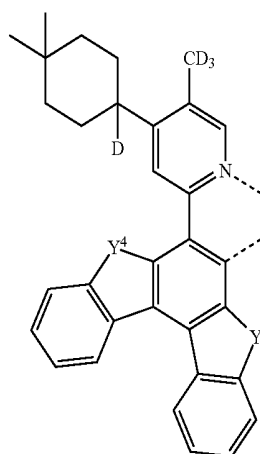
-continued

Ligand L_{A181} through L_{A185} , each represented by the formulawherein in ligand L_{A181} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A182} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A183} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A184} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A185} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A186} through L_{A190} , each represented by the formulawherein in ligand L_{A186} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A187} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A188} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A189} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A190} , $Y^1 = S$, $Y^4 = O$;

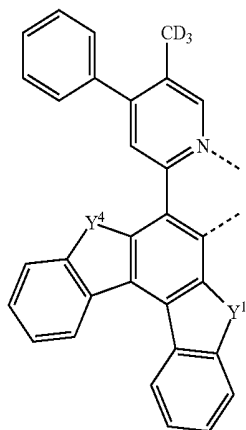
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Ligand L₄₁₉₁ through L₄₁₉₅, each represented by the formulawherein in ligand L₄₁₉₁, Y¹ = O, Y⁴ = O;in ligand L₄₁₉₂, Y¹ = S, Y⁴ = S;in ligand L₄₁₉₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₁₉₄, Y¹ = O, Y⁴ = S;in ligand L₄₁₉₅, Y¹ = S, Y⁴ = O;

-continued

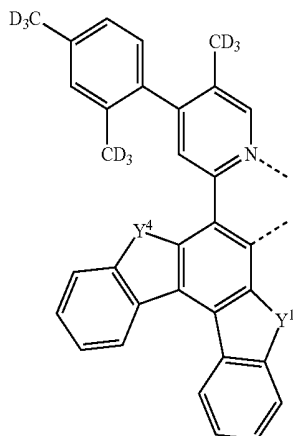
Ligand L₄₂₀₁ through L₄₂₀₅, each represented by the formulawherein in ligand L₄₂₀₁, Y¹ = O, Y⁴ = O;in ligand L₄₂₀₂, Y¹ = S, Y⁴ = S;in ligand L₄₂₀₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₂₀₄, Y¹ = O, Y⁴ = S;in ligand L₄₂₀₅, Y¹ = S, Y⁴ = O;Ligand L₄₁₉₆ through L₄₂₀₀, each represented by the formulawherein in ligand L₄₁₉₆, Y¹ = O, Y⁴ = O;in ligand L₄₁₉₇, Y¹ = S, Y⁴ = S;in ligand L₄₁₉₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₁₉₉, Y¹ = O, Y⁴ = S;in ligand L₄₂₀₀, Y¹ = S, Y⁴ = O;Ligand L₄₂₆₁ through L₄₂₁₀, each represented by the formulawherein in ligand L₄₂₀₆, Y¹ = O, Y⁴ = O;in ligand L₄₂₀₇, Y¹ = S, Y⁴ = S;in ligand L₄₂₀₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₂₀₉, Y¹ = O, Y⁴ = S;in ligand L₄₂₁₀, Y¹ = S, Y⁴ = O;

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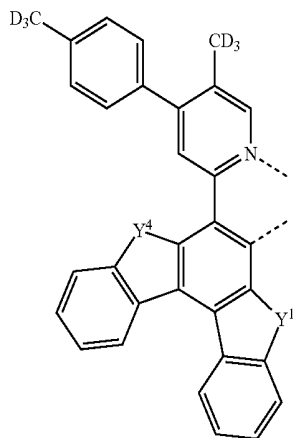
Ligand L₄₂₁₁ through L₄₂₁₅, each represented by the formula

wherein in ligand L₄₂₁₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₁₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₁₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₁₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₁₅, Y¹ = S, Y⁴ = O;

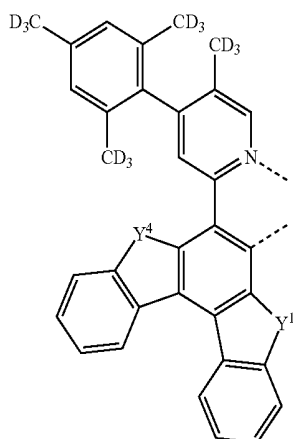
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Ligand L₄₂₂₁ through L₄₂₂₅, each represented by the formula

wherein in ligand L₄₂₂₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₂₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₂₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₂₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₂₅, Y¹ = S, Y⁴ = O;

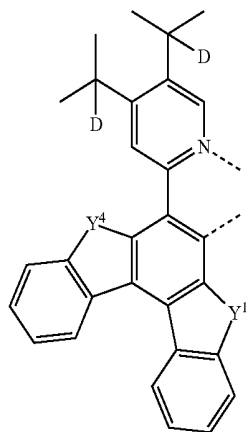
Ligand L₄₂₁₆ through L₄₂₂₀, each represented by the formula

wherein in ligand L₄₂₁₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₁₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₁₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₁₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₂₀, Y¹ = S, Y⁴ = O;

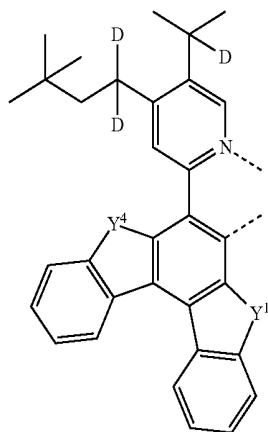
Ligand L₄₂₂₆ through L₄₂₃₀, each represented by the formula

wherein in ligand L₄₂₂₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₂₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₂₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₂₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₃₀, Y¹ = S, Y⁴ = O;

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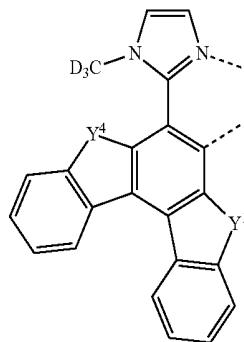
Ligand L₄₂₃₁ through L₄₂₃₅, each represented by the formula

wherein in ligand L₄₂₃₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₃₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₃₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₃₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₃₅, Y¹ = S, Y⁴ = O;

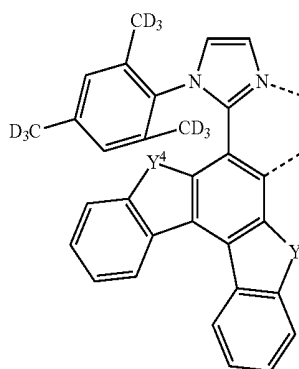
Ligand L₄₂₃₆ through L₄₂₄₀, each represented by the formula

wherein in ligand L₄₂₃₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₃₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₃₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₃₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₄₀, Y¹ = S, Y⁴ = O;

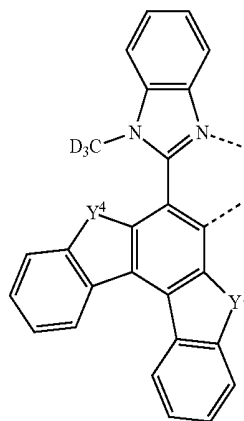
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Ligand L₄₂₄₁ through L₄₂₄₅, each represented by the formula

wherein in ligand L₄₂₄₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₄₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₄₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₄₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₄₅, Y¹ = S, Y⁴ = O;

Ligand L₄₂₄₆ through L₄₂₅₀, each represented by the formula

wherein in ligand L₄₂₄₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₄₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₄₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₄₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₅₀, Y¹ = S, Y⁴ = O;

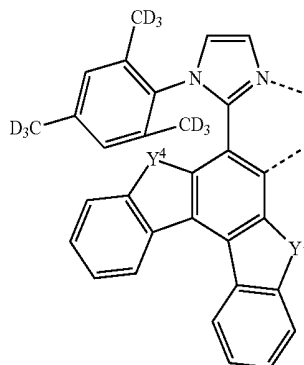
Ligand L₄₂₅₁ through L₄₂₅₅, each represented by the formula

wherein in ligand L₄₂₅₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₅₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₅₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

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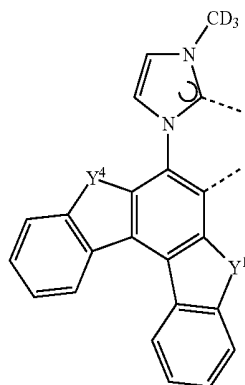
in ligand L_{4254} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4255} , $Y^1 = S$, $Y^4 = O$;

Ligand L_{4256} through L_{4260} , each represented by the formula



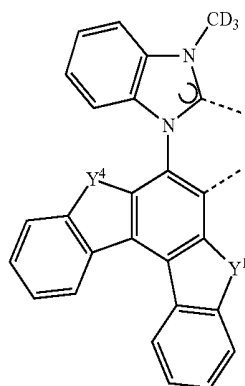
wherein in ligand L_{4256} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4257} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4258} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4259} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4260} , $Y^1 = S$, $Y^4 = O$;

Ligand L_{4261} through L_{4265} , each represented by the formula



wherein in ligand L_{4261} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4262} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4263} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4264} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4265} , $Y^1 = S$, $Y^4 = O$;

Ligand L_{4266} through L_{4270} , each represented by the formula



wherein in ligand L_{4266} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4267} , $Y^1 = S$, $Y^4 = S$;

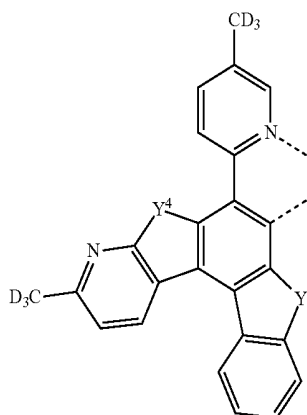
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in ligand L_{4268} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

in ligand L_{4269} , $Y^1 = O$, $Y^4 = S$;

in ligand L_{4270} , $Y^1 = S$, $Y^4 = O$;

Ligand L_{4271} through L_{4275} , each represented by the formula



wherein in ligand L_{4271} , $Y^1 = O$, $Y^4 = O$;

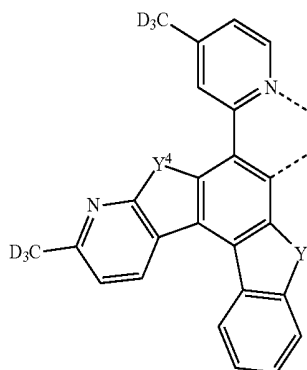
in ligand L_{4272} , $Y^1 = S$, $Y^4 = S$;

in ligand L_{4273} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

in ligand L_{4274} , $Y^1 = O$, $Y^4 = S$;

in ligand L_{4275} , $Y^1 = S$, $Y^4 = O$;

Ligand L_{4276} through L_{4280} , each represented by the formula



wherein in ligand L_{4276} , $Y^1 = O$, $Y^4 = O$;

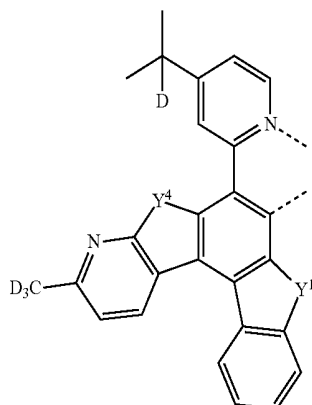
in ligand L_{4277} , $Y^1 = S$, $Y^4 = S$;

in ligand L_{4278} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

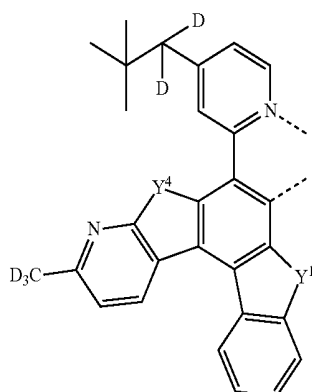
in ligand L_{4279} , $Y^1 = O$, $Y^4 = S$;

in ligand L_{4280} , $Y^1 = S$, $Y^4 = O$;

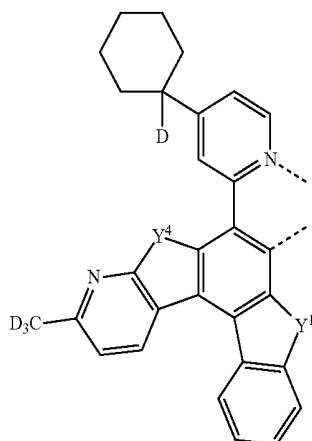
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Ligand L₄₂₈₁ through L₄₂₈₅, each represented by the formula

wherein in ligand L₄₂₈₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₈₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₈₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₈₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₈₅, Y¹ = S, Y⁴ = O;

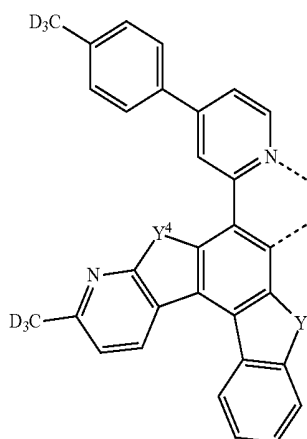
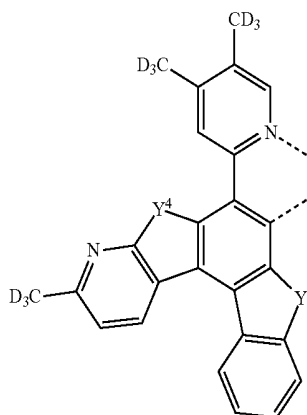
Ligand L₄₂₈₆ through L₄₂₉₀, each represented by the formula

wherein in ligand L₄₂₈₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₈₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₈₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₈₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₉₀, Y¹ = S, Y⁴ = O;

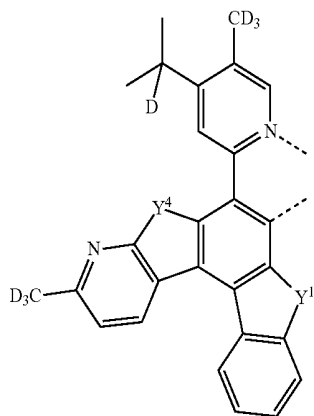
Ligand L₄₂₉₁ through L₄₂₉₅, each represented by the formula

wherein in ligand L₄₂₉₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₉₂, Y¹ = S, Y⁴ = S;

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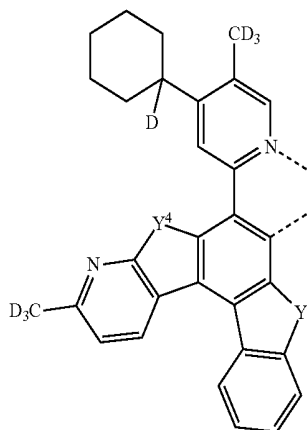
in ligand L₄₂₉₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₂₉₄, Y¹ = O, Y⁴ = S;in ligand L₄₂₉₅, Y¹ = S, Y⁴ = O;Ligand L₄₂₉₆ through L₄₃₀₀, each represented by the formulawherein in ligand L₄₂₉₆, Y¹ = O, Y⁴ = O;in ligand L₄₂₉₇, Y¹ = S, Y⁴ = S;in ligand L₄₂₉₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₂₉₉, Y¹ = O, Y⁴ = S;in ligand L₄₃₀₀, Y¹ = S, Y⁴ = O;Ligand L₄₃₀₁ through L₄₃₀₅, each represented by the formulawherein in ligand L₄₃₀₁, Y¹ = O, Y⁴ = O;in ligand L₄₃₀₂, Y¹ = S, Y⁴ = S;in ligand L₄₃₀₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₃₀₄, Y¹ = O, Y⁴ = S;in ligand L₄₃₀₅, Y¹ = S, Y⁴ = O;

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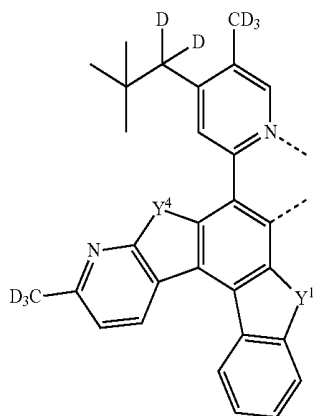
Ligand L_{4306} through L_{4310} , each represented by the formula

wherein in ligand L_{4306} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4307} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4308} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4309} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4310} , $Y^1 = S$, $Y^4 = O$;

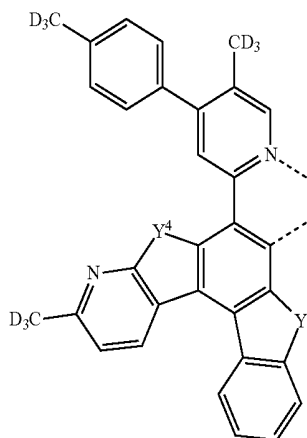
-continued

Ligand L_{4316} through L_{4320} , each represented by the formula

wherein in ligand L_{4316} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4317} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4318} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4319} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4320} , $Y^1 = S$, $Y^4 = O$;

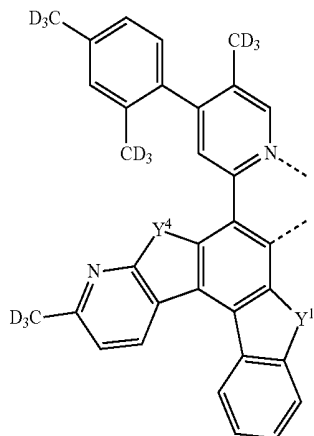
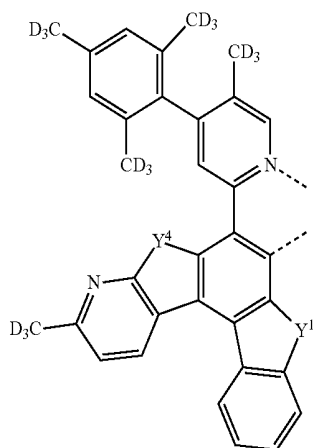
Ligand L_{4311} through L_{4315} , each represented by the formula

wherein in ligand L_{4311} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4312} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4313} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4314} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4315} , $Y^1 = S$, $Y^4 = O$;

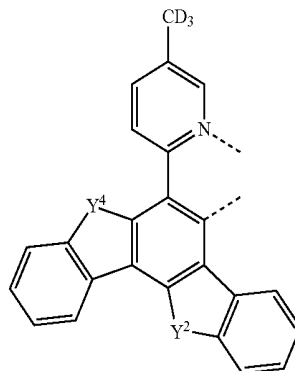
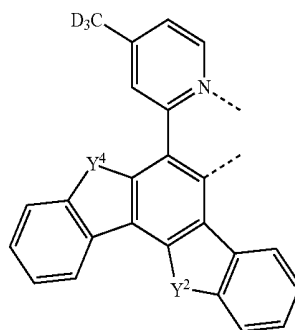
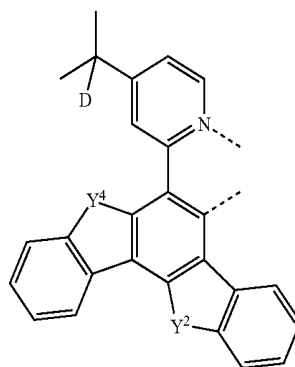
Ligand L_{4321} through L_{4325} , each represented by the formula

wherein in ligand L_{4321} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4322} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4323} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4324} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4325} , $Y^1 = S$, $Y^4 = O$;

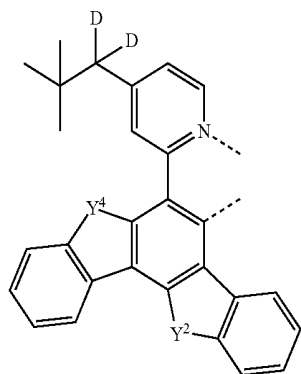
-continued

Ligand L₄₃₂₆ through L₄₃₃₀, each represented by the formulawherein in ligand L₄₃₂₆, Y¹ = O, Y⁴ = O;in ligand L₄₃₂₇, Y¹ = S, Y⁴ = S;in ligand L₄₃₂₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₃₂₉, Y¹ = O, Y⁴ = S;in ligand L₄₃₃₀, Y¹ = S, Y⁴ = O;Ligand L₄₃₃₁ through L₄₃₃₅, each represented by the formulawherein in ligand L₄₃₃₁, Y¹ = O, Y⁴ = O;in ligand L₄₃₃₂, Y¹ = S, Y⁴ = S;in ligand L₄₃₃₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₃₃₄, Y¹ = O, Y⁴ = S;in ligand L₄₃₃₅, Y¹ = S, Y⁴ = O;

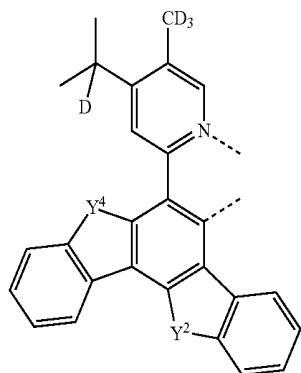
-continued

Ligand L₄₃₃₆ through L₄₃₄₀, each represented by the formulawherein in ligand L₄₃₃₆, Y² = O, Y⁴ = O;in ligand L₄₃₃₇, Y² = S, Y⁴ = S;in ligand L₄₃₃₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₃₃₉, Y² = O, Y⁴ = S;in ligand L₄₃₄₀, Y² = S, Y⁴ = O;Ligand L₄₃₄₁ through L₄₃₄₅, each represented by the formulawherein in ligand L₄₃₄₁, Y² = O, Y⁴ = O;in ligand L₄₃₄₂, Y² = S, Y⁴ = S;in ligand L₄₃₄₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₃₄₄, Y² = O, Y⁴ = S;in ligand L₄₃₄₅, Y² = S, Y⁴ = O;Ligand L₄₃₄₆ through L₄₃₅₀, each represented by the formulawherein in ligand L₄₃₄₆, Y² = O, Y⁴ = O;in ligand L₄₃₄₇, Y² = S, Y⁴ = S;in ligand L₄₃₄₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₃₄₉, Y² = O, Y⁴ = S;in ligand L₄₃₅₀, Y² = S, Y⁴ = O;

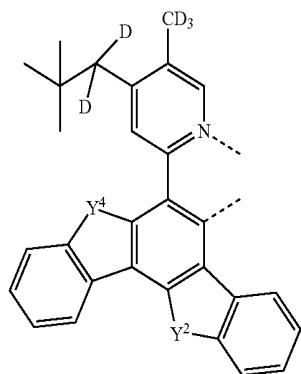
-continued

Ligand L₄₃₅₁ through L₄₃₅₅, each represented by the formula

wherein in ligand L₄₃₅₁, Y² = O, Y⁴ = O;
 in ligand L₄₃₅₂, Y² = S, Y⁴ = S;
 in ligand L₄₃₅₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₅₄, Y² = O, Y⁴ = S;
 in ligand L₄₃₅₅, Y² = S, Y⁴ = O;

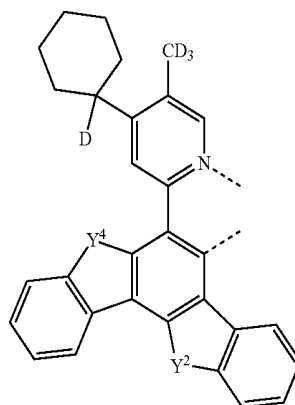
Ligand L₄₃₅₆ through L₄₃₆₀, each represented by the formula

wherein in ligand L₄₃₅₆, Y² = O, Y⁴ = O;
 in ligand L₄₃₅₇, Y² = S, Y⁴ = S;
 in ligand L₄₃₅₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₅₉, Y² = O, Y⁴ = S;
 in ligand L₄₃₆₀, Y² = S, Y⁴ = O;

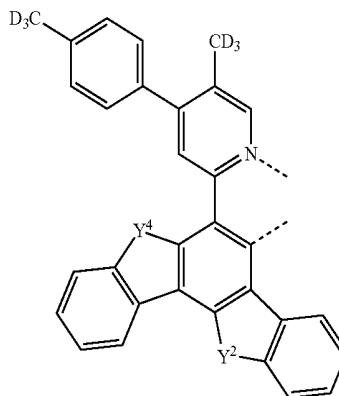
Ligand L₄₃₆₁ through L₄₃₆₅, each represented by the formula

wherein in ligand L₄₃₆₁, Y² = O, Y⁴ = O;
 in ligand L₄₃₆₂, Y² = S, Y⁴ = S;
 in ligand L₄₃₆₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₆₄, Y² = O, Y⁴ = S;
 in ligand L₄₃₆₅, Y² = S, Y⁴ = O;

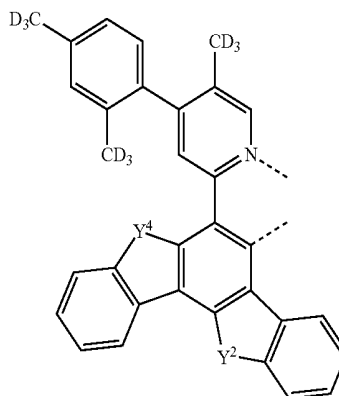
-continued

Ligand L₄₃₆₆ through L₄₃₇₀, each represented by the formula

wherein in ligand L₄₃₆₆, Y² = O, Y⁴ = O;
 in ligand L₄₃₆₇, Y² = S, Y⁴ = S;
 in ligand L₄₃₆₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₆₉, Y² = O, Y⁴ = S;
 in ligand L₄₃₇₀, Y² = S, Y⁴ = O;

Ligand L₄₃₇₁ through L₄₃₇₅, each represented by the formula

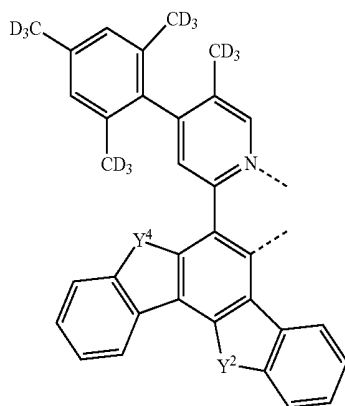
wherein in ligand L₄₃₇₁, Y² = O, Y⁴ = O;
 in ligand L₄₃₇₂, Y² = S, Y⁴ = S;
 in ligand L₄₃₇₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₇₄, Y² = O, Y⁴ = S;
 in ligand L₄₃₇₅, Y² = S, Y⁴ = O;

Ligand L₄₃₇₆ through L₄₃₈₀, each represented by the formula

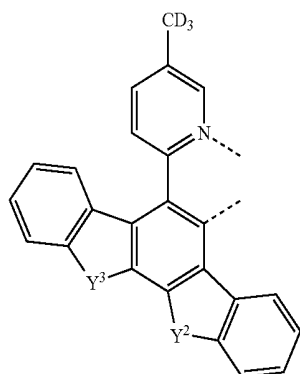
wherein in ligand L₄₃₇₆, Y² = O, Y⁴ = O;
 in ligand L₄₃₇₇, Y² = S, Y⁴ = S;

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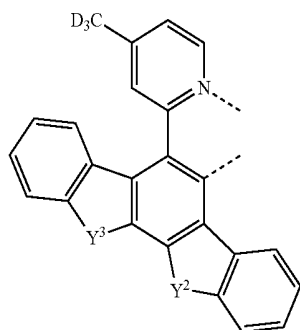
in ligand L₄₃₇₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₇₉, Y² = O, Y⁴ = S;
 in ligand L₄₃₈₀, Y² = S, Y⁴ = O;

Ligand L₄₃₈₁ through L₄₃₈₅, each represented by the formula

wherein in ligand L₄₃₈₁, Y² = O, Y⁴ = O;
 in ligand L₄₃₈₂, Y² = S, Y⁴ = S;
 in ligand L₄₃₈₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₈₄, Y² = O, Y⁴ = S;
 in ligand L₄₃₈₅, Y² = S, Y⁴ = O;

Ligand L₄₃₈₆ through L₄₃₉₀, each represented by the formula

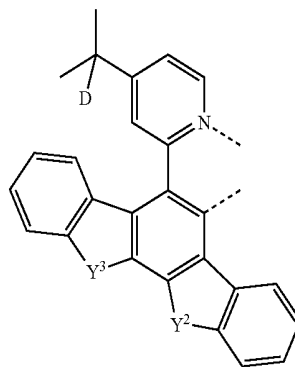
wherein in ligand L₄₃₈₆, Y² = O, Y⁴ = O;
 in ligand L₄₃₈₇, Y² = S, Y⁴ = S;
 in ligand L₄₃₈₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₈₉, Y² = O, Y⁴ = S;
 in ligand L₄₃₉₀, Y² = S, Y⁴ = O;

Ligand L₄₃₉₁ through L₄₃₉₅, each represented by the formula

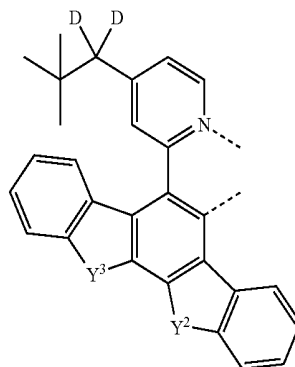
wherein in ligand L₄₃₉₁, Y² = O, Y⁴ = O;
 in ligand L₄₃₉₂, Y² = S, Y⁴ = S;

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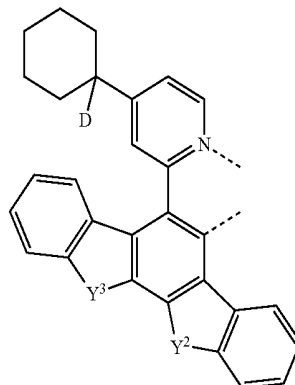
in ligand L₄₃₉₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₉₄, Y² = O, Y⁴ = S;
 in ligand L₄₃₉₅, Y² = S, Y⁴ = O;

Ligand L₄₃₉₆ through L₄₄₀₀, each represented by the formula

wherein in ligand L₄₃₉₆, Y² = O, Y⁴ = O;
 in ligand L₄₃₉₇, Y² = S, Y⁴ = S;
 in ligand L₄₃₉₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₉₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₀₀, Y² = S, Y⁴ = O;

Ligand L₄₄₀₁ through L₄₄₀₅, each represented by the formula

wherein in ligand L₄₄₀₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₀₂, Y² = S, Y⁴ = S;
 in ligand L₄₄₀₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₀₄, Y² = O, Y⁴ = S;
 in ligand L₄₄₀₅, Y² = S, Y⁴ = O;

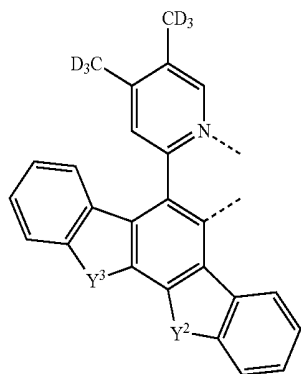
Ligand L₄₄₀₆ through L₄₄₁₀, each represented by the formula

wherein in ligand L₄₄₀₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₀₇, Y² = S, Y⁴ = S;

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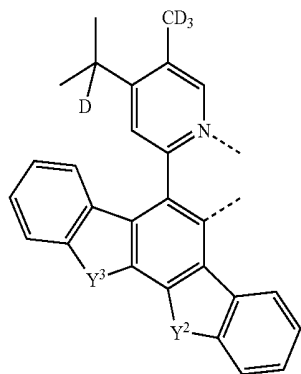
in ligand L₄₄₀₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₀₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₁₀, Y² = S, Y⁴ = O;

Ligand L₄₄₁₁ through L₄₄₁₅, each represented by the formula



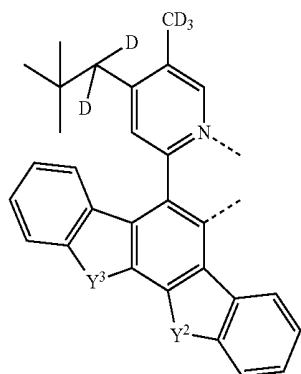
wherein in ligand L₄₄₁₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₁₂, Y² = S, Y⁴ = S;
 in ligand L₄₄₁₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₁₄, Y² = O, Y⁴ = S;
 in ligand L₄₄₁₅, Y² = S, Y⁴ = O;

Ligand L₄₄₁₆ through L₄₄₂₀, each represented by the formula



wherein in ligand L₄₄₁₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₁₇, Y² = S, Y⁴ = S;
 in ligand L₄₄₁₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₁₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₂₀, Y² = S, Y⁴ = O;

Ligand L₄₄₁₆ through L₄₄₂₀, each represented by the formula

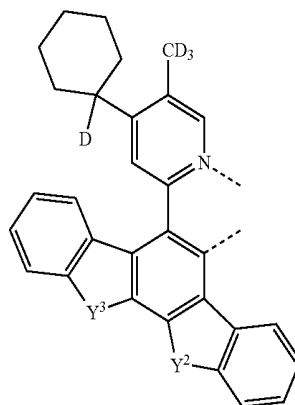


wherein in ligand L₄₄₁₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₁₇, Y² = S, Y⁴ = S;

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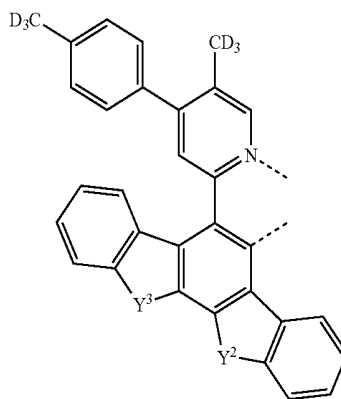
in ligand L₄₄₁₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₁₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₂₀, Y² = S, Y⁴ = O;

Ligand L₄₄₂₁ through L₄₄₂₅, each represented by the formula



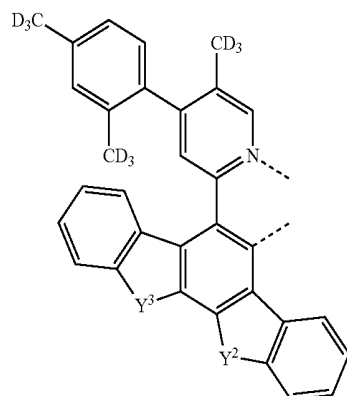
wherein in ligand L₄₄₂₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₂₂, Y² = S, Y⁴ = S;
 in ligand L₄₄₂₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₂₄, Y² = O, Y⁴ = S;
 in ligand L₄₄₂₅, Y² = S, Y⁴ = O;

Ligand L₄₄₂₆ through L₄₄₃₀, each represented by the formula

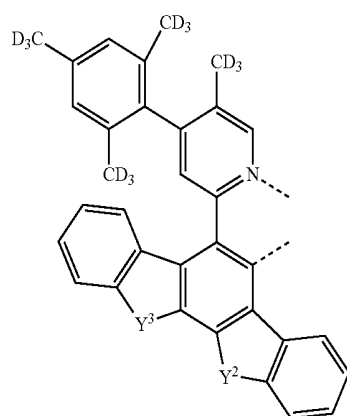


wherein in ligand L₄₄₂₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₂₇, Y² = S, Y⁴ = S;
 in ligand L₄₄₂₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₂₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₃₀, Y² = S, Y⁴ = O;

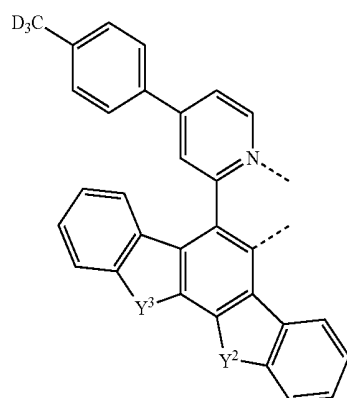
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Ligand L₄₄₃₁ through L₄₄₃₅, each represented by the formula

wherein in ligand L₄₄₃₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₃₂, Y² = S, Y⁴ = S;
 in ligand L₄₄₃₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₃₄, Y² = O, Y⁴ = S;
 in ligand L₄₄₃₅, Y² = S, Y⁴ = O;

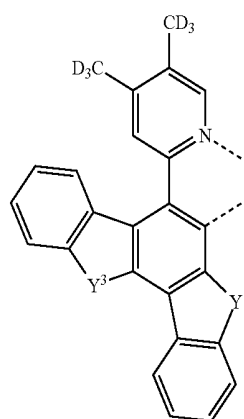
Ligand L₄₄₃₆ through L₄₄₄₀, each represented by the formula

wherein in ligand L₄₄₃₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₃₇, Y² = S, Y⁴ = S;
 in ligand L₄₄₃₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₃₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₄₀, Y² = S, Y⁴ = O;

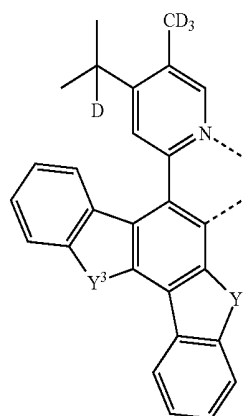
Ligand L₄₄₄₁ through L₄₄₄₅, each represented by the formula

wherein in ligand L₄₄₄₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₄₂, Y² = S, Y⁴ = S;

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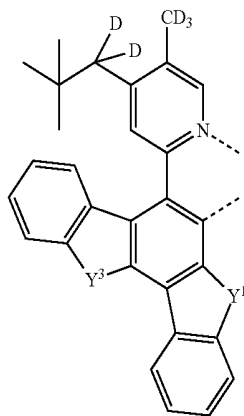
in ligand L₄₄₄₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₄₄₄, Y² = O, Y⁴ = S;in ligand L₄₄₄₅, Y² = S, Y⁴ = O;Ligand L₄₄₄₆ through L₄₄₅₀, each represented by the formula

wherein in ligand L₄₄₄₆, Y¹ = O, Y³ = O;
 in ligand L₄₄₄₇, Y¹ = S, Y³ = S;
 in ligand L₄₄₄₈, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;
 in ligand L₄₄₄₉, Y¹ = O, Y³ = S;
 in ligand L₄₄₅₀, Y¹ = S, Y³ = O;

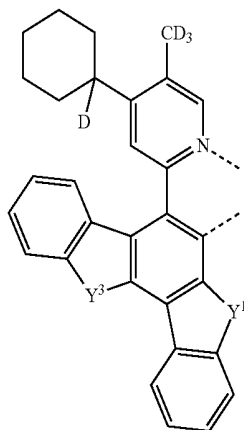
Ligand L₄₄₅₁ through L₄₄₅₅, each represented by the formula

wherein in ligand L₄₄₅₁, Y¹ = O, Y³ = O;
 in ligand L₄₄₅₂, Y¹ = S, Y³ = S;
 in ligand L₄₄₅₃, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;
 in ligand L₄₄₅₄, Y¹ = O, Y³ = S;
 in ligand L₄₄₅₅, Y¹ = S, Y³ = O;

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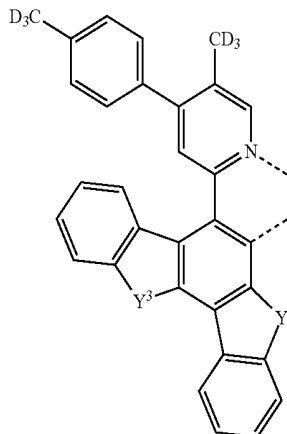
Ligand L₄₄₅₆ through L₄₄₆₀, each represented by the formula

wherein in ligand L₄₄₅₆, Y¹ = O, Y³ = O;
 in ligand L₄₄₅₇, Y¹ = S, Y³ = S;
 in ligand L₄₄₅₈, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;
 in ligand L₄₄₅₉, Y¹ = O, Y³ = S;
 in ligand L₄₄₆₀, Y¹ = S, Y³ = O;

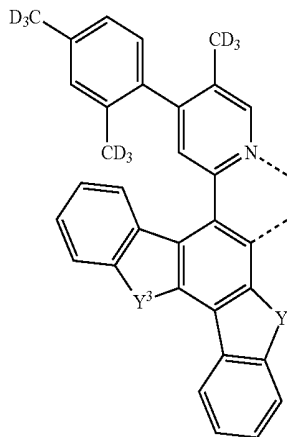
Ligand L₄₄₆₁ through L₄₄₆₅, each represented by the formula

wherein in ligand L₄₄₆₁, Y¹ = O, Y³ = O;
 in ligand L₄₄₆₂, Y¹ = S, Y³ = S;
 in ligand L₄₄₆₃, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;
 in ligand L₄₄₆₄, Y¹ = O, Y³ = S;
 in ligand L₄₄₆₅, Y¹ = S, Y³ = O;

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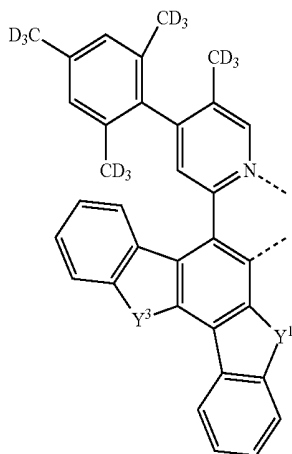
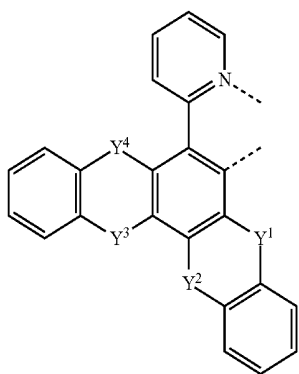
Ligand L₄₄₆₆ through L₄₄₇₀, each represented by the formula

wherein in ligand L₄₄₆₆, Y¹ = O, Y³ = O;
 in ligand L₄₄₆₇, Y¹ = S, Y³ = S;
 in ligand L₄₄₆₈, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;
 in ligand L₄₄₆₉, Y¹ = O, Y³ = S;
 in ligand L₄₄₇₀, Y¹ = S, Y³ = O;

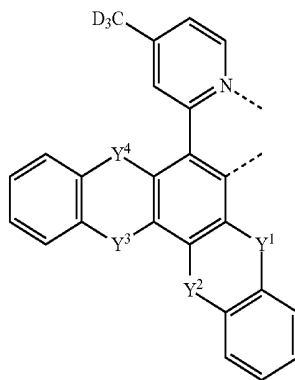
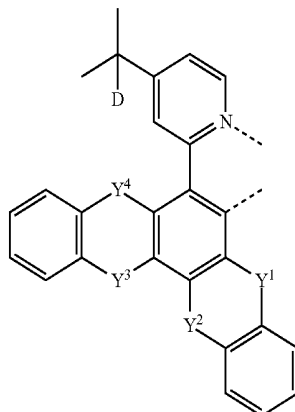
Ligand L₄₄₇₁ through L₄₄₇₅, each represented by the formula

wherein in ligand L₄₄₇₁, Y¹ = O, Y³ = O;
 in ligand L₄₄₇₂, Y¹ = S, Y³ = S;
 in ligand L₄₄₇₃, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;
 in ligand L₄₄₇₄, Y¹ = O, Y³ = S;
 in ligand L₄₄₇₅, Y¹ = S, Y³ = O;

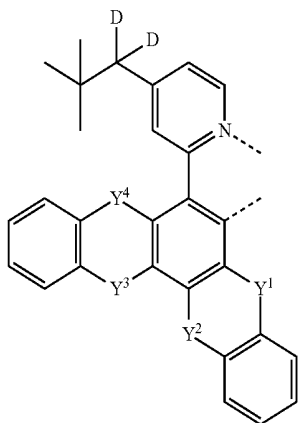
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Ligand L₄₄₇₆ through L₄₄₈₀, each represented by the formulawherein in ligand L₄₄₇₆, Y¹ = O, Y³ = O;in ligand L₄₄₇₇, Y¹ = S, Y³ = S;in ligand L₄₄₇₈, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;in ligand L₄₄₇₉, Y¹ = O, Y³ = S;in ligand L₄₄₈₀, Y¹ = S, Y³ = O;Ligand L₄₄₈₁ through L₄₄₈₅, each represented by the formulawherein in ligand L₄₄₈₁, Y¹ = O, Y² = O, Y³ = O, Y⁴ = O;in ligand L₄₄₈₂, Y¹ = S, Y² = S, Y³ = S, Y⁴ = S;in ligand L₄₄₈₃, Y¹ = O, Y² = O, Y³ = S, Y⁴ = S;in ligand L₄₄₈₄, Y¹ = O, Y² = S, Y³ = S, Y⁴ = O;in ligand L₄₄₈₅, Y¹ = C(CH₃)₂, Y² = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

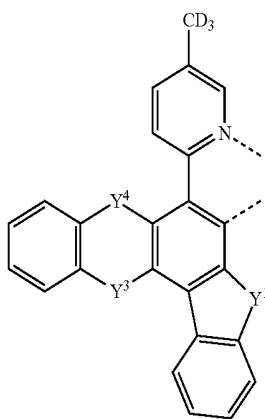
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Ligand L₄₄₈₆ through L₄₄₉₀, each represented by the formulawherein in ligand L₄₄₈₆, Y¹ = O, Y² = O, Y³ = O, Y⁴ = O;in ligand L₄₄₈₇, Y¹ = S, Y² = S, Y³ = S, Y⁴ = S;in ligand L₄₄₈₈, Y¹ = O, Y² = O, Y³ = S, Y⁴ = S;in ligand L₄₄₈₉, Y¹ = O, Y² = S, Y³ = S, Y⁴ = O;in ligand L₄₄₉₀, Y¹ = C(CH₃)₂, Y² = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;Ligand L₄₄₉₁ through L₄₄₉₅, each represented by the formulawherein in ligand L₄₄₉₁, Y¹ = O, Y² = O, Y³ = O, Y⁴ = O;in ligand L₄₄₉₂, Y¹ = S, Y² = S, Y³ = S, Y⁴ = S;in ligand L₄₄₉₃, Y¹ = O, Y² = O, Y³ = S, Y⁴ = S;in ligand L₄₄₉₄, Y¹ = O, Y² = S, Y³ = S, Y⁴ = O;in ligand L₄₄₉₅, Y¹ = C(CH₃)₂, Y² = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

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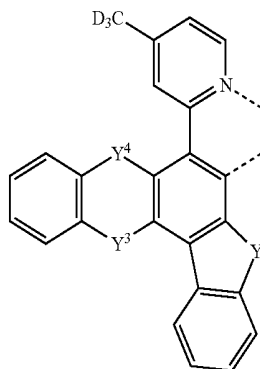
Ligand L₄₄₉₆ through L₄₅₀₀, each represented by the formula

wherein in ligand L₄₄₉₆, Y¹ = O, Y² = O, Y³ = O, Y⁴ = O;
 in ligand L₄₄₉₇, Y¹ = S, Y² = S, Y³ = S, Y⁴ = S;
 in ligand L₄₄₉₈, Y¹ = O, Y² = O, Y³ = S, Y⁴ = S;
 in ligand L₄₄₉₉, Y¹ = O, Y² = S, Y³ = S, Y⁴ = O;
 in ligand L₄₅₀₀, Y¹ = C(CH₃)₂, Y² = C(CH₃)₂, Y³ = C(CH₃)₂,
 Y⁴ = C(CH₃)₂;

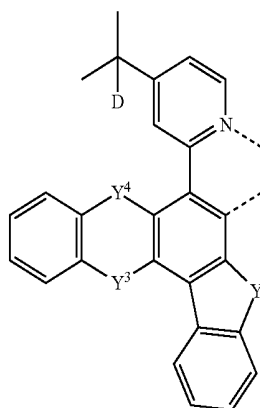
Ligand L₄₅₀₁ through L₄₅₀₅, each represented by the formula

wherein in ligand L₄₅₀₁, Y¹ = O, Y³ = O, Y⁴ = O;
 in ligand L₄₅₀₂, Y¹ = S, Y³ = S, Y⁴ = S;
 in ligand L₄₅₀₃, Y¹ = O, Y³ = S, Y⁴ = S;
 in ligand L₄₅₀₄, Y¹ = S, Y³ = O, Y⁴ = O;
 in ligand L₄₅₀₅, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

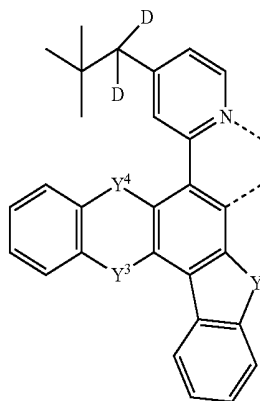
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Ligand L₄₅₀₅ through L₄₅₁₀, each represented by the formula

wherein in ligand L₄₅₀₅, Y¹ = O, Y³ = O, Y⁴ = O;
 in ligand L₄₅₀₆, Y¹ = S, Y³ = S, Y⁴ = S;
 in ligand L₄₅₀₇, Y¹ = O, Y³ = S, Y⁴ = S;
 in ligand L₄₅₀₈, Y¹ = S, Y³ = O, Y⁴ = O;
 in ligand L₄₅₀₉, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

Ligand L₄₅₁₁ through L₄₅₁₅, each represented by the formula

wherein in ligand L₄₅₁₁, Y¹ = O, Y³ = O, Y⁴ = O;
 in ligand L₄₅₁₂, Y¹ = S, Y³ = S, Y⁴ = S;
 in ligand L₄₅₁₃, Y¹ = O, Y³ = S, Y⁴ = S;
 in ligand L₄₅₁₄, Y¹ = S, Y³ = O, Y⁴ = O;
 in ligand L₄₅₁₅, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

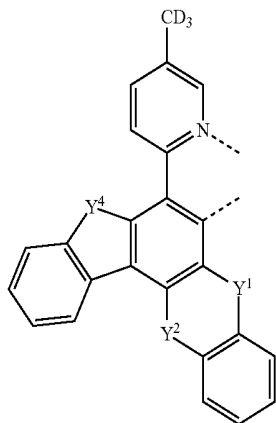
Ligand L₄₅₁₆ through L₄₅₂₀, each represented by the formula

wherein in ligand L₄₅₁₆, Y¹ = O, Y³ = O, Y⁴ = O;
 in ligand L₄₅₁₇, Y¹ = S, Y³ = S, Y⁴ = S;

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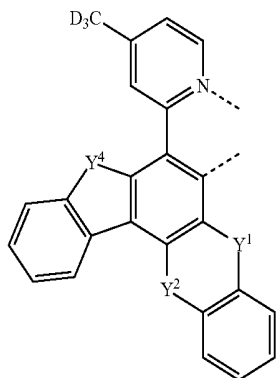
in ligand L_{4518} , $Y^1 = O$, $Y^3 = S$, $Y^4 = S$;
 in ligand L_{4519} , $Y^1 = S$, $Y^3 = O$, $Y^4 = O$;
 in ligand L_{4520} , $Y^1 = C(CH_3)_2$, $Y^3 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

Ligand L_{4521} through L_{4525} , each represented by the formula



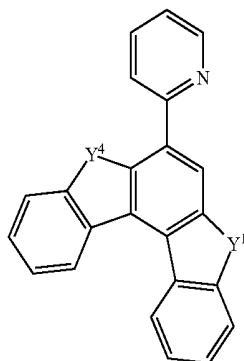
wherein in ligand L_{4521} , $Y^1 = O$, $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4522} , $Y^1 = S$, $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4523} , $Y^1 = O$, $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4524} , $Y^1 = S$, $Y^2 = S$, $Y^4 = O$;
 in ligand L_{4525} , $Y^1 = C(CH_3)_2$, $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

Ligand L_{4526} through L_{4530} , each represented by the formula



wherein in ligand L_{4526} , $Y^1 = O$, $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4527} , $Y^1 = S$, $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4528} , $Y^1 = O$, $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4529} , $Y^1 = S$, $Y^2 = S$, $Y^4 = O$;
 in ligand L_{4530} , $Y^1 = C(CH_3)_2$, $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

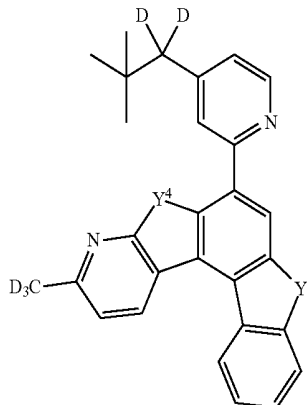
Ligand L_{4531} through L_{4537} , each represented by the formula



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wherein in ligand L_{4531} , $Y^1 = N(CH_3)$, $Y^4 = N(CH_3)$;
 in ligand L_{4532} , $Y^1 = Se$, $Y^4 = Se$;
 in ligand L_{4533} , $Y^1 = Si(CH_3)_2$, $Y^4 = Si(CH_3)_2$;
 in ligand L_{4534} , $Y^1 = O$, $Y^4 = Si(CH_3)_2$;
 in ligand L_{4535} , $Y^1 = O$, $Y^4 = N(CH_3)$;
 in ligand L_{4536} , $Y^1 = S$, $Y^4 = Si(CH_3)_2$;
 in ligand L_{4537} , $Y^1 = S$, $Y^4 = N(CH_3)$;

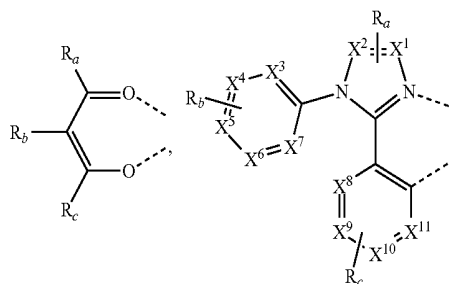
Ligand L_{4538} through L_{4544} , each represented by the formula



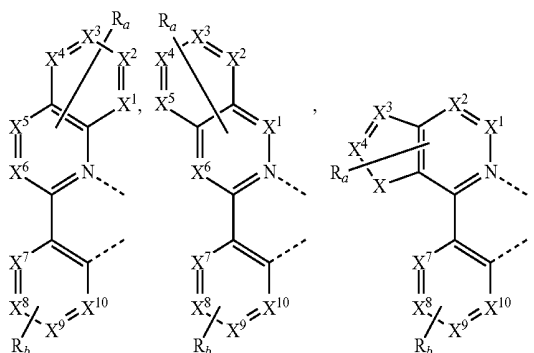
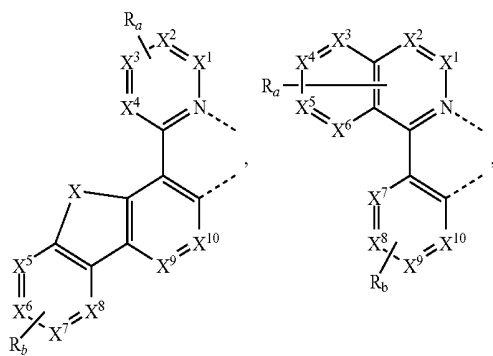
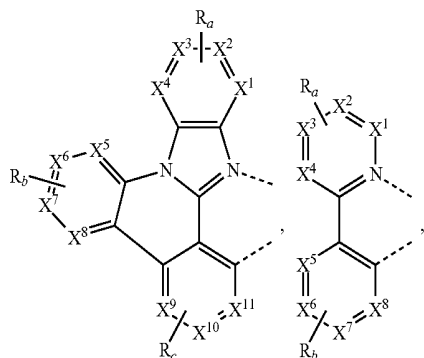
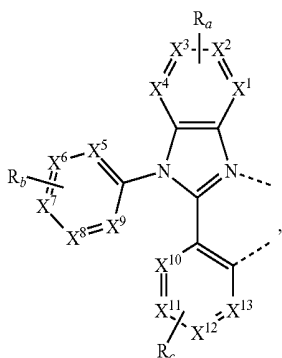
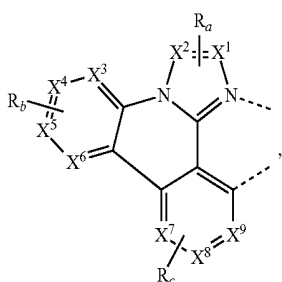
wherein in ligand L_{4538} , $Y^1 = N(CH_3)$, $Y^4 = N(CH_3)$;
 in ligand L_{4539} , $Y^1 = Se$, $Y^4 = Se$;
 in ligand L_{4540} , $Y^1 = Si(CH_3)_2$, $Y^4 = Si(CH_3)_2$;
 in ligand L_{4541} , $Y^1 = O$, $Y^4 = Si(CH_3)_2$;
 in ligand L_{4542} , $Y^1 = O$, $Y^4 = N(CH_3)$;
 in ligand L_{4543} , $Y^1 = S$, $Y^4 = Si(CH_3)_2$; and
 in ligand L_{4544} , $Y^1 = S$, $Y^4 = N(CH_3)$.

[0101] In some embodiments, the compound has a formula of $M(L_A)_x(L_B)_y(L_C)_z$ wherein L_B and L_C are each a bidentate ligand; x is 1, 2, or 3; y is 1, or 2; z is 0, 1, or 2; and $x+y+z$ is the oxidation state of the metal M . In some embodiments having the structure of formula of $M(L_A)_x(L_B)_y(L_C)_z$, the compound has a formula selected from the group consisting of $Ir(L_A)_3$, $Ir(L_A)(L_B)_2$, $Ir(L_A)_2(L_B)$, and $Ir(L_A)(L_B)(L_C)$; and wherein L_A , L_B , and L_C are different from each other. In some embodiments having the structure of formula of $M(L_A)_x(L_B)_y(L_C)_z$, the compound has a formula of $Pt(L_A)(L_B)$; and wherein L_A and L_B can be same or different. In some embodiments having the structure of formula of $M(L_A)_x(L_B)_y(L_C)_z$, L_A and L_B are connected to form a tetradentate ligand. In some embodiments having the structure of formula of $M(L_A)_x(L_B)_y(L_C)_z$, L_A and L_B are connected at two places to form a macrocyclic tetradentate ligand.

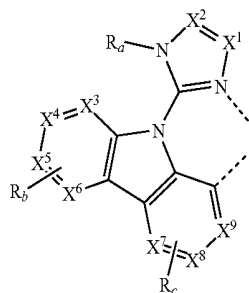
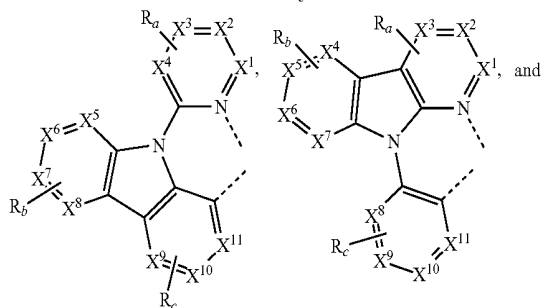
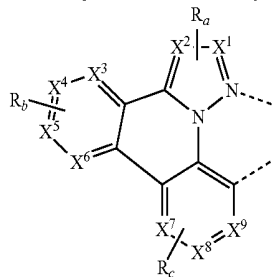
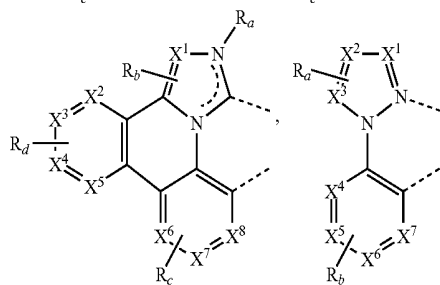
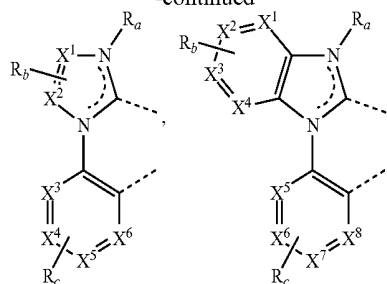
[0102] In some embodiments having the structure of formula of $M(L_A)_x(L_B)_y(L_C)_z$, L_B and L_C are each independently selected from the group consisting of:



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where:

[0103] each X¹ to X¹³ are independently selected from the group consisting of carbon and nitrogen;

[0104] X is selected from the group consisting of BR', NR', PR', O, S, Se, C=O, S=O, SO₂, CR'R'', SiR'R'', and GeR'R'';

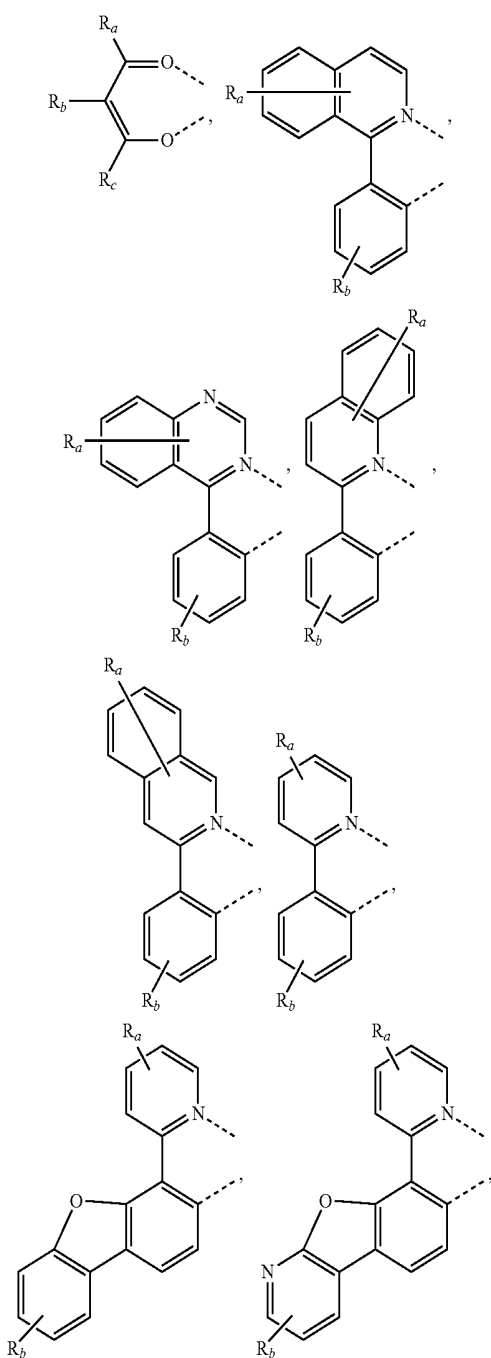
[0105] R' and R'' are optionally fused or joined to form a ring;

[0106] each R_a, R_b, R_c, and R_d may represent from mono substitution to the possible maximum number of substitution, or no substitution;

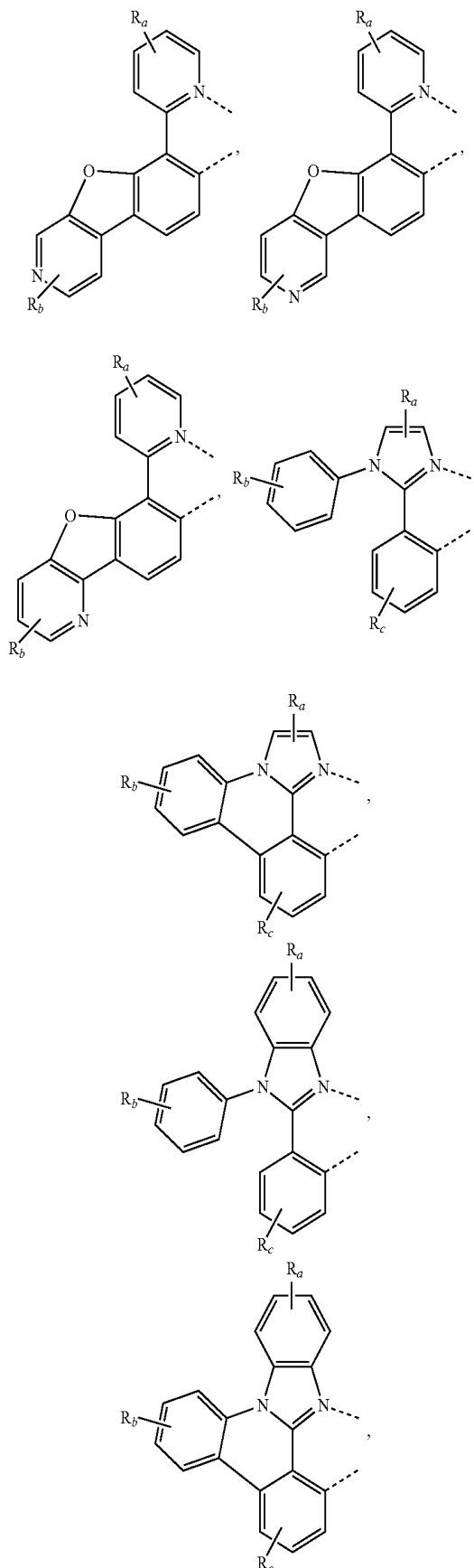
[0107] R', R'', R_a, R_b, R_c, and R_d are each independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof; and

[0108] any two adjacent substituents of R_a, R_b, R_c, and R_d are optionally fused or joined to form a ring or form a multidentate ligand.

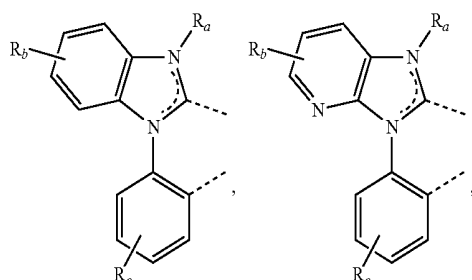
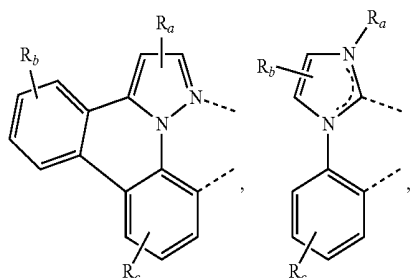
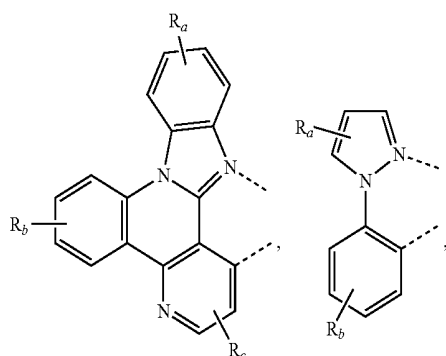
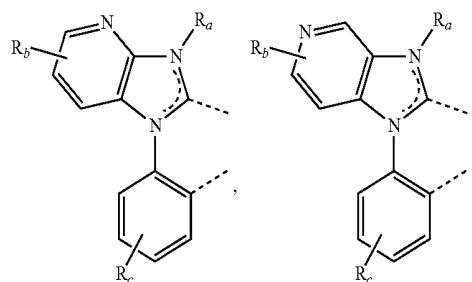
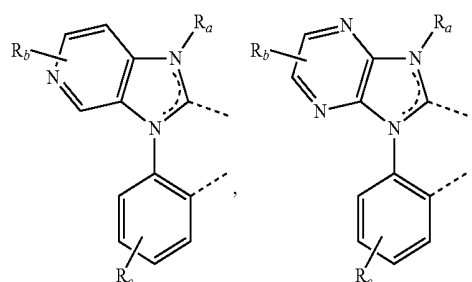
[0109] In some such embodiments, L_B and L_C are each independently selected from the group consisting of:



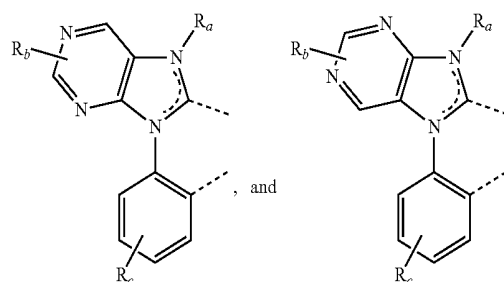
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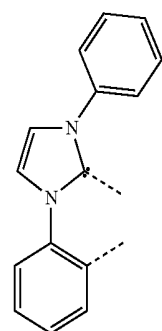
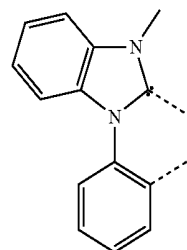
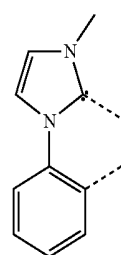
L_{B1}L_{B2}L_{B3}

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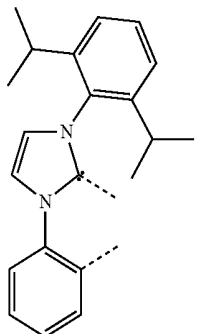


[0110] In some embodiments, the compound is selected from Compound A1 through Compound A544, where Compound Ax has the formula $\text{Ir}(L_{Ai})_3$; $x=i$; and i is an integer from 1 to 544.

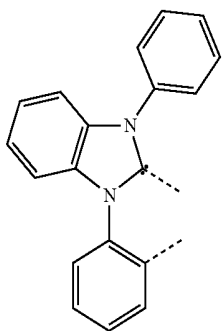
[0111] In some embodiments, the compound is selected from Compound B1 through Compound B254592, where Compound By has the formula $\text{Ir}(L_{Ai})(L_{Bk})_2$; $y=468i+k-468$; i is an integer from 1 to 544, and k is an integer from 1 to 468; and where L_{B1} to L_{B460} have the following structures:



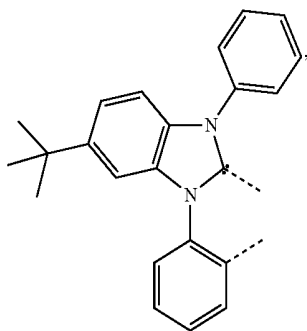
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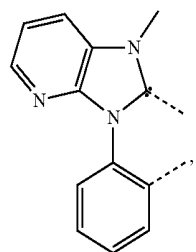
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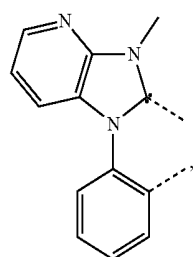
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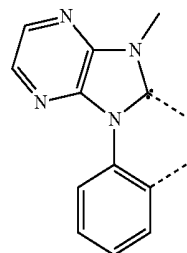


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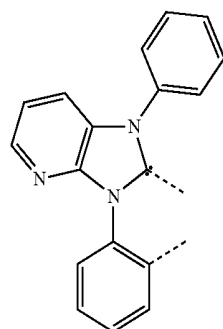


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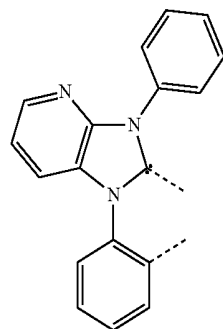
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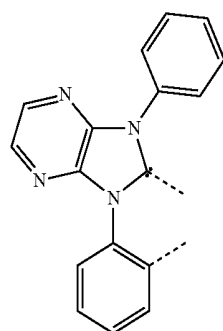
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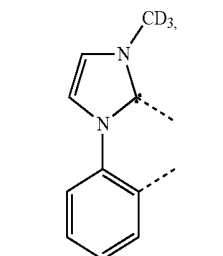
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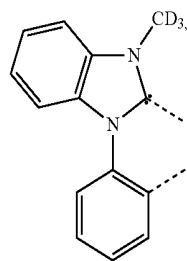


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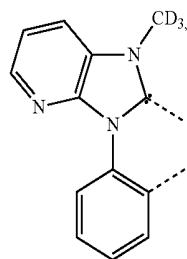


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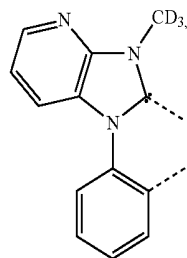
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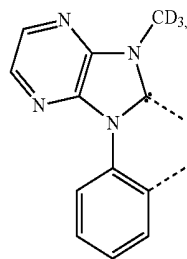
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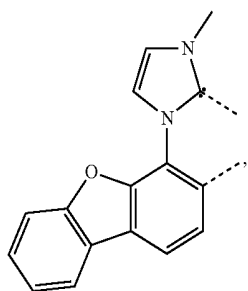
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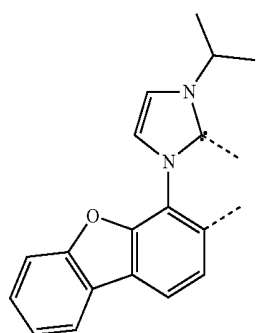


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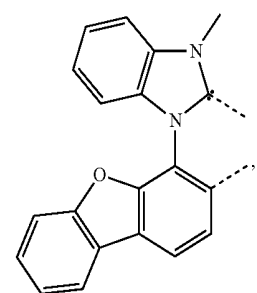


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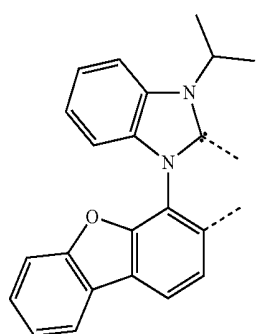
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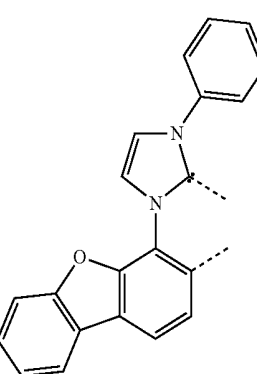
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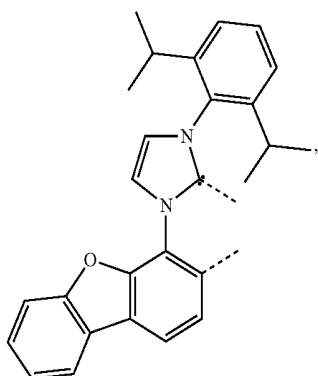


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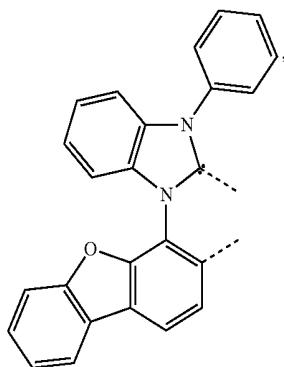


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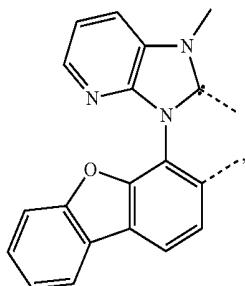
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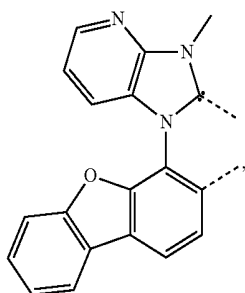
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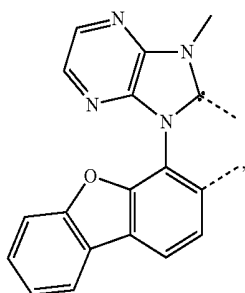
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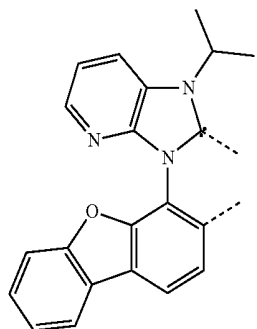


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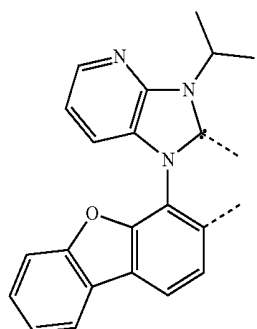


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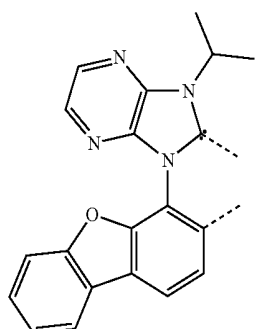
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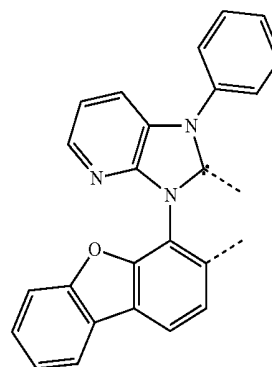
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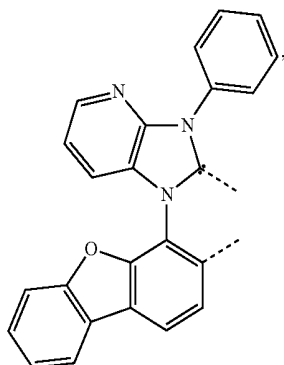


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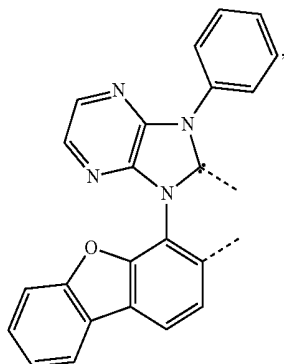


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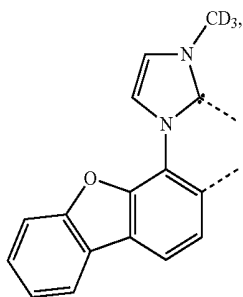
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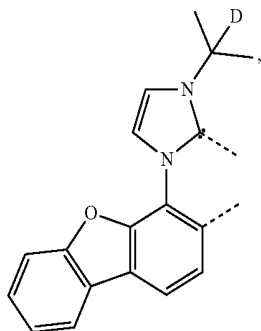
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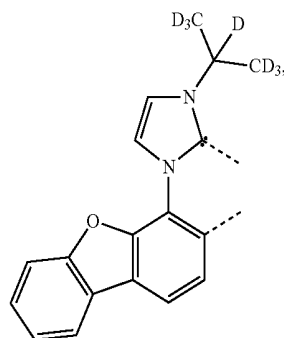


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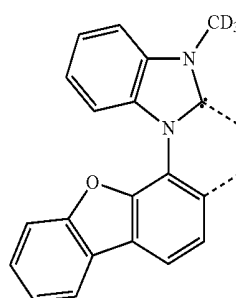


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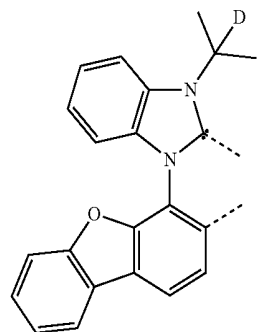
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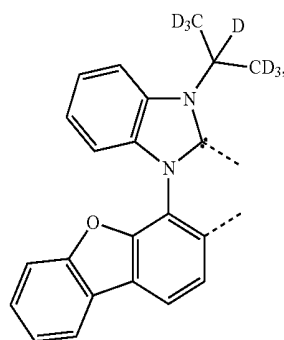
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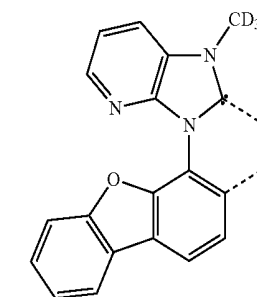
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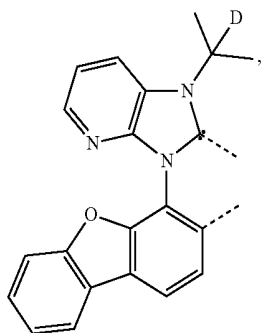


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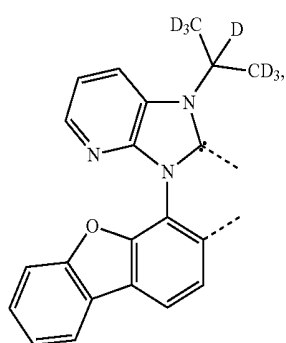


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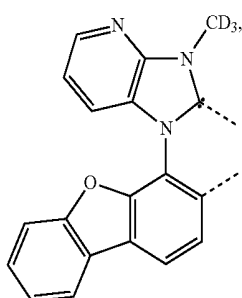
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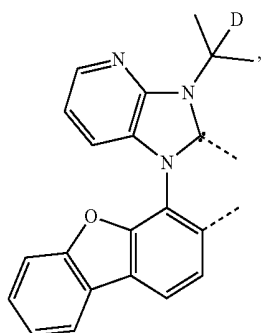
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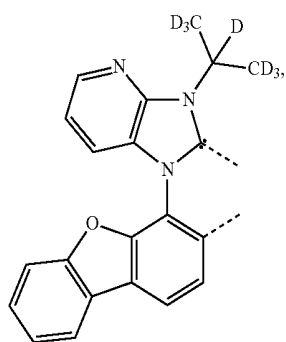
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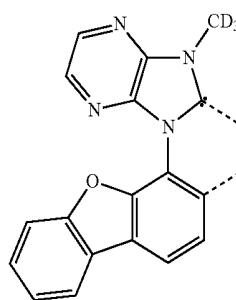


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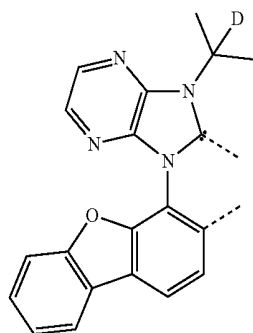


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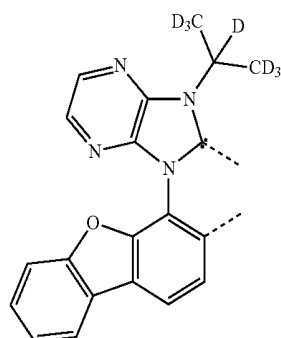
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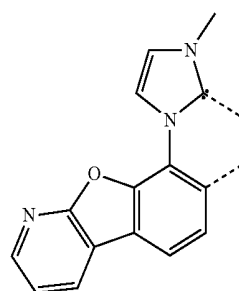
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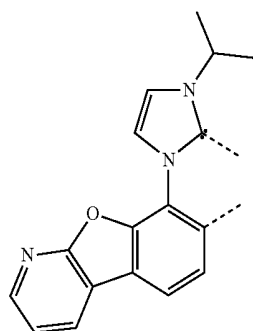
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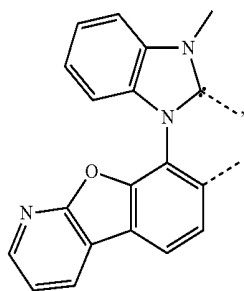


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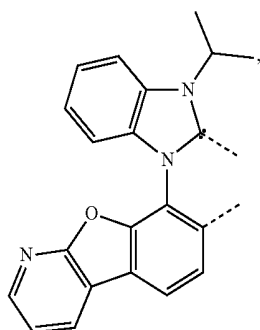


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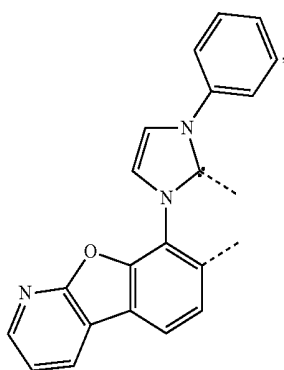
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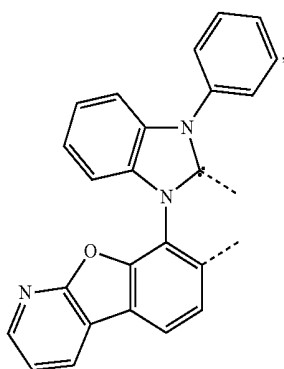
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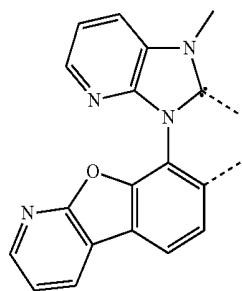


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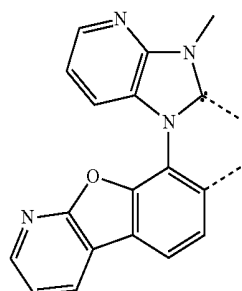


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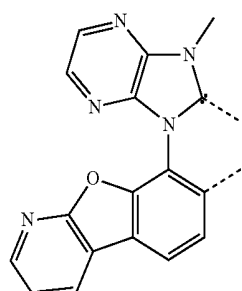
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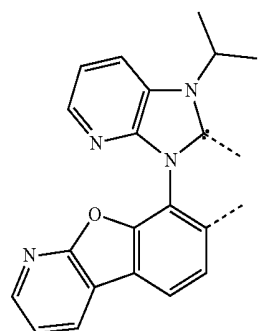
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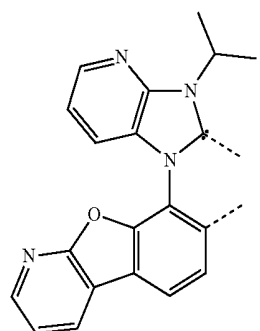
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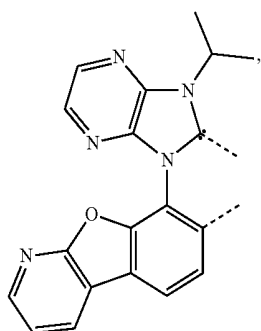


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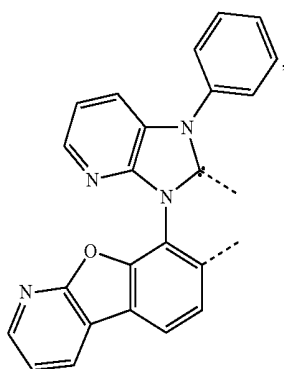


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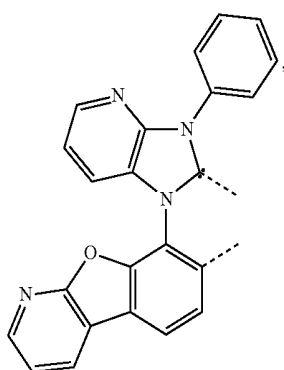
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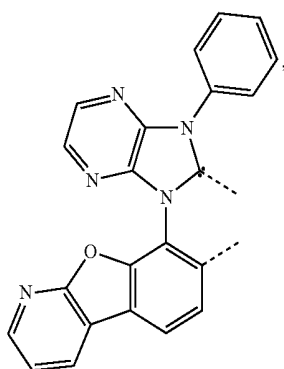
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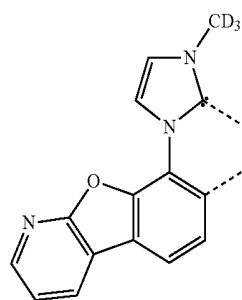


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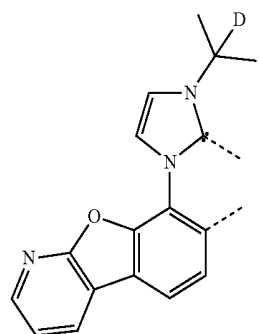


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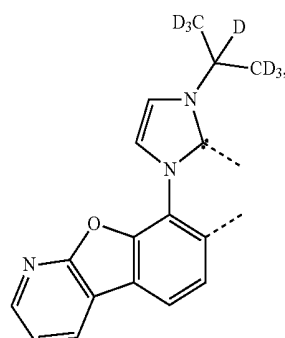
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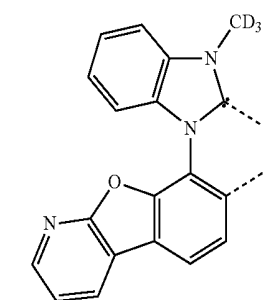
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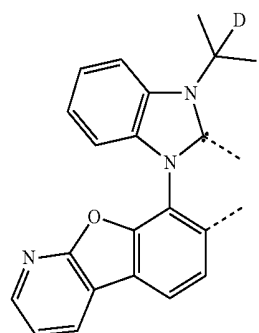
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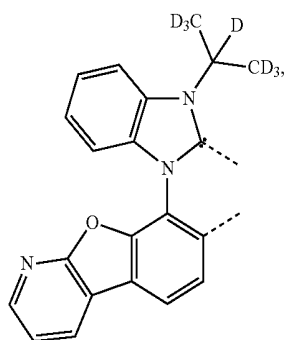
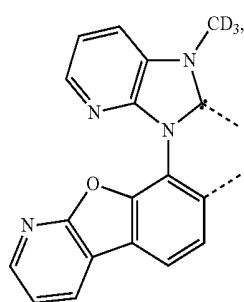
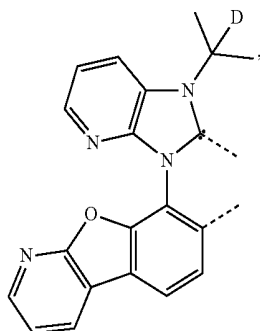
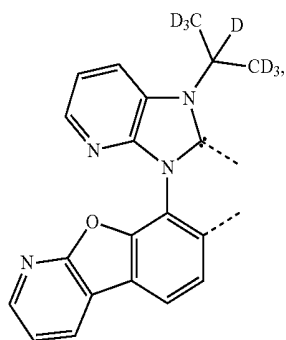
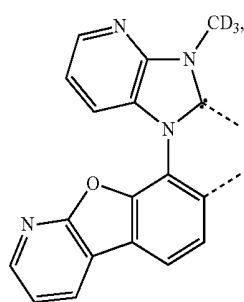


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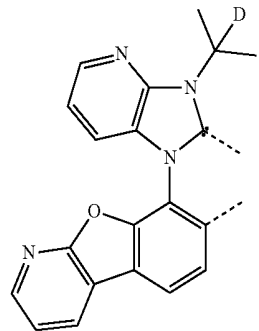
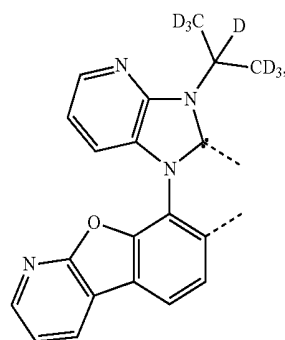
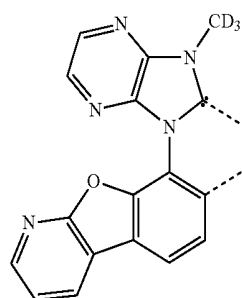
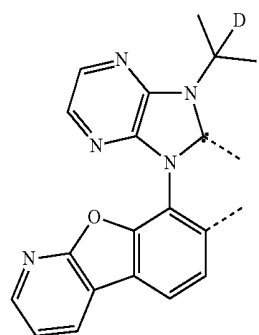
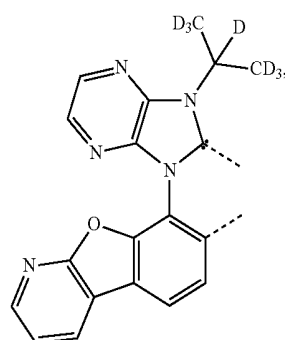


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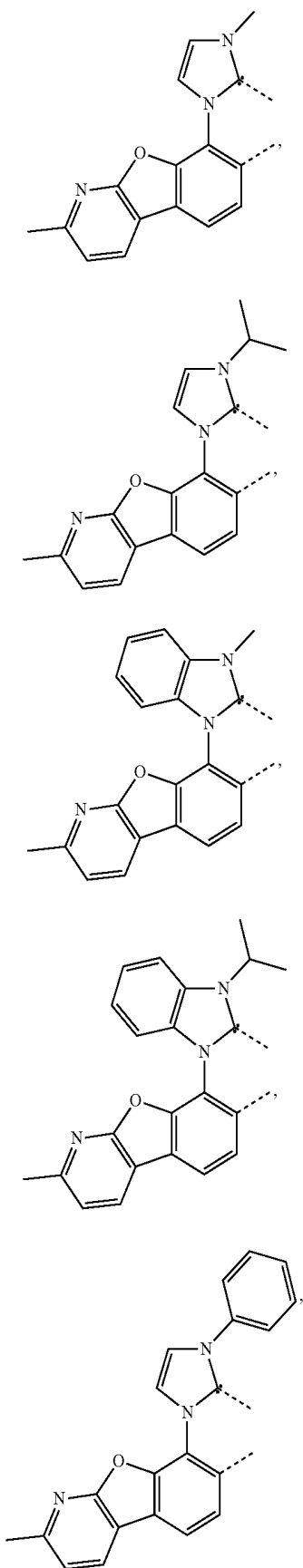
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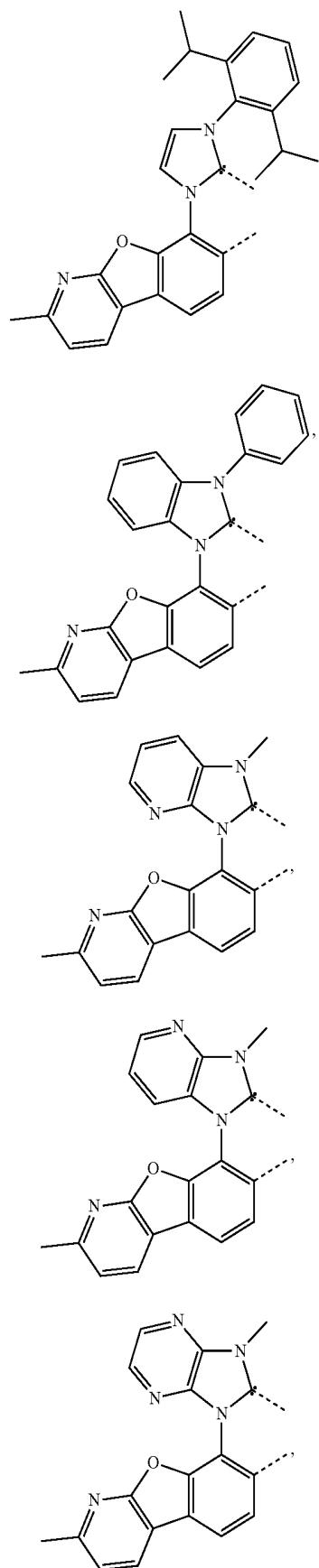
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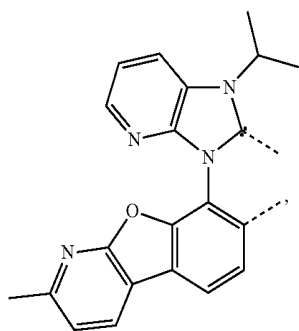
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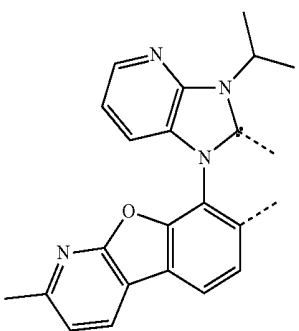
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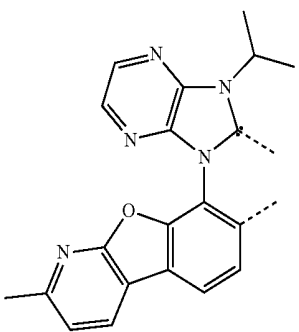
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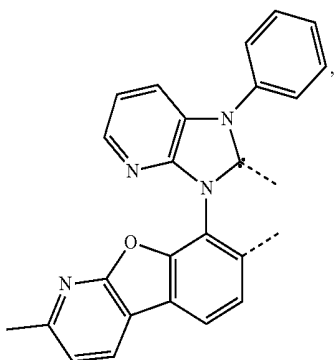
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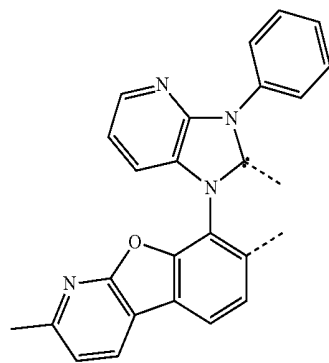


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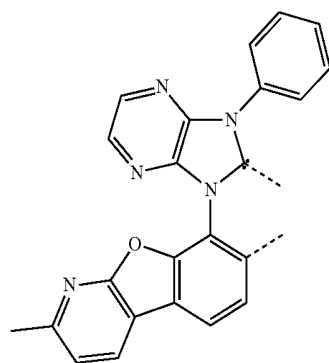


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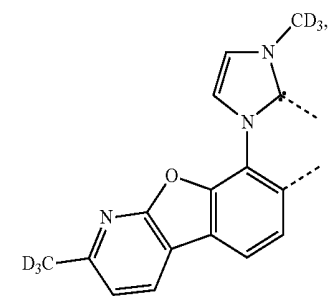
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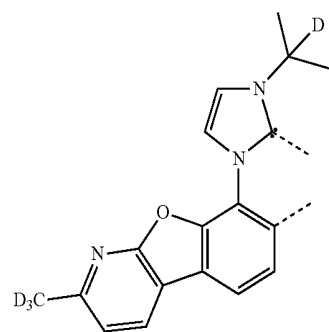
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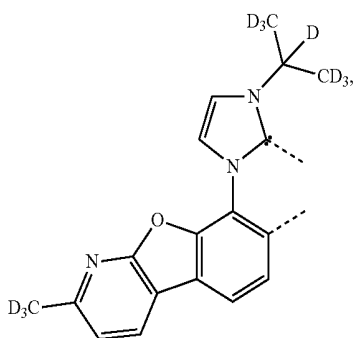


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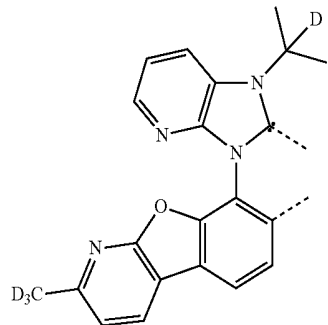
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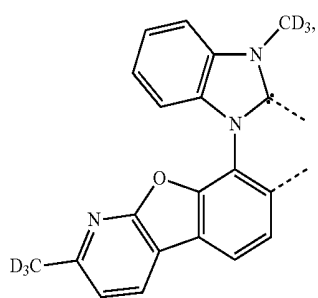


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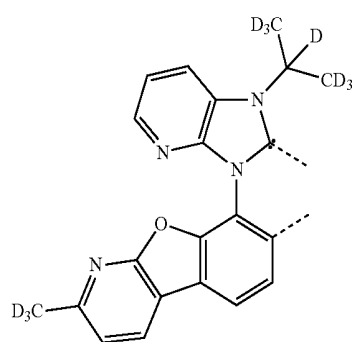
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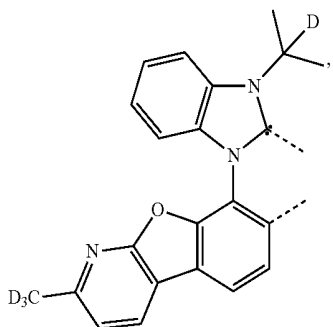
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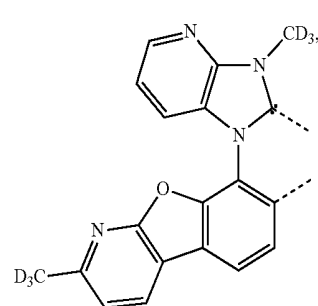
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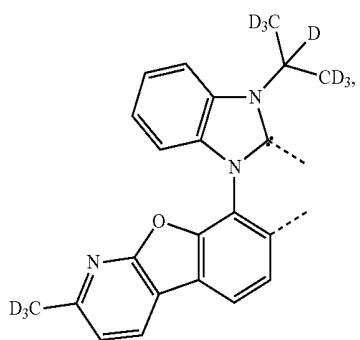
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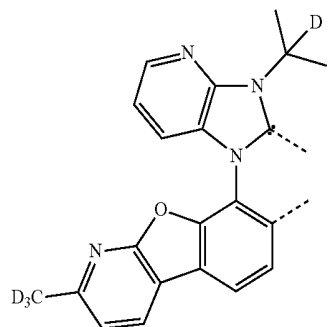
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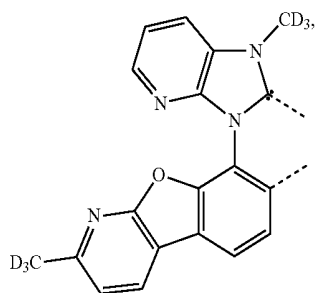
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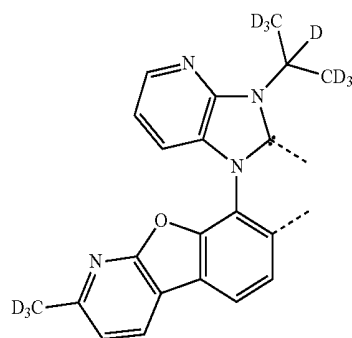
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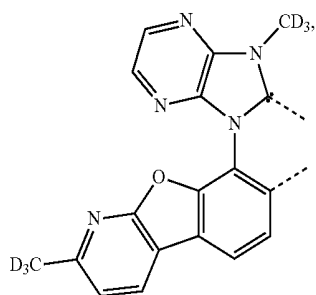


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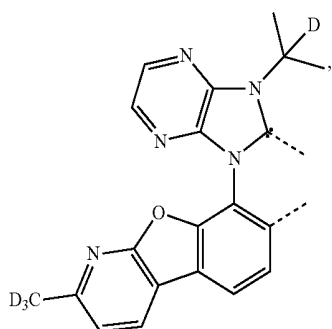


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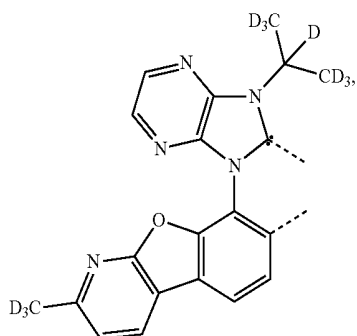
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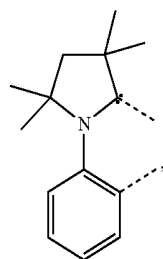
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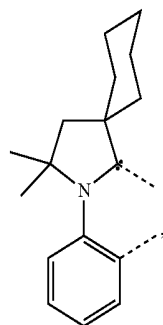
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L_{B109}

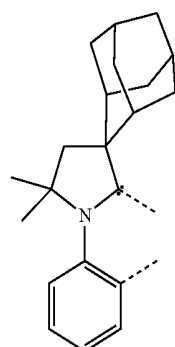


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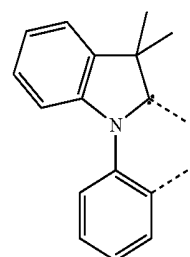


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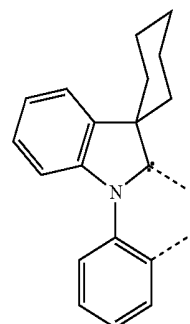
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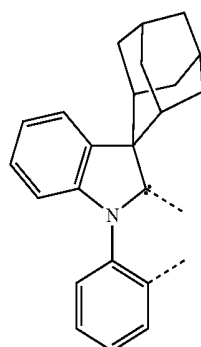
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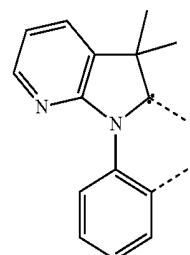
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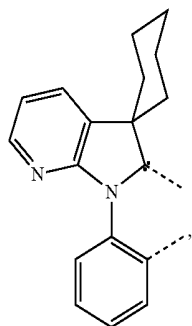


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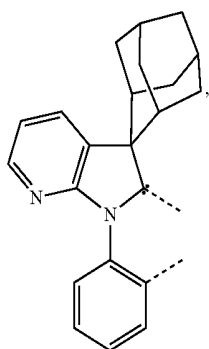


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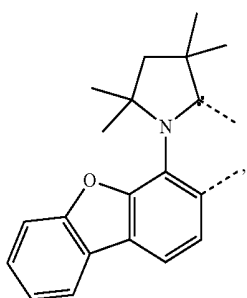
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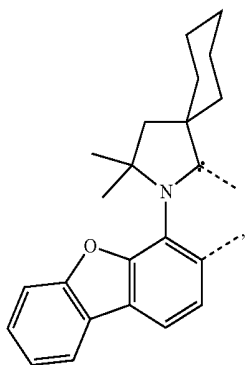
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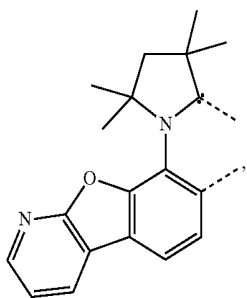
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LB119

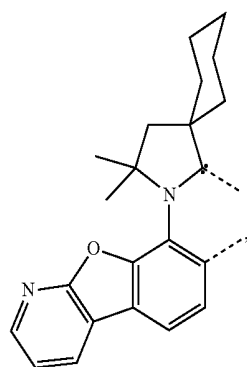


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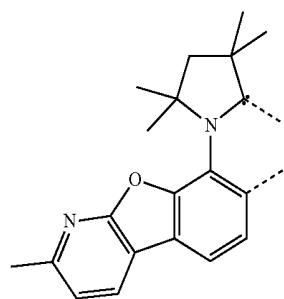


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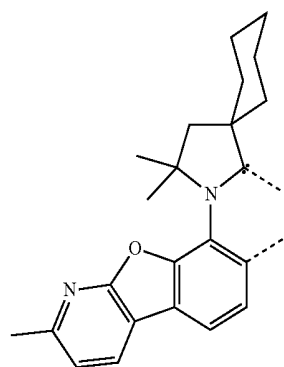
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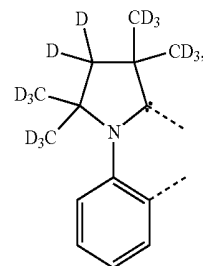
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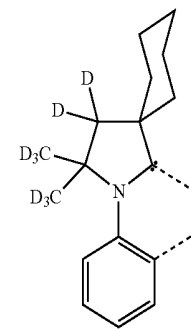
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LB124

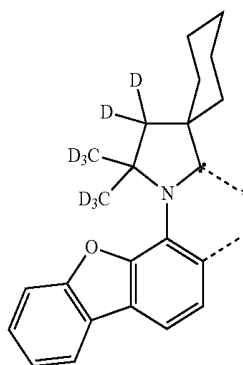
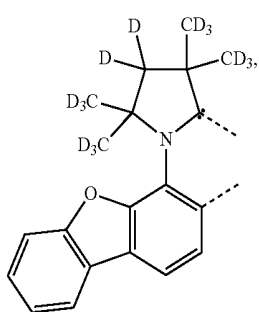
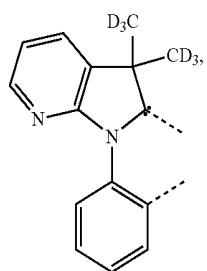
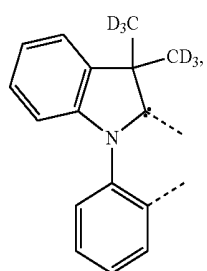
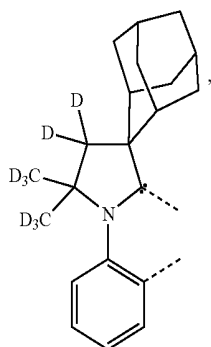


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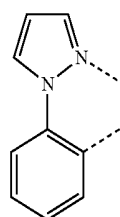
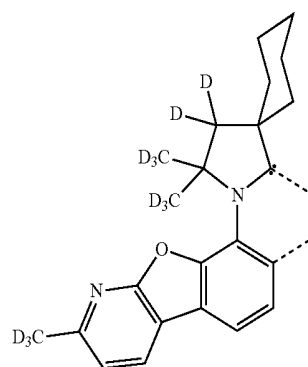
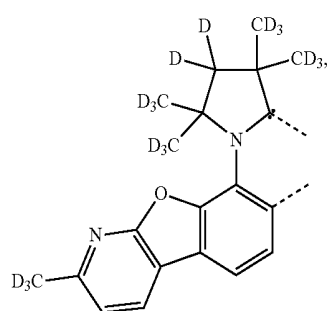
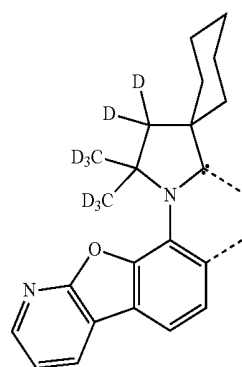
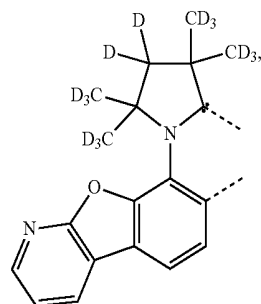


LB126

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L_{B127}

L_{B132}

L_{B128}

L_{B133}

L_{B129}

L_{B134}

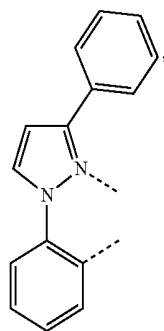
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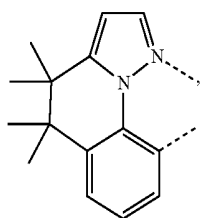
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L_{B136}

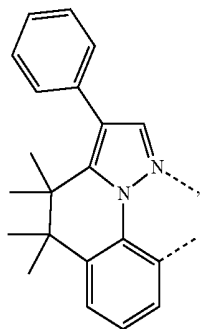
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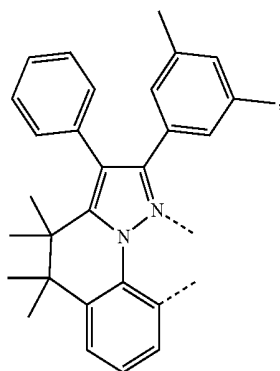
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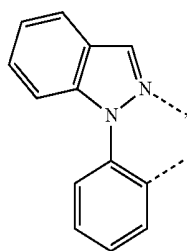
LB138



LB139

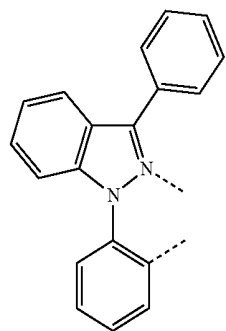


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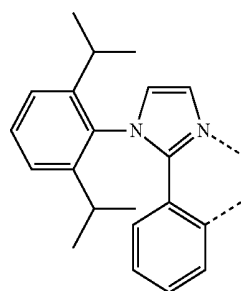


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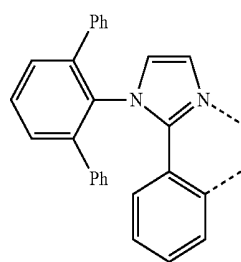
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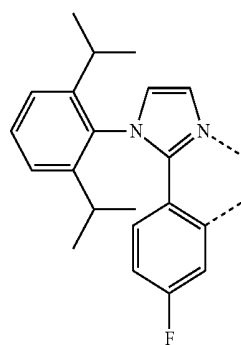
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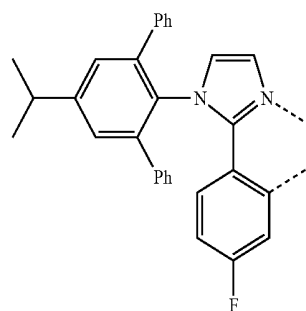
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LB144

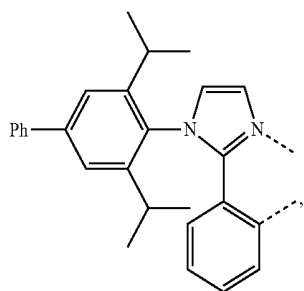


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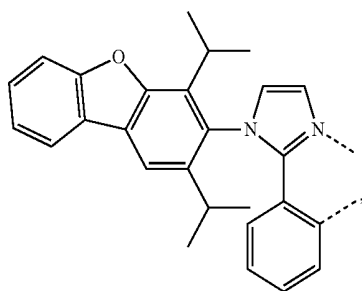


LB146

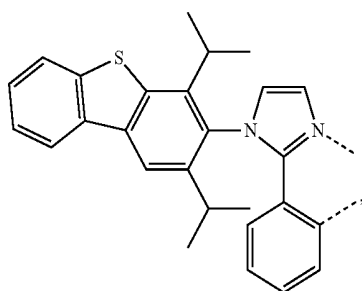
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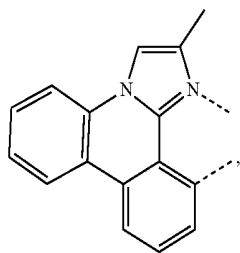
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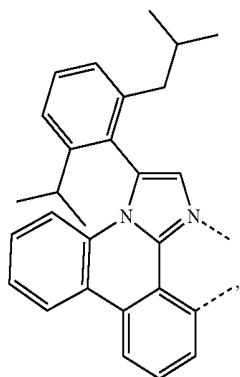
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L_{B149}

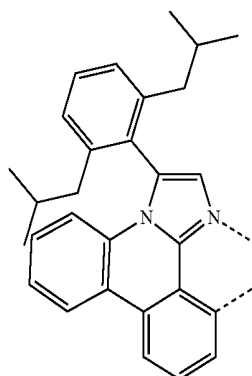


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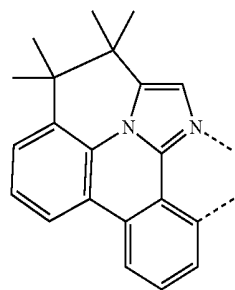


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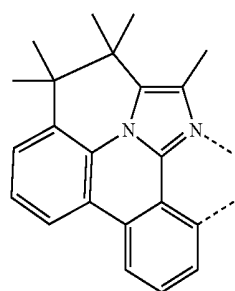
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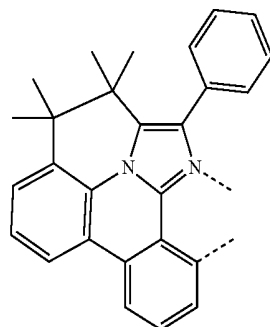
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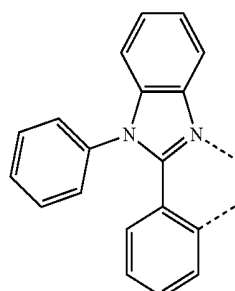
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L_{B154}

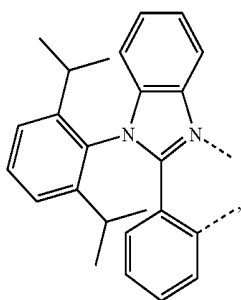


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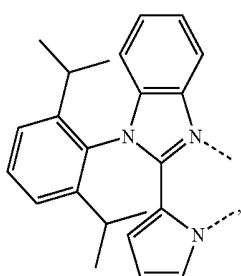


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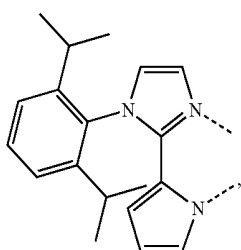
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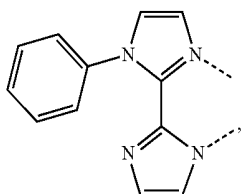
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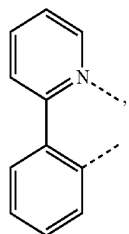
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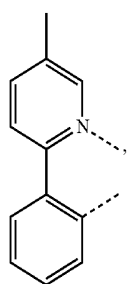
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L_{B160}

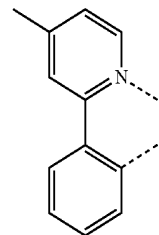


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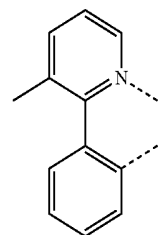


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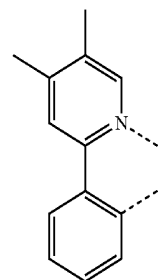
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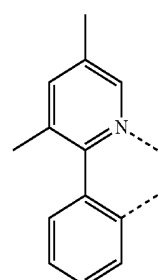
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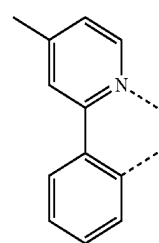
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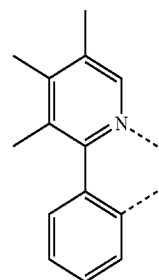
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L_{B166}

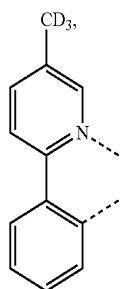
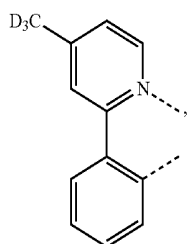
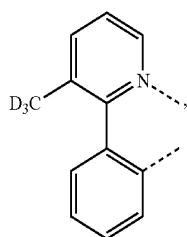
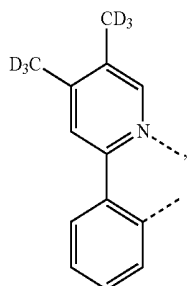
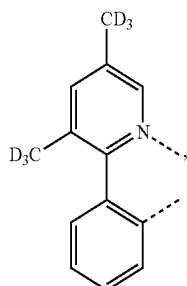
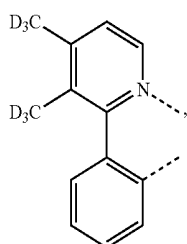


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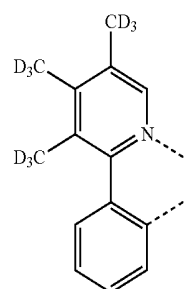
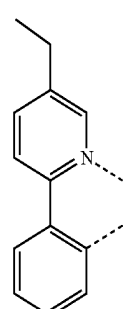
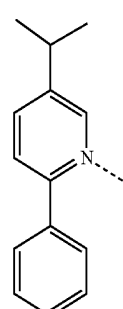
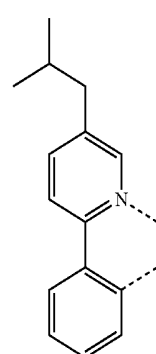
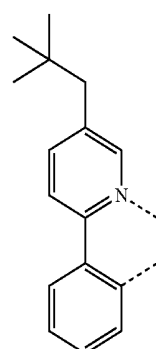


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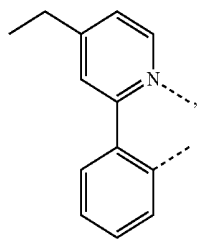
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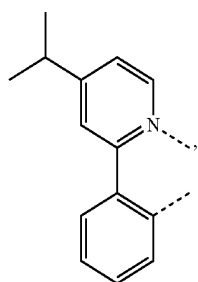
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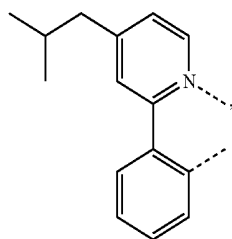
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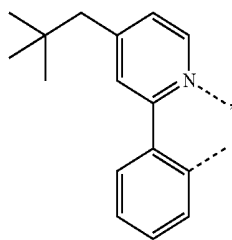
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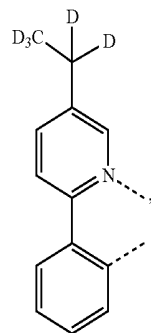
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L_{B182}

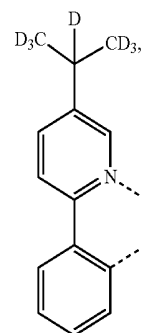


L_{B183}

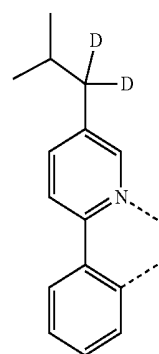


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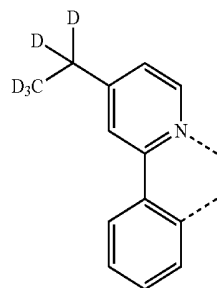
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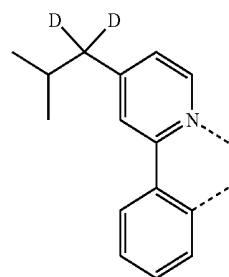
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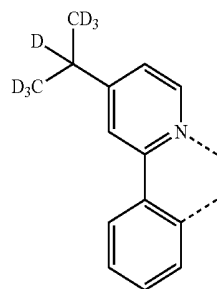
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L_{B187}

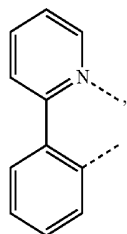


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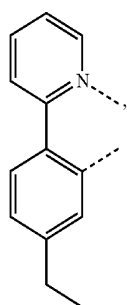


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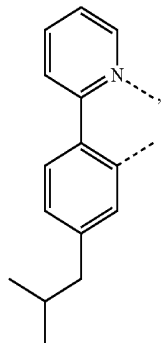
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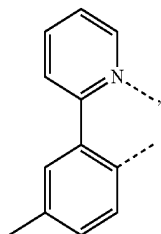
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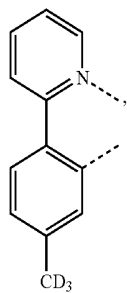
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LB192

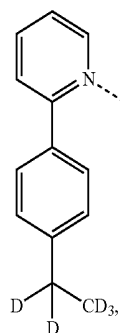


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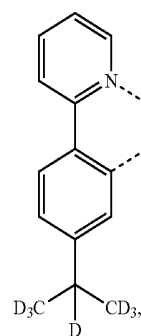


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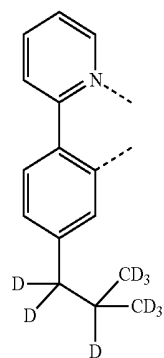
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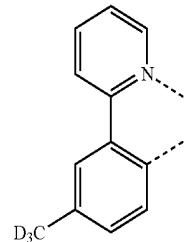
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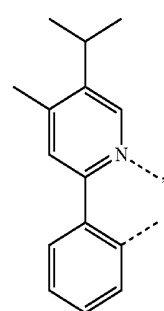
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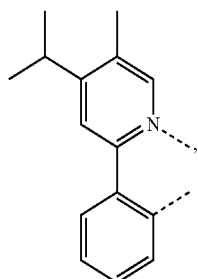


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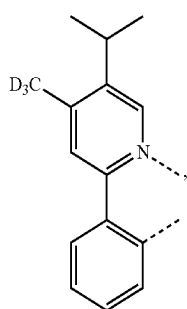


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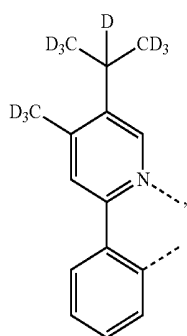
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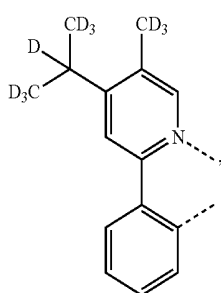
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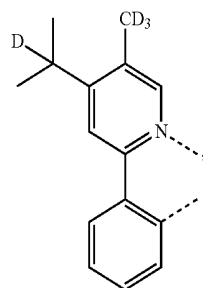
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LB202

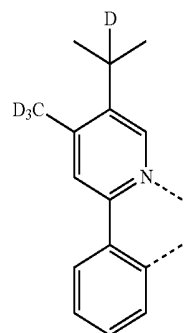


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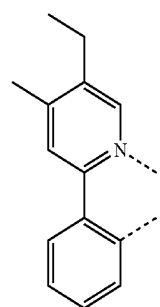


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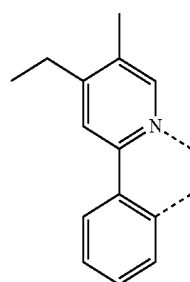
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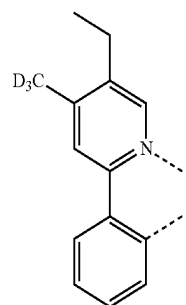
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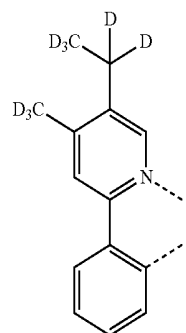
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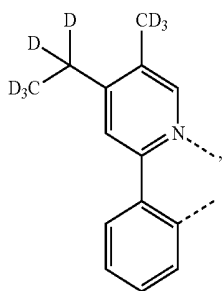
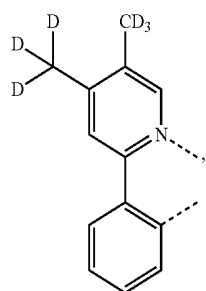
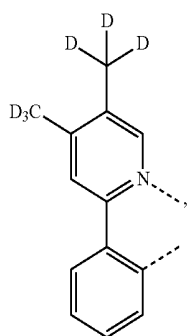
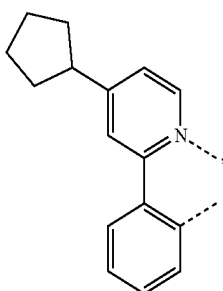
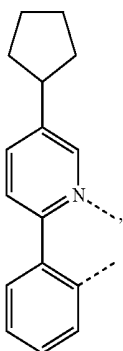


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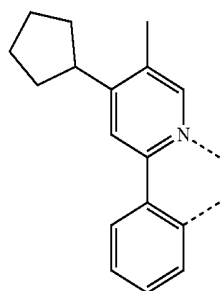
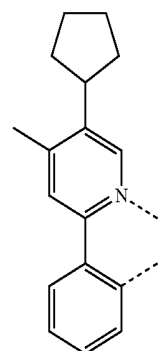
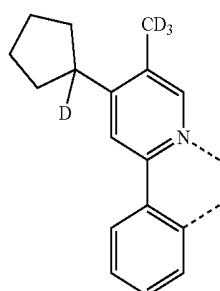
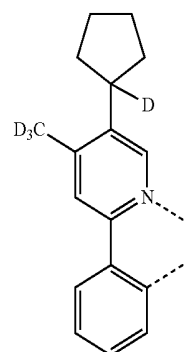
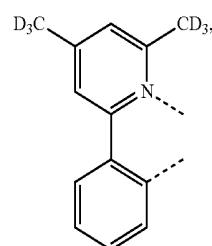


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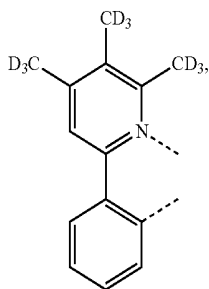
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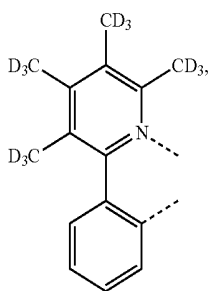
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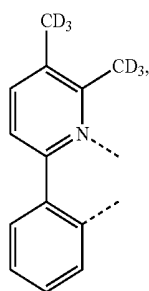
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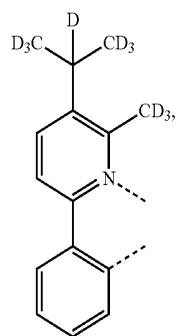
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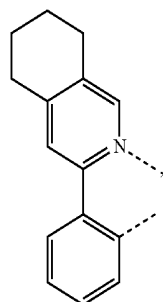
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L_{B222}

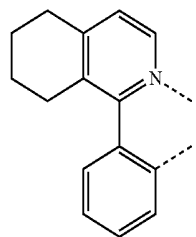


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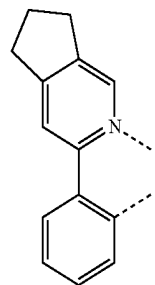


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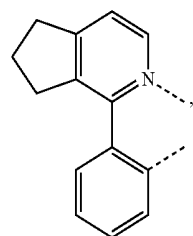
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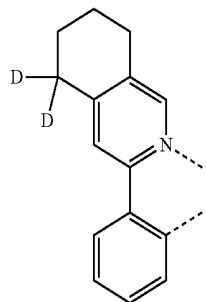
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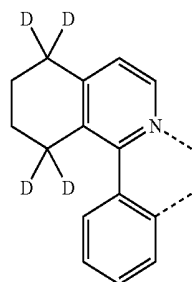
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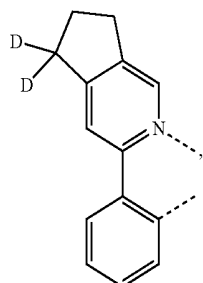


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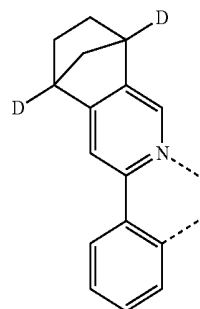
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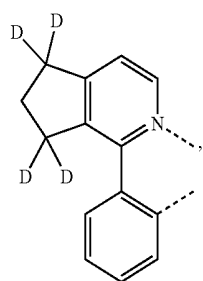


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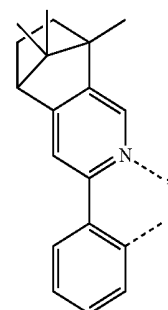
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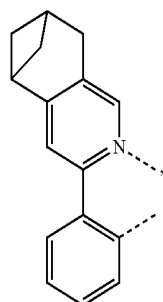
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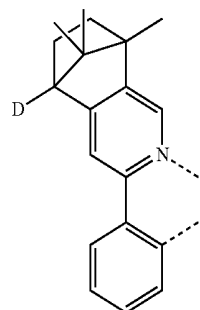
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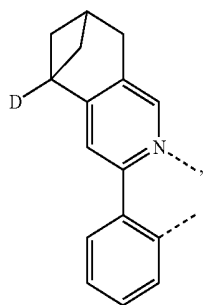
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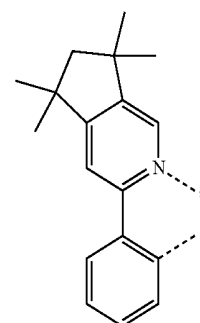
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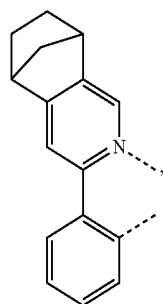
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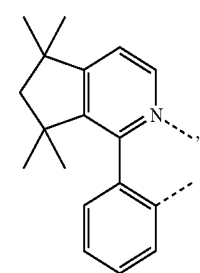
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LB238

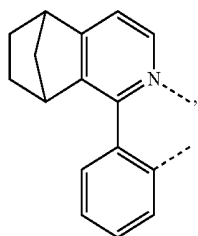


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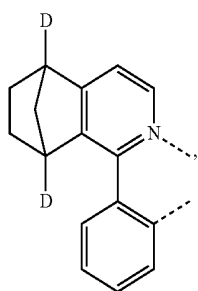


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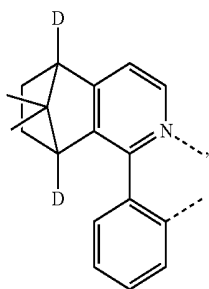
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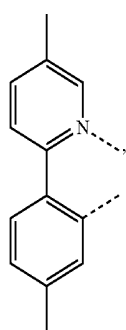
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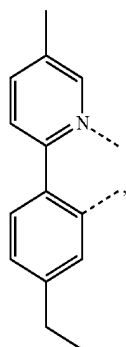
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LB242

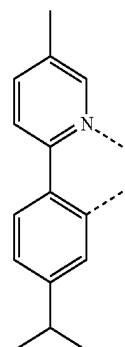


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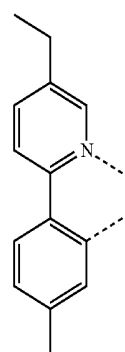


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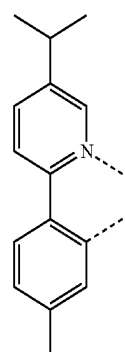
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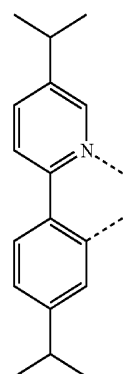
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LB246

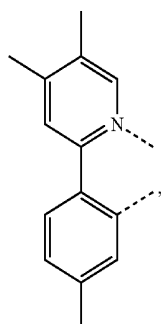


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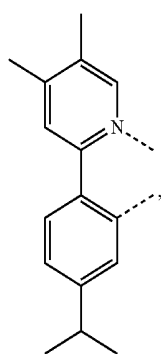


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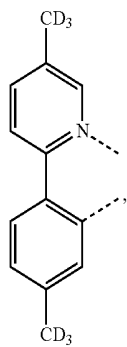
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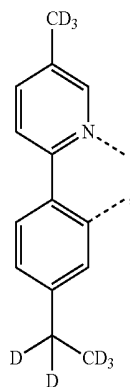
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L_{B250}

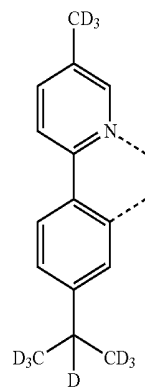


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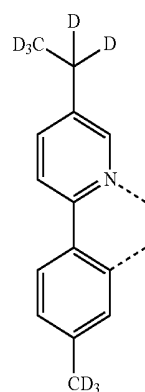


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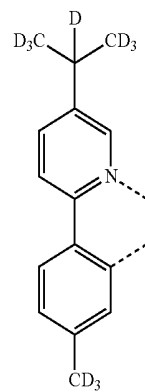
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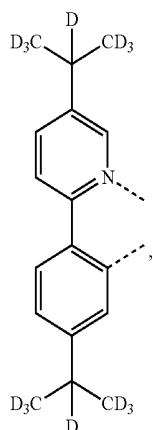


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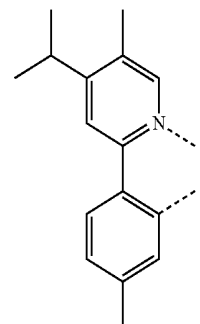
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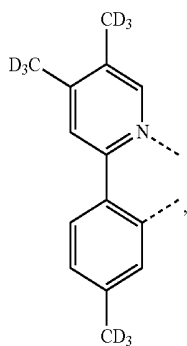


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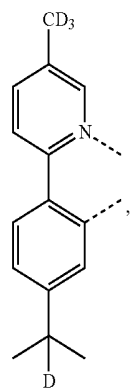
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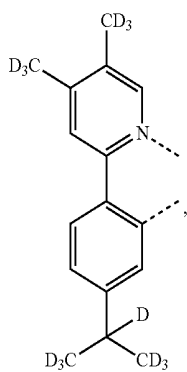
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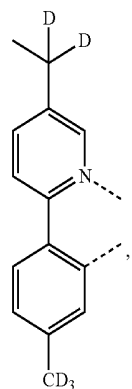
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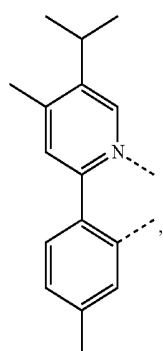
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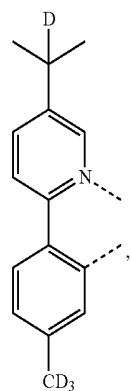
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L_{B262}

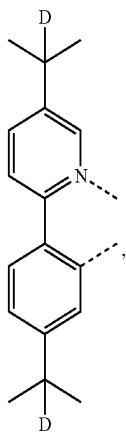


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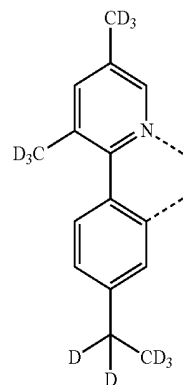
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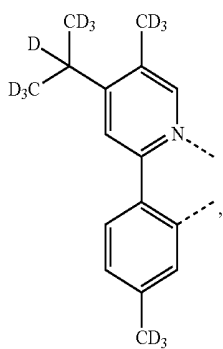


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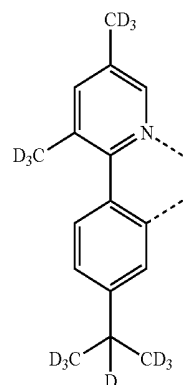
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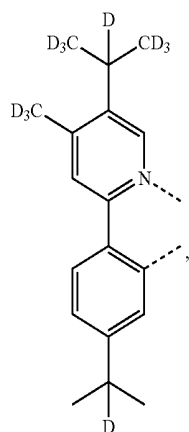
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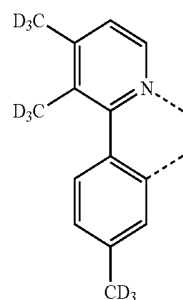
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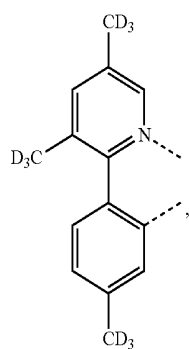
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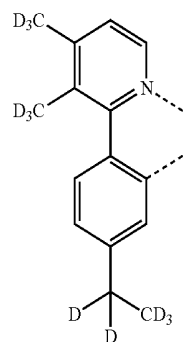
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L_{B270}

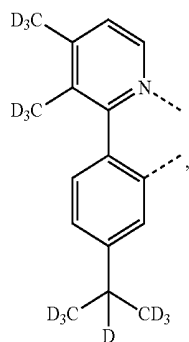


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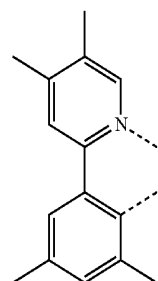
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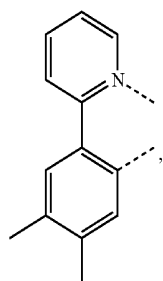


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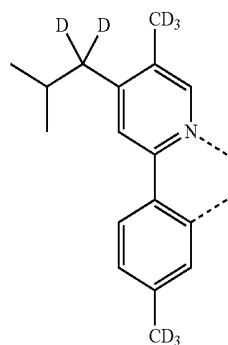
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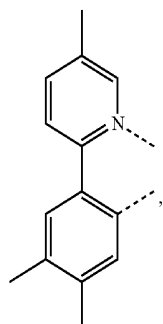
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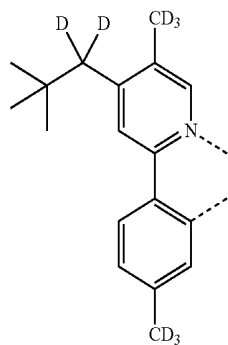
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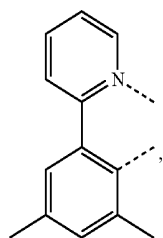
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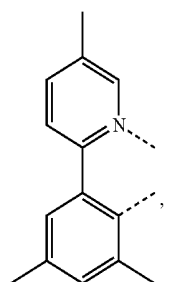
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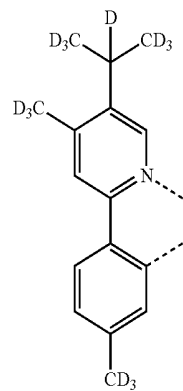
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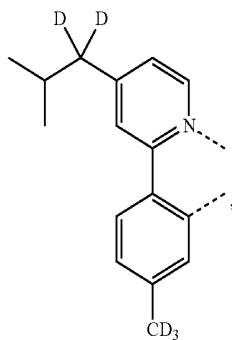


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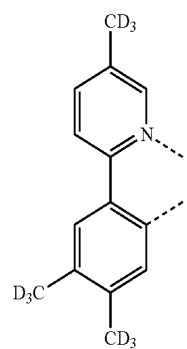
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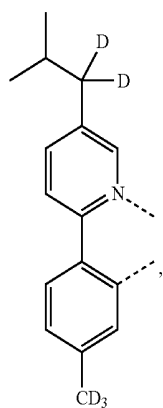


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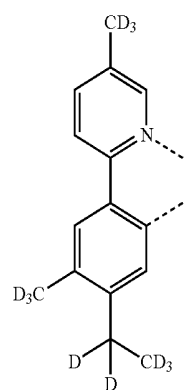
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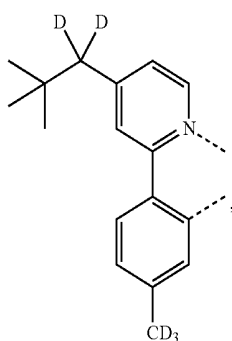
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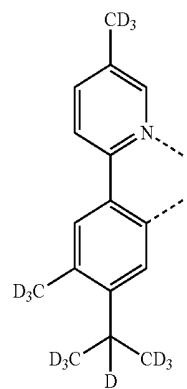
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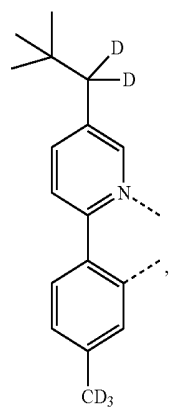
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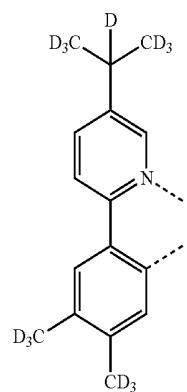
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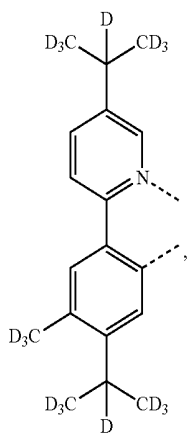


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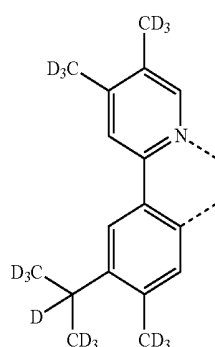
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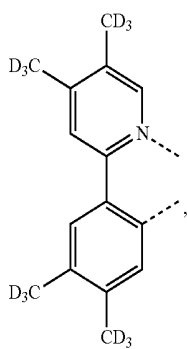


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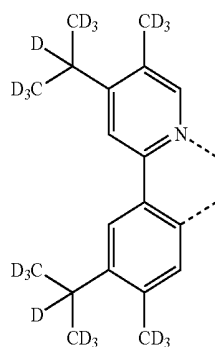
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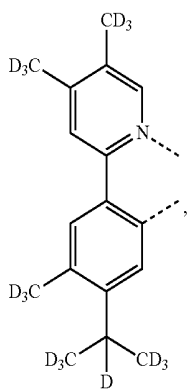
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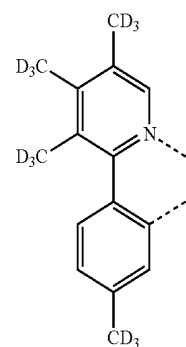
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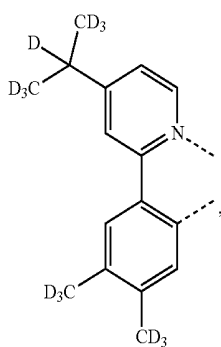
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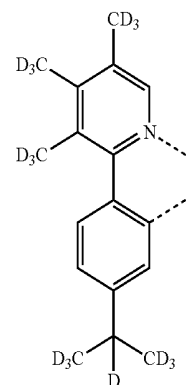
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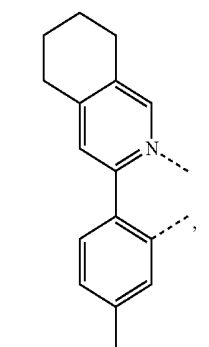


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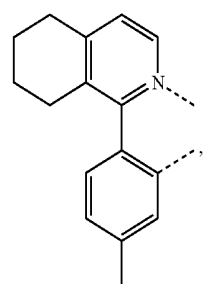


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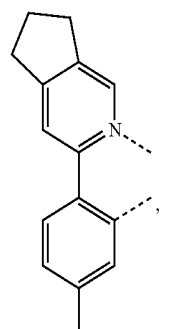
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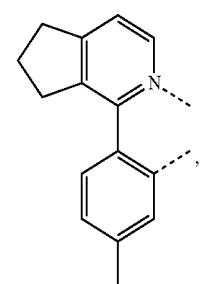
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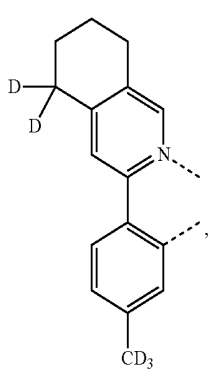
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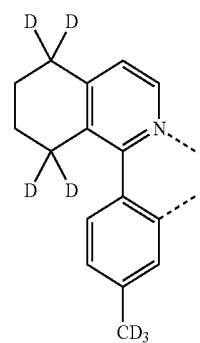


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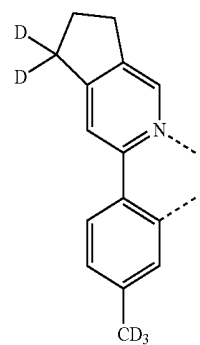


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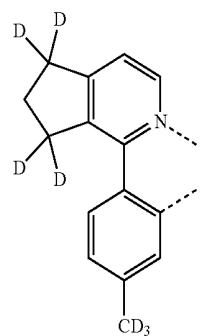
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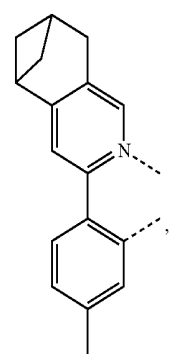
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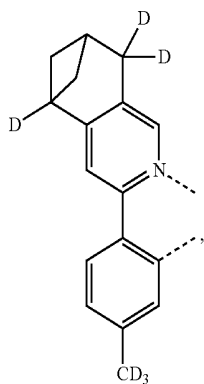


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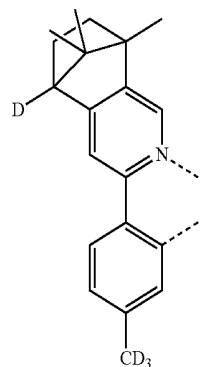


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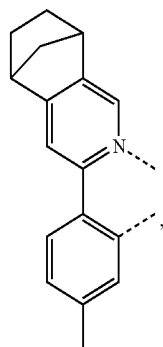
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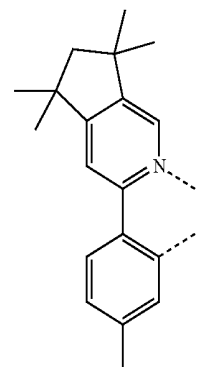
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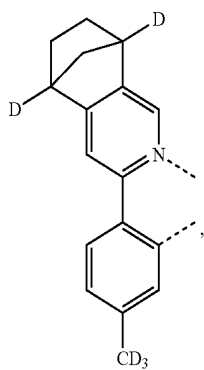
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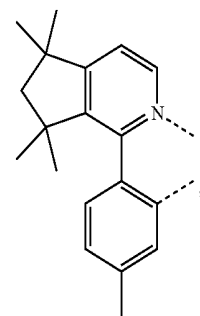
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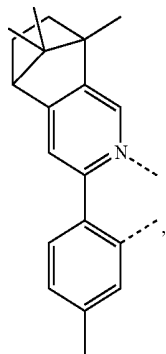
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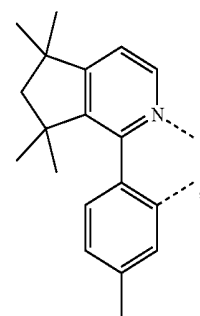
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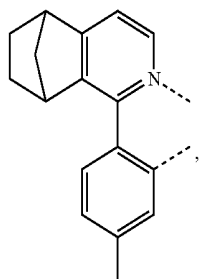
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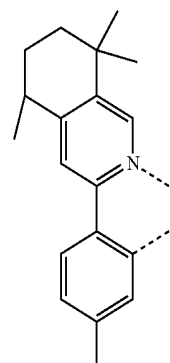


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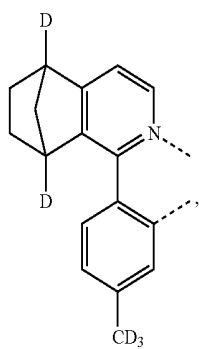


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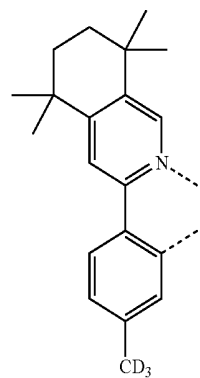
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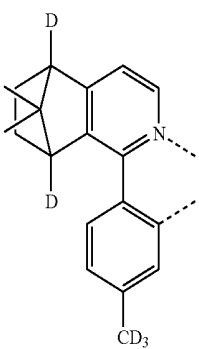
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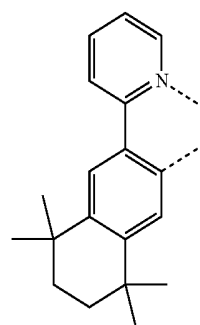
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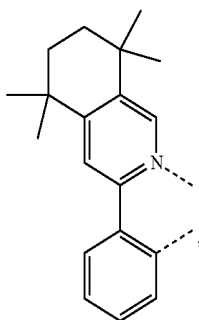
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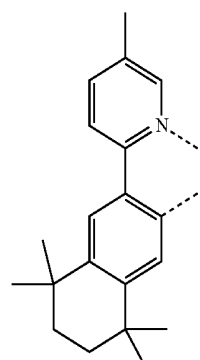
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LB319

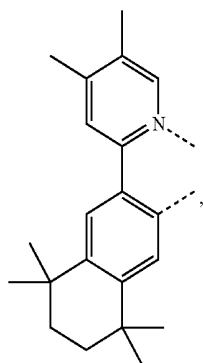


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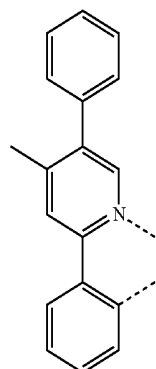
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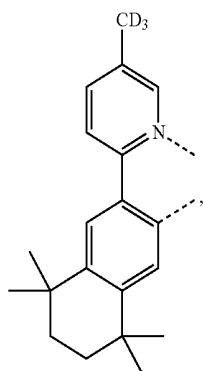


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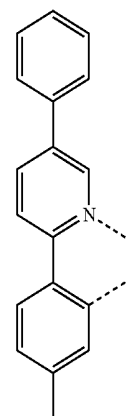
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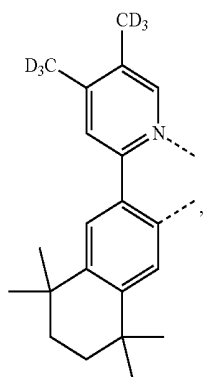
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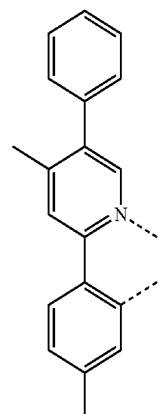
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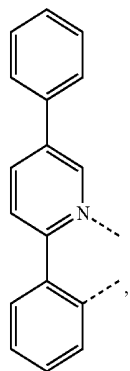
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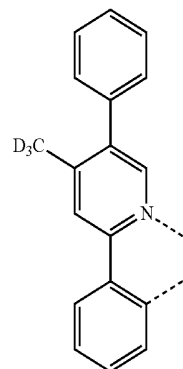
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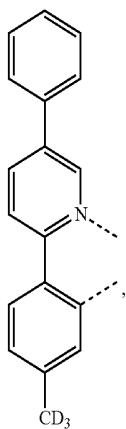


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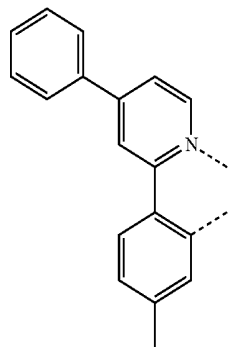
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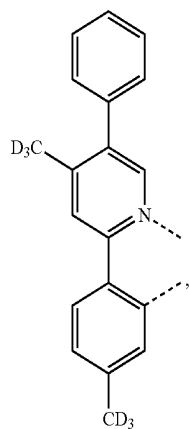


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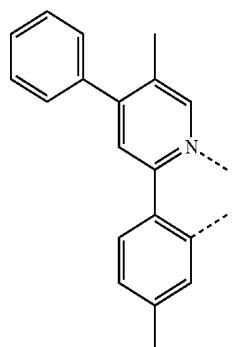
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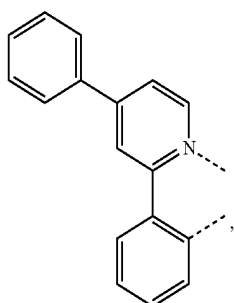
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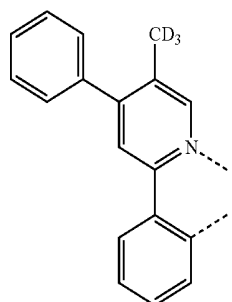
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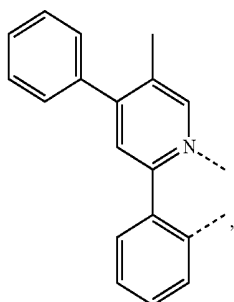
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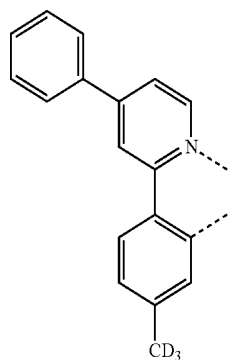
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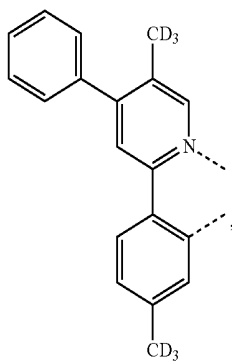


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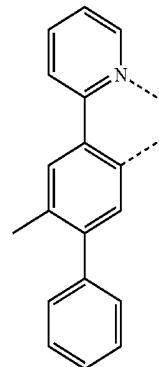
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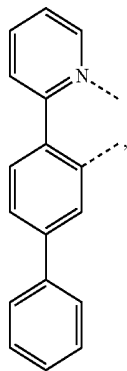


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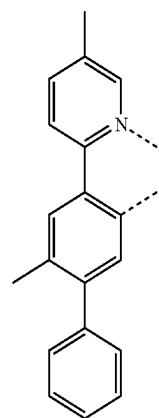
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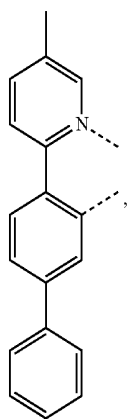
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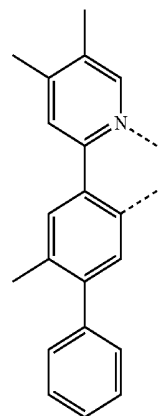
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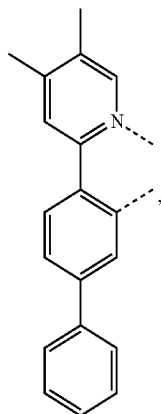
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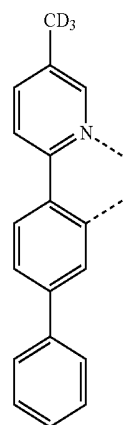
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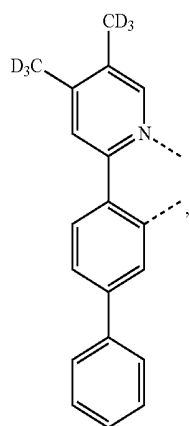


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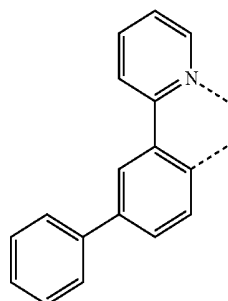
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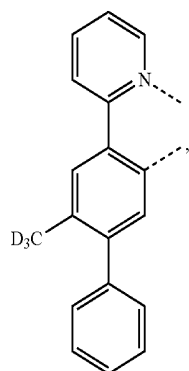


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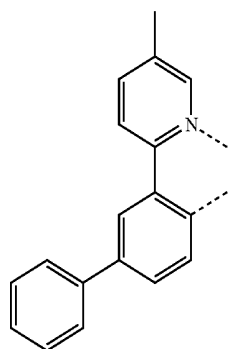
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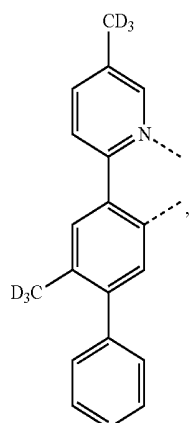
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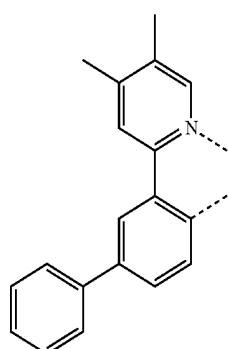
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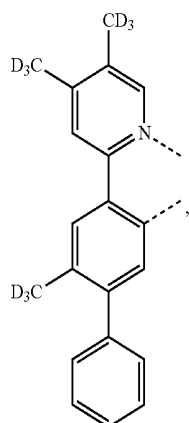
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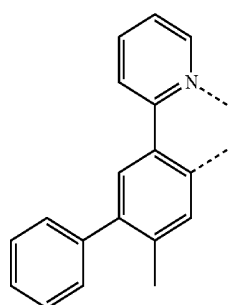
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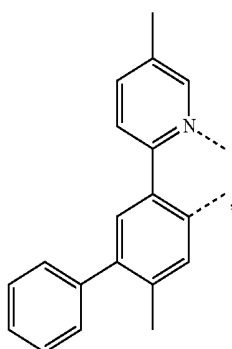


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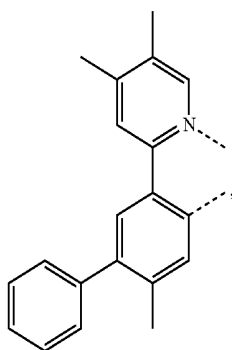


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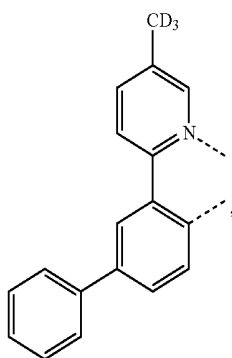
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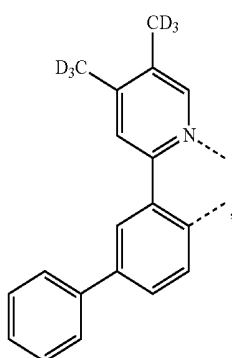
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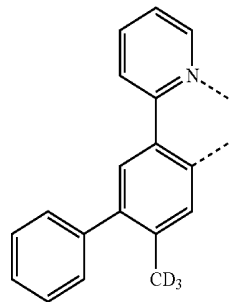


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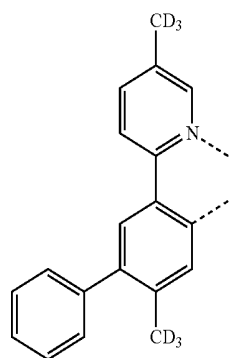


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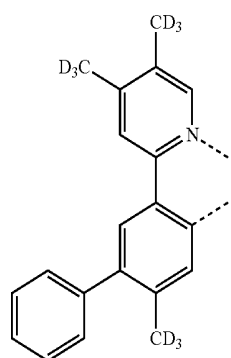
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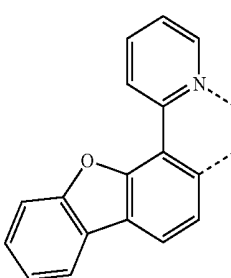
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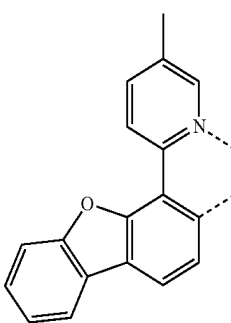
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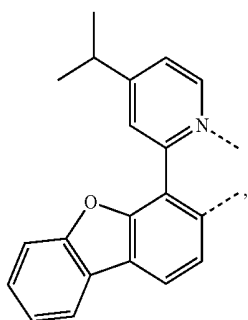


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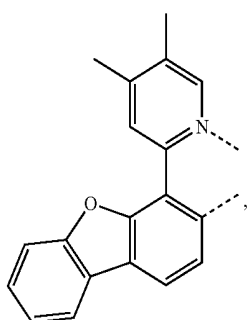


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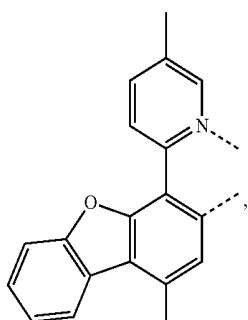
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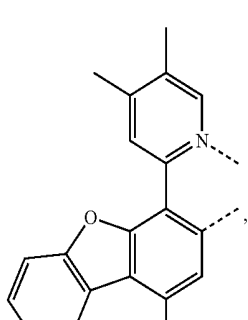
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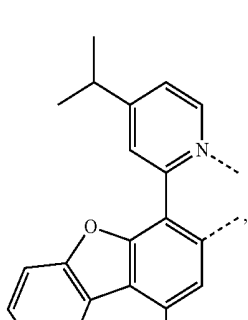
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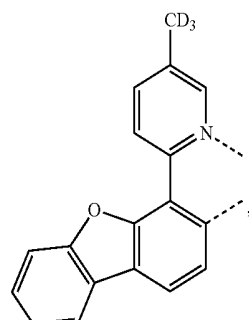


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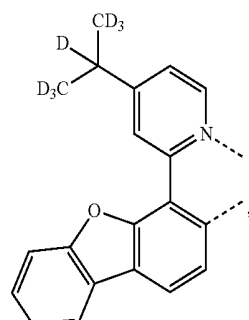


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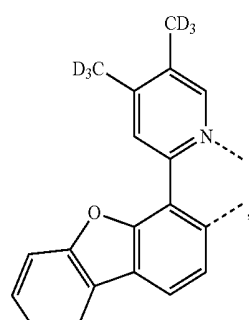
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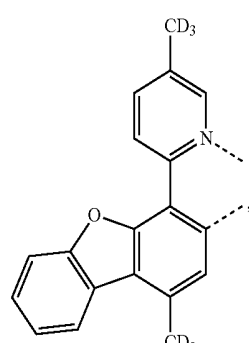
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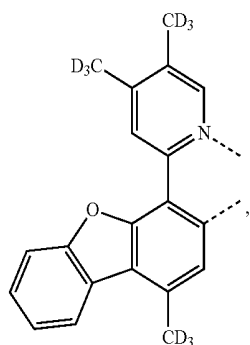


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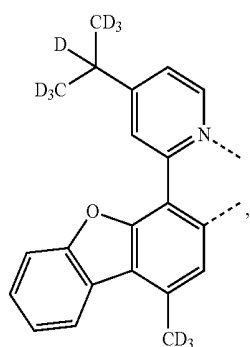


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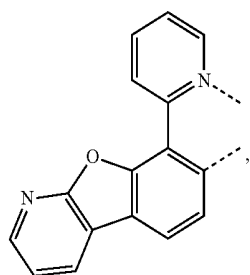
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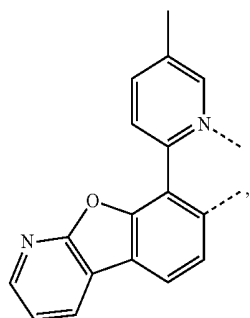
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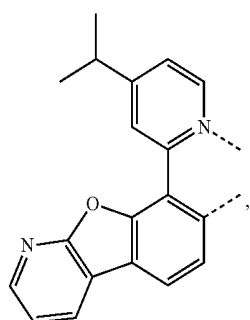
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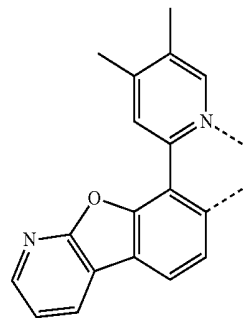


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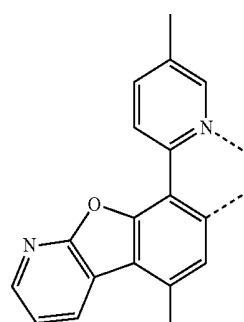


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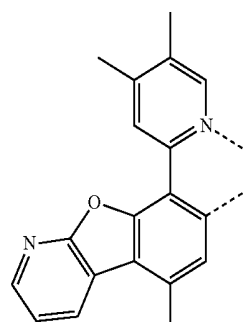
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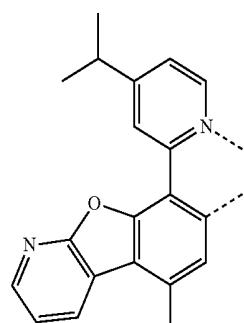
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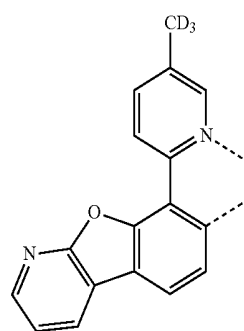
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LB378

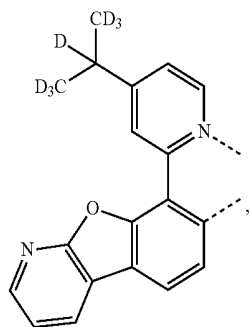


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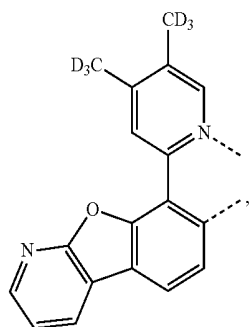


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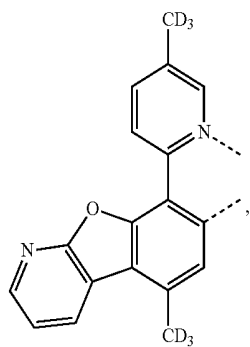
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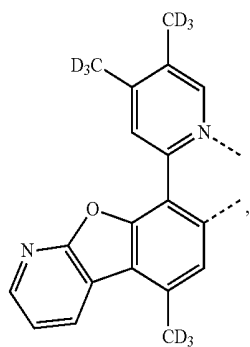
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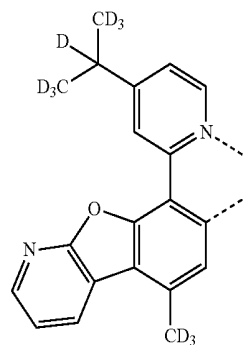


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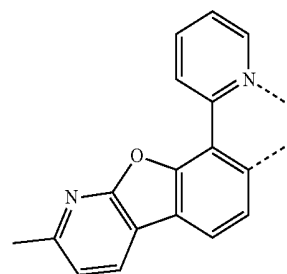


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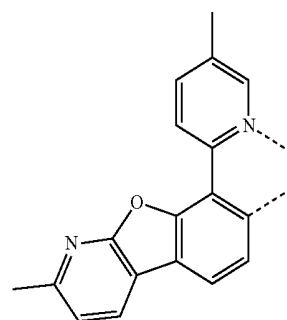
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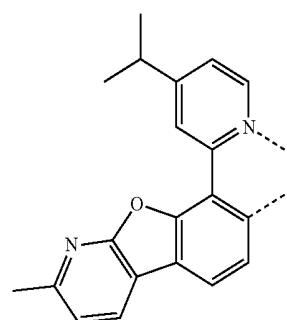
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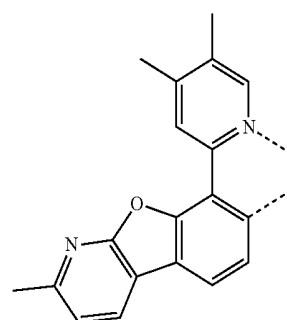
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LB387

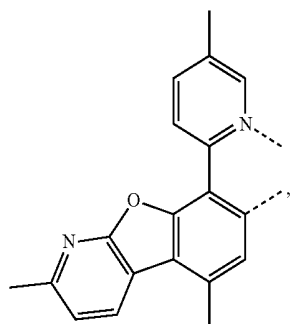


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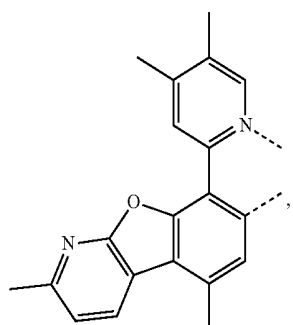


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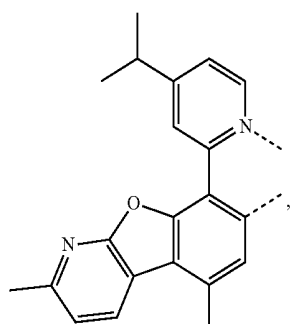
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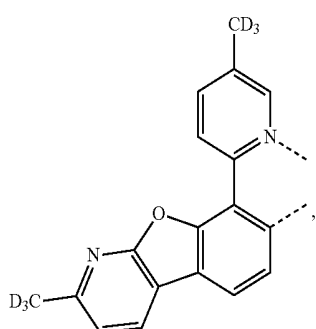
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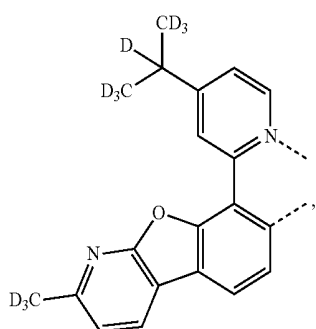
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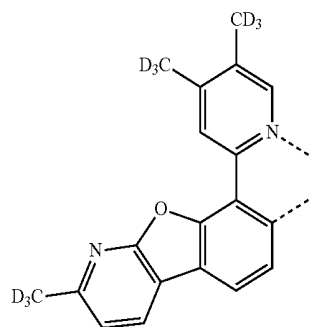


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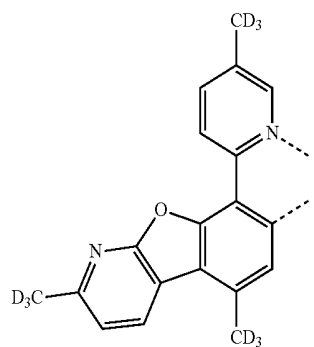


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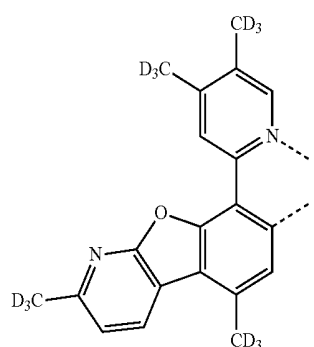
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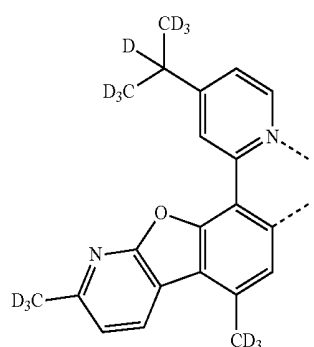
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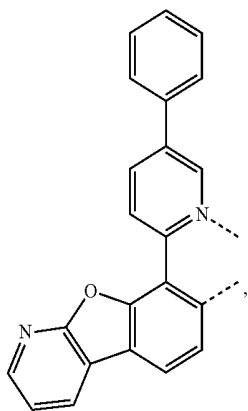


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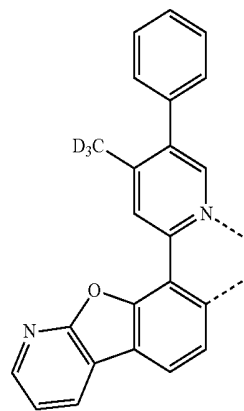
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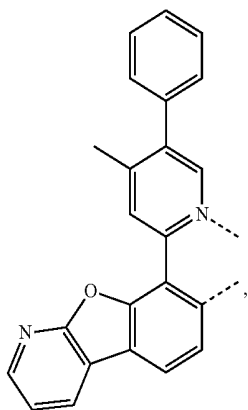


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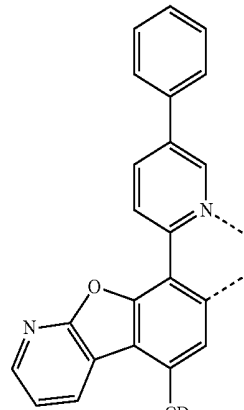
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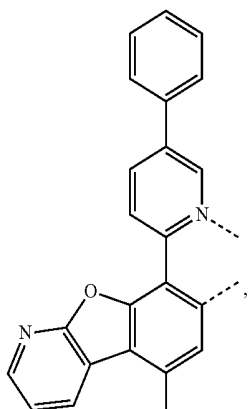
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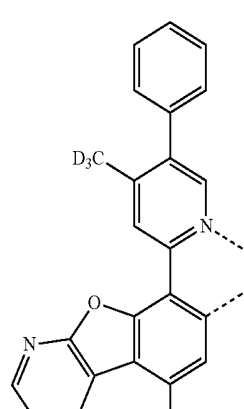
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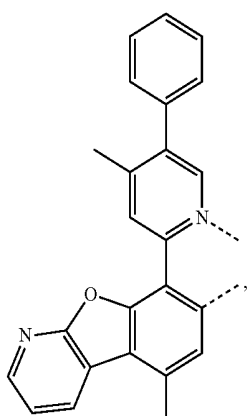
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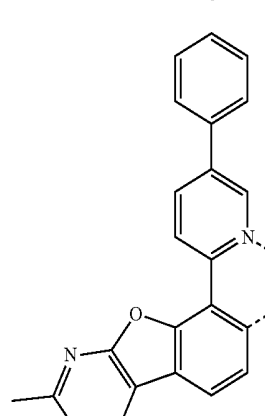
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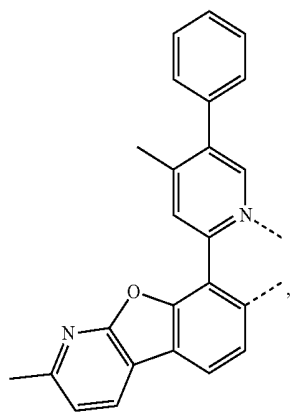


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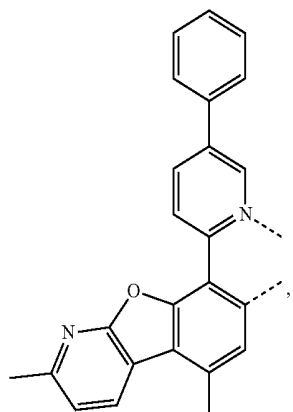


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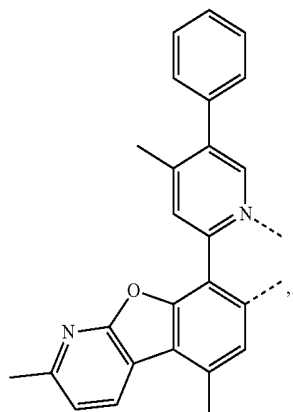
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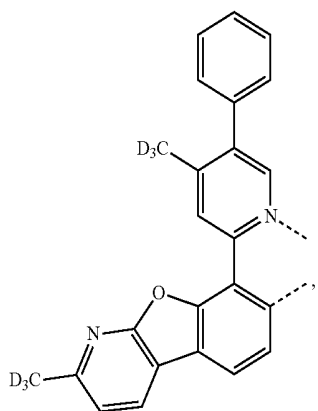
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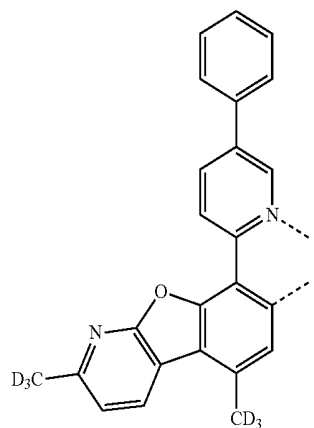


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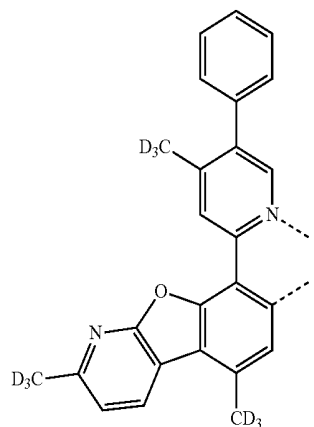


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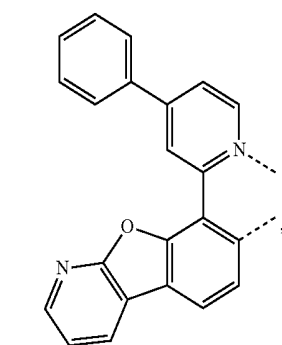
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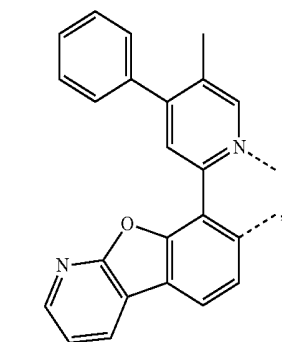
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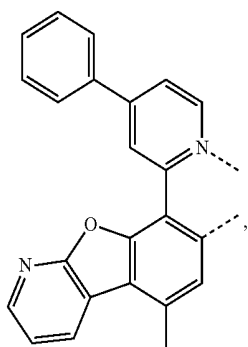


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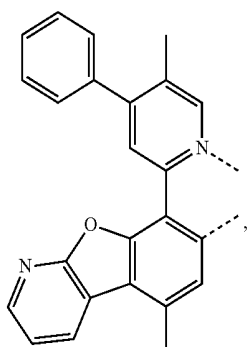


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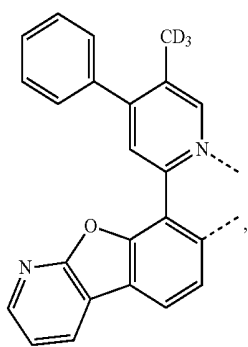
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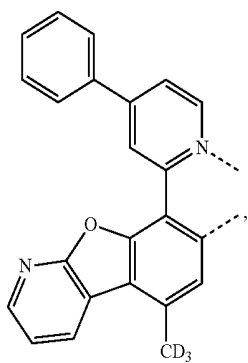
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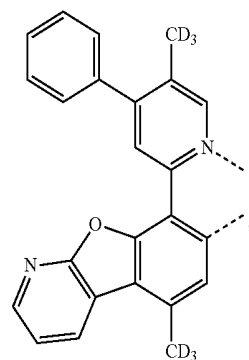


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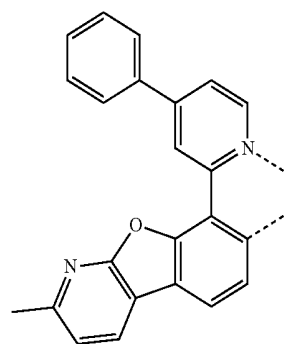


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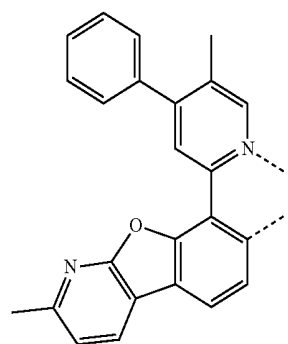
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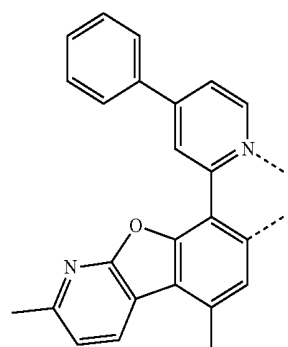
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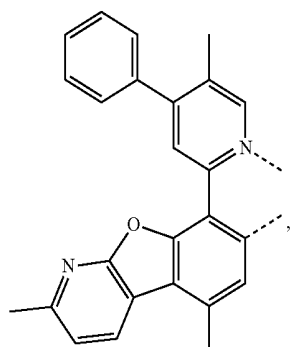


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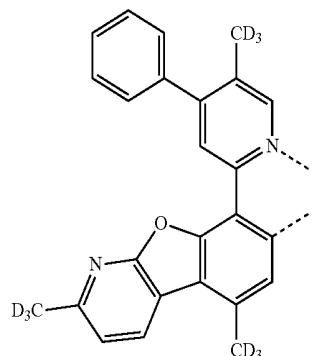
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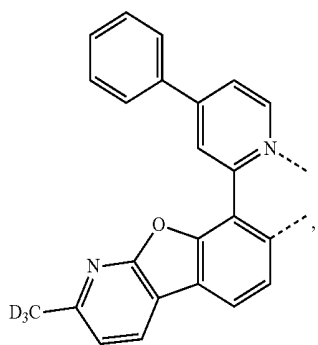


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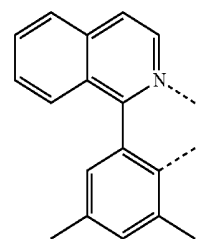
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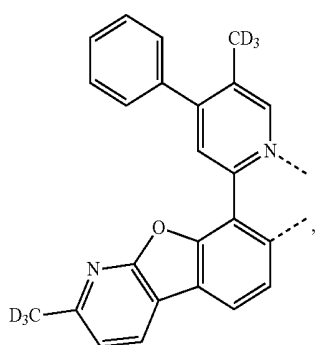
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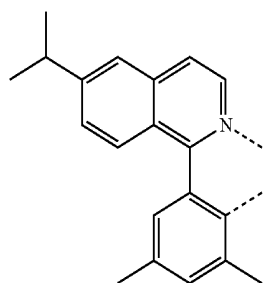
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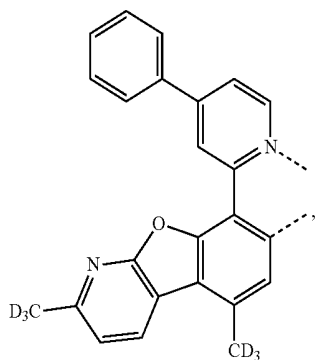
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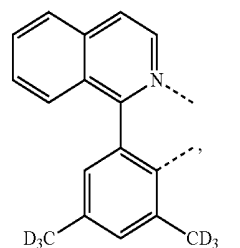
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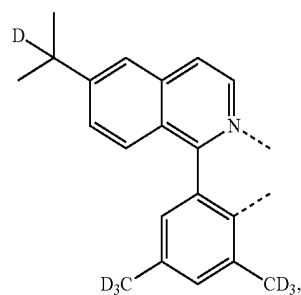
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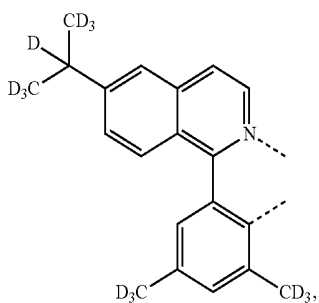


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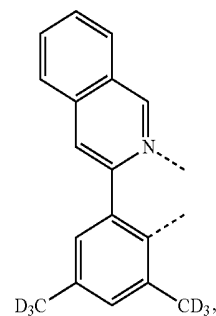
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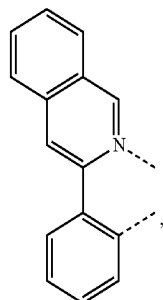
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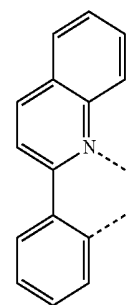


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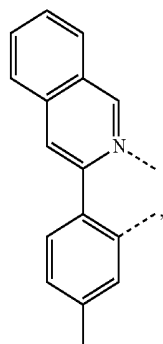
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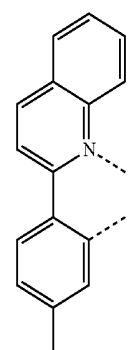
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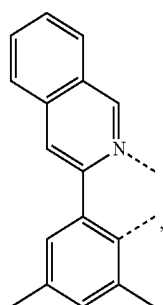
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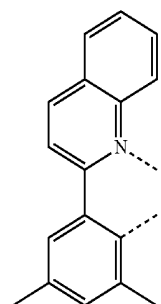
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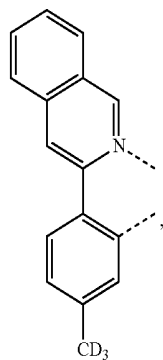
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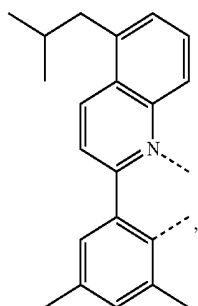
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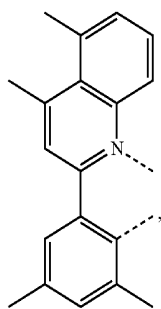
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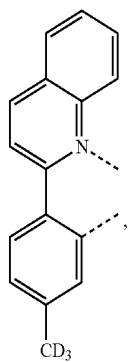
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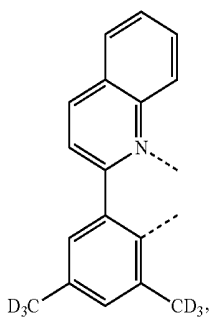
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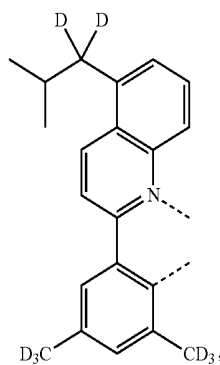


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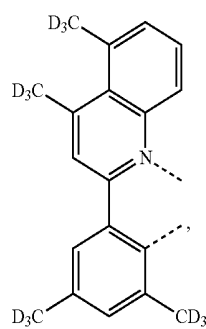


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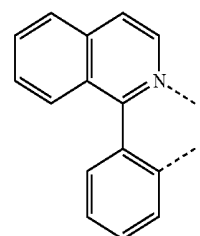
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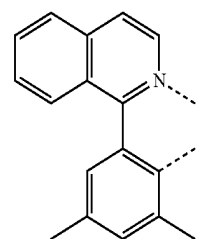
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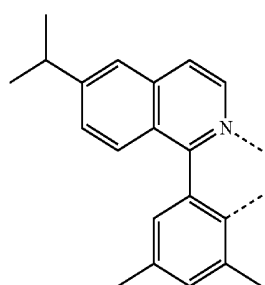
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L_{B447}

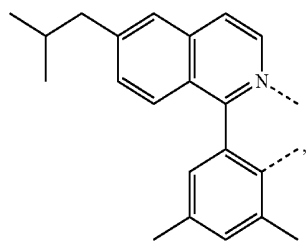


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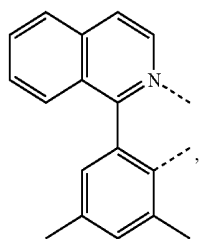


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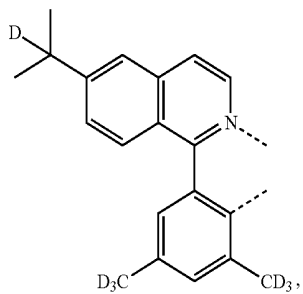
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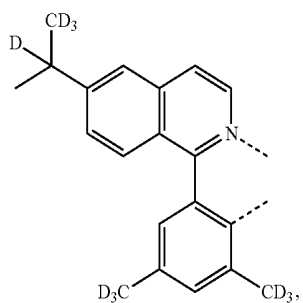
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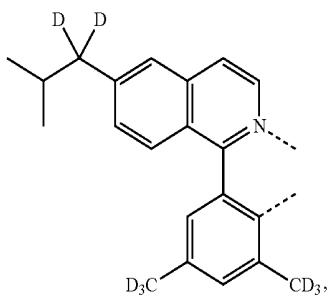
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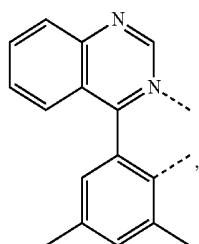
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L_{B453}

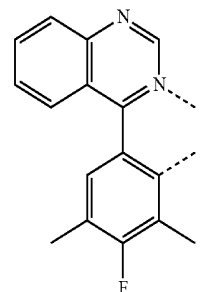


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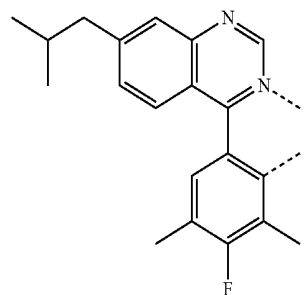


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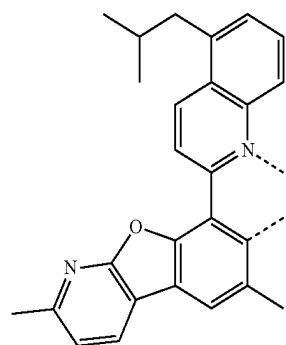
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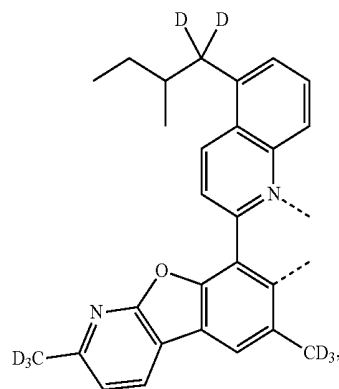
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L_{B457}

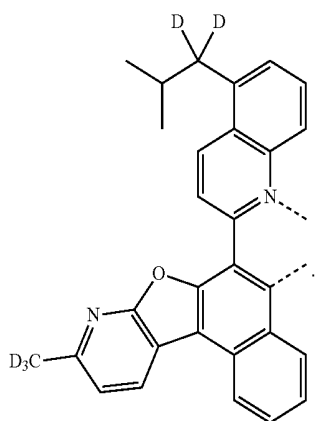


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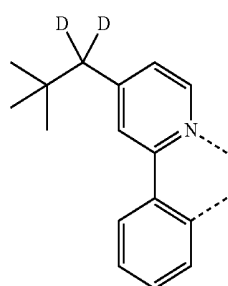
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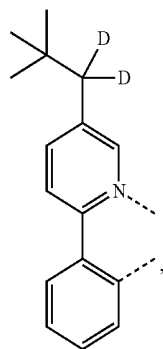


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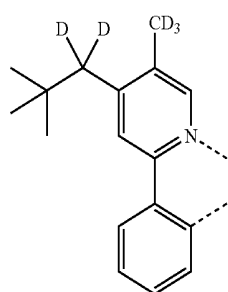
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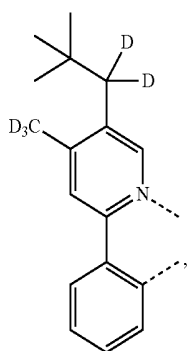
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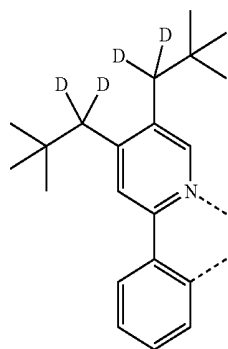
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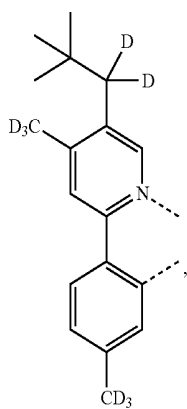
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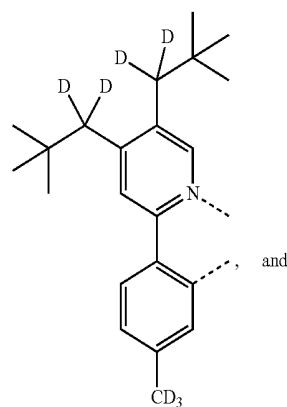
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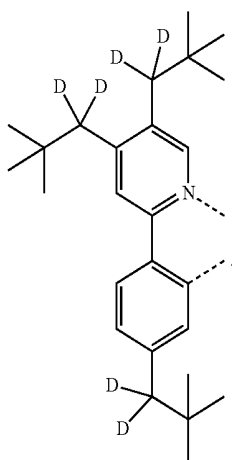


L_{B463}



L_{B467}

-continued

L_{B468}

[0112] In some embodiments, each R^A, R^B, R^C, R and R' is independently selected from the group consisting of hydrogen, deuterium, fluorine, alkyl, cycloalkyl, heteroalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, aryl, heteroaryl, nitrile, isonitrile, and combinations thereof.

[0113] An organic light emitting device (OLED) comprising: an anode; a cathode; and an organic layer, disposed between the anode and the cathode, comprising a compound comprising a first ligand L_A of Formula I.

[0114] In some embodiments, a consumer product comprising an OLED as described herein is described.

[0115] In some embodiments, the OLED has one or more characteristics selected from the group consisting of being flexible, being rollable, being foldable, being stretchable, and being curved. In some embodiments, the OLED is transparent or semi-transparent. In some embodiments, the OLED further comprises a layer comprising carbon nanotubes.

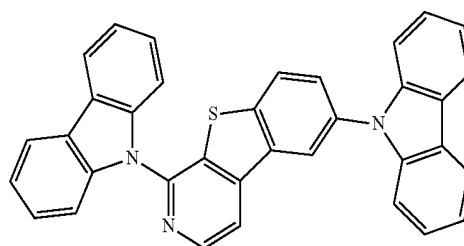
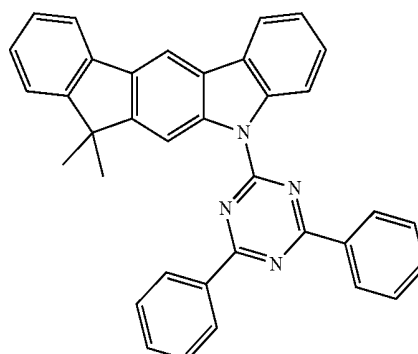
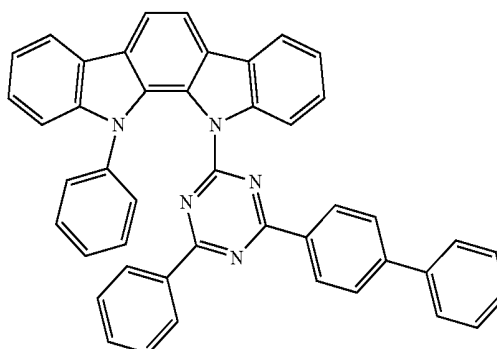
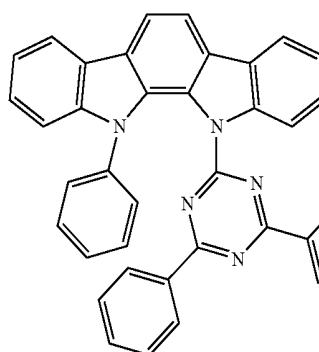
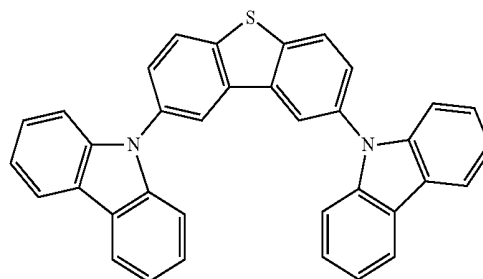
[0116] In some embodiments, the OLED further comprises a layer comprising a delayed fluorescent emitter. In some embodiments, the OLED comprises a RGB pixel arrangement or white plus color filter pixel arrangement. In some embodiments, the OLED is a mobile device, a hand held device, or a wearable device. In some embodiments, the OLED is a display panel having less than 10 inch diagonal or 50 square inch area. In some embodiments, the OLED is a display panel having at least 10 inch diagonal or 50 square inch area. In some embodiments, the OLED is a lighting panel.

[0117] According to another aspect, an emissive region in an OLED is disclosed. The emissive region comprises a compound comprising a first ligand L_A of Formula I as defined herein.

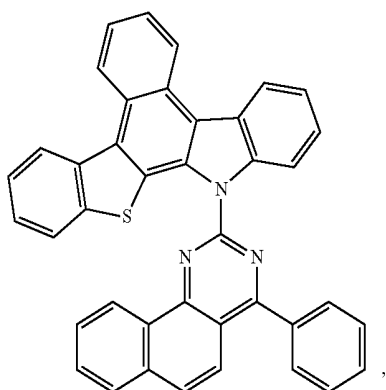
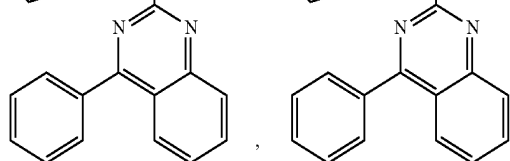
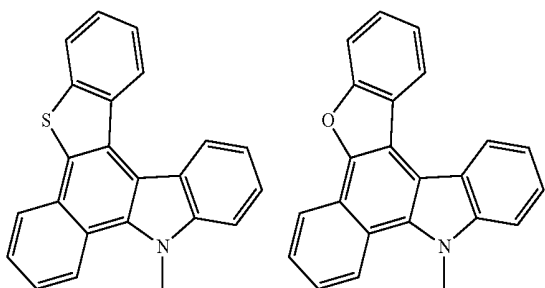
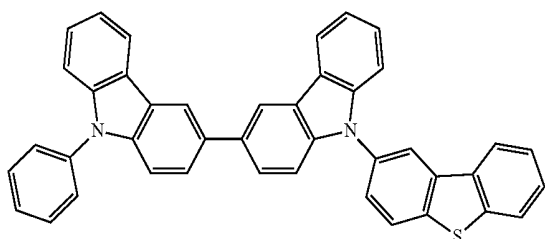
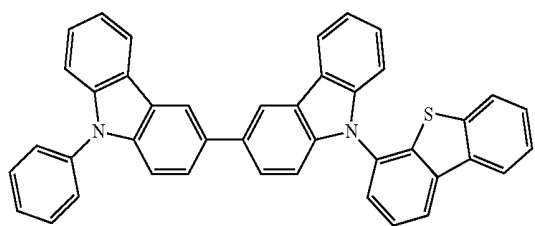
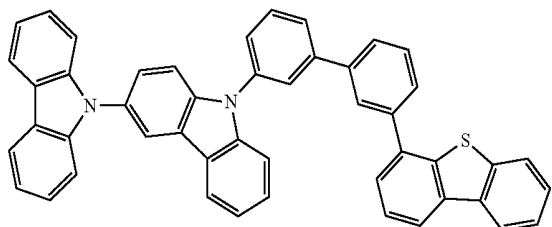
[0118] In some embodiments of the emissive region, the compound is an emissive dopant or a non-emissive dopant.

[0119] In some embodiments, the emissive region further comprises a host, wherein the host comprises at least one selected from the group consisting of metal complex, triphenylene, carbazole, dibenzothiophene, dibenzofuran, dibenzoselenophene, aza-triphenylene, aza-carbazole, aza-dibenzothiophene, aza-dibenzofuran, and aza-dibenzoselenophene.

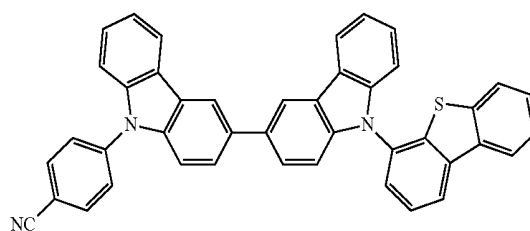
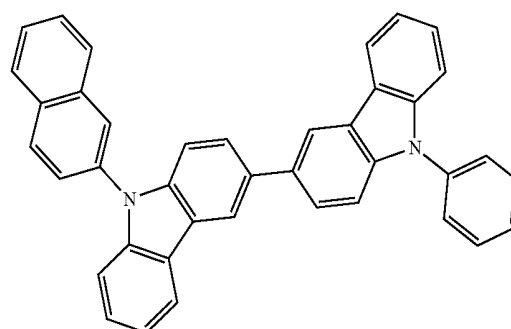
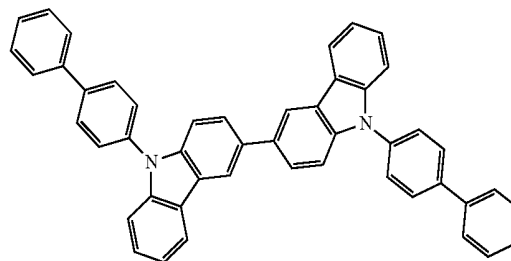
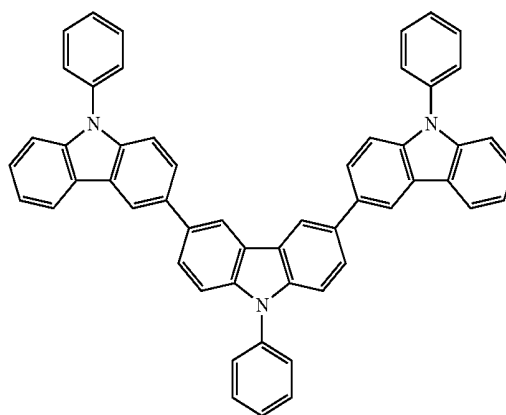
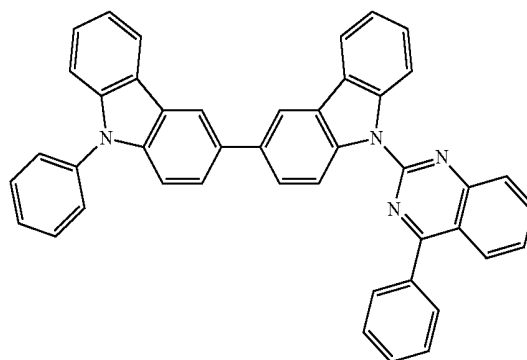
[0120] In some embodiments, the emissive region further comprises a host, wherein the host is selected from the group consisting of:



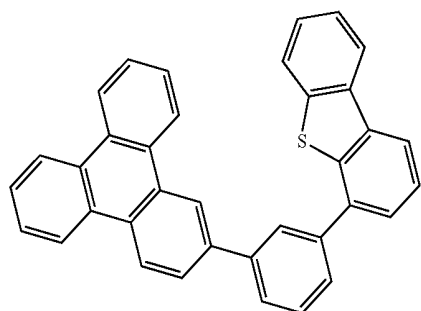
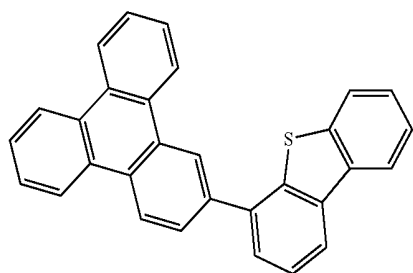
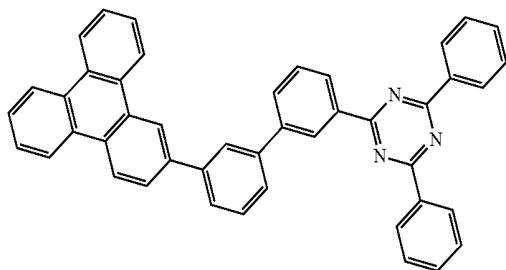
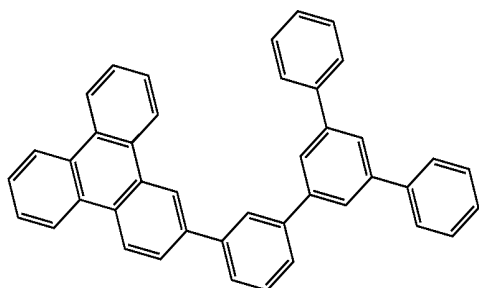
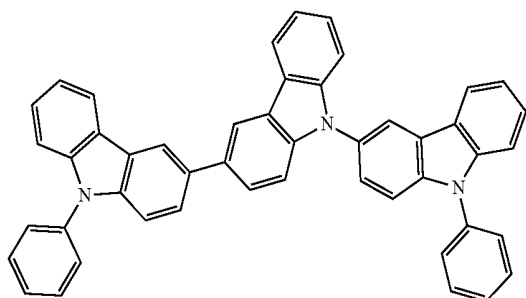
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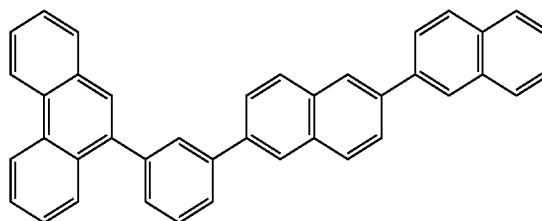
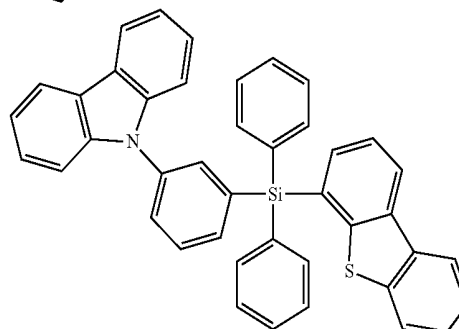
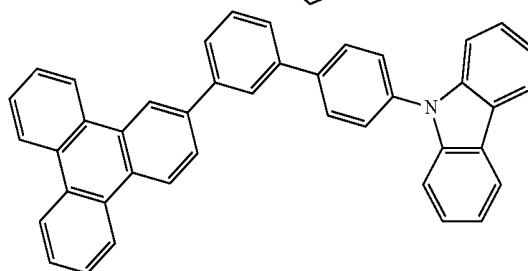
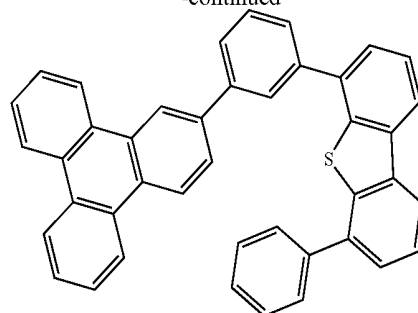
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and combinations thereof.

[0121] In some embodiments, the compound can be an emissive dopant. In some embodiments, the compound can produce emissions via phosphorescence, fluorescence, thermally activated delayed fluorescence, i.e., TADF (also referred to as E-type delayed fluorescence; see, e.g., U.S. application Ser. No. 15/700,352, which is hereby incorporated by reference in its entirety), triplet-triplet annihilation, or combinations of these processes.

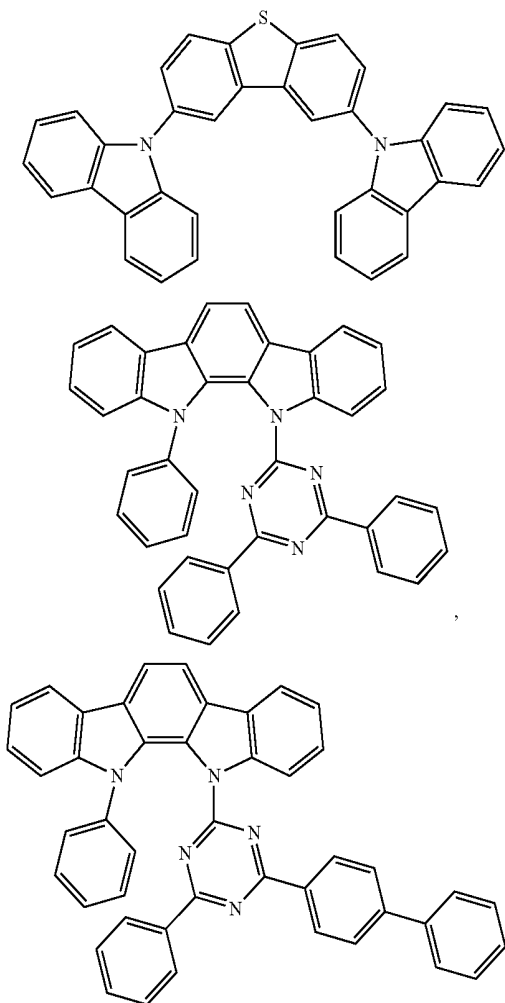
[0122] According to another aspect, a formulation comprising the compound described herein is also disclosed.

[0123] The OLED disclosed herein can be incorporated into one or more of a consumer product, an electronic component module, and a lighting panel. The organic layer can be an emissive layer and the compound can be an emissive dopant in some embodiments, while the compound can be a non-emissive dopant in other embodiments.

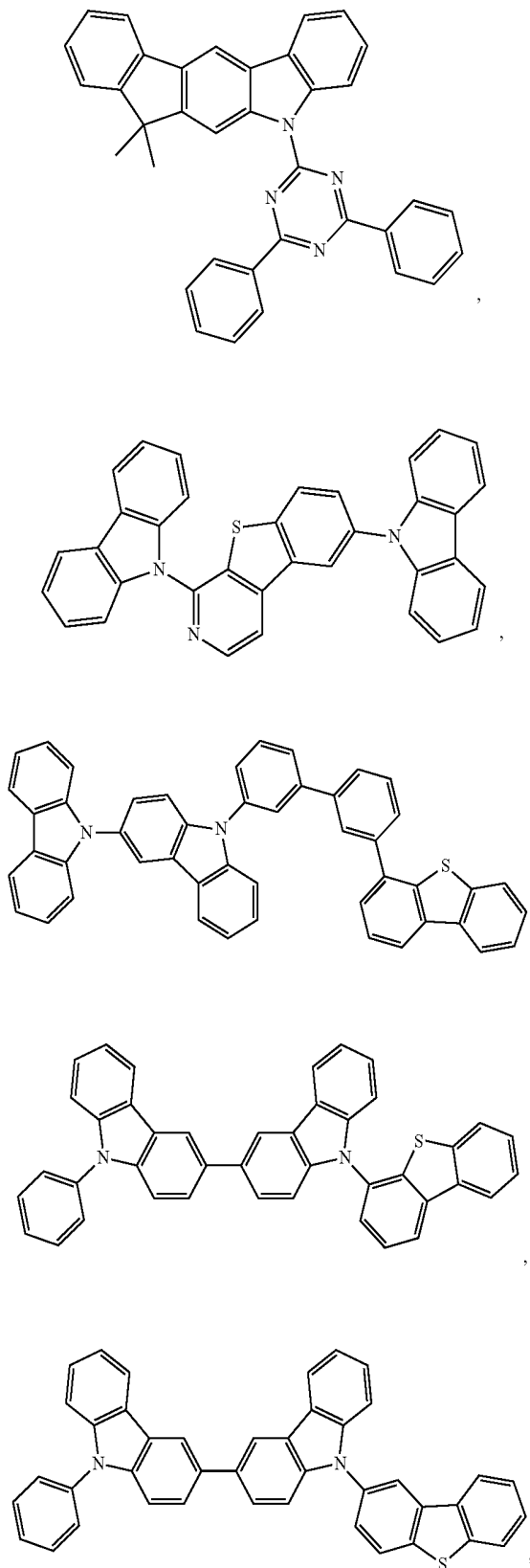
[0124] The organic layer can also include a host. In some embodiments, two or more hosts are preferred. In some embodiments, the hosts used maybe a) bipolar, b) electron transporting, c) hole transporting or d) wide band gap

materials that play little role in charge transport. In some embodiments, the host can include a metal complex. The host can be a triphenylene containing benzo-fused thiophene or benzo-fused furan. Any substituent in the host can be an unfused substituent independently selected from the group consisting of C_nH_{2n+1} , OC_nH_{2n+1} , OAr_1 , $N(C_nH_{2n+1})_2$, $N(Ar_1)(Ar_2)$, $CH=CH-C_nH_{2n+1}$, $C\equiv C-C_nH_{2n+1}$, Ar_1 , Ar_1-Ar_2 , and $C_nH_{2n}-Ar_1$, or the host has no substitutions. In the preceding substituents n can range from 1 to 10; and Ar_1 and Ar_2 can be independently selected from the group consisting of benzene, biphenyl, naphthalene, triphenylene, carbazole, and heteroaromatic analogs thereof. The host can be an inorganic compound. For example a Zn containing inorganic material e.g. ZnS.

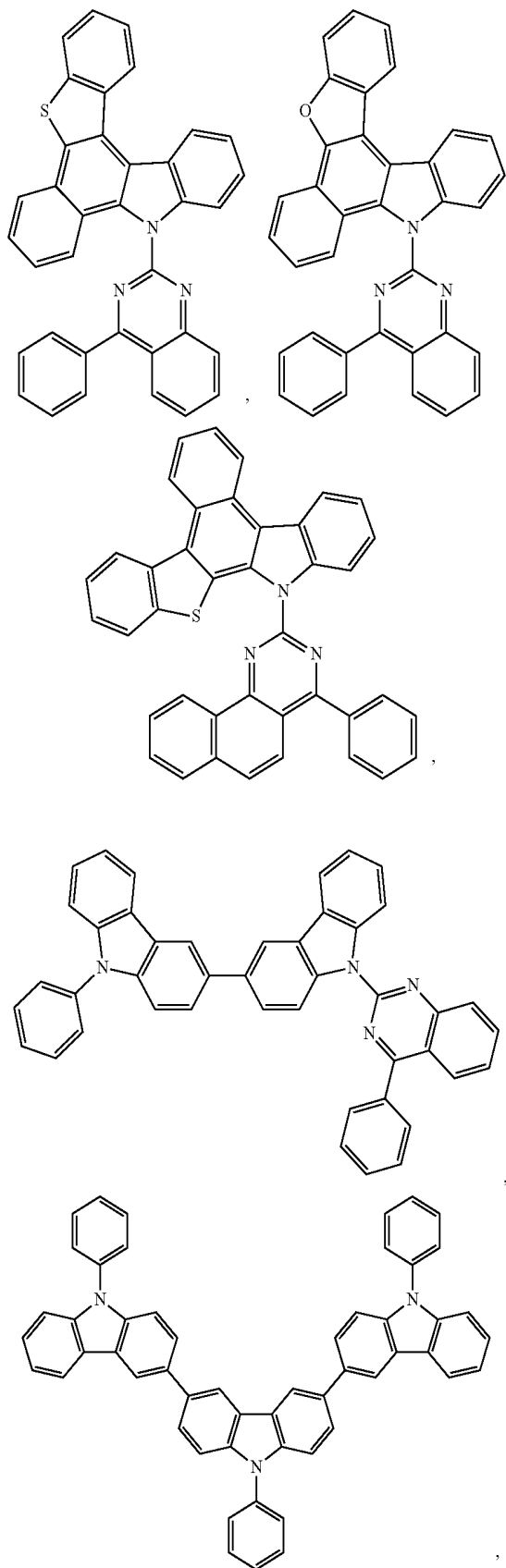
[0125] The host can be a compound comprising at least one chemical group selected from the group consisting of triphenylene, carbazole, dibenzothiophene, dibenzofuran, dibenzoselenophene, azatriphenylene, azacarbazole, aza-dibenzothiophene, aza-dibenzofuran, and aza-dibenzoselenophene. The host can include a metal complex. The host can be, but is not limited to, a specific compound selected from the group consisting of:



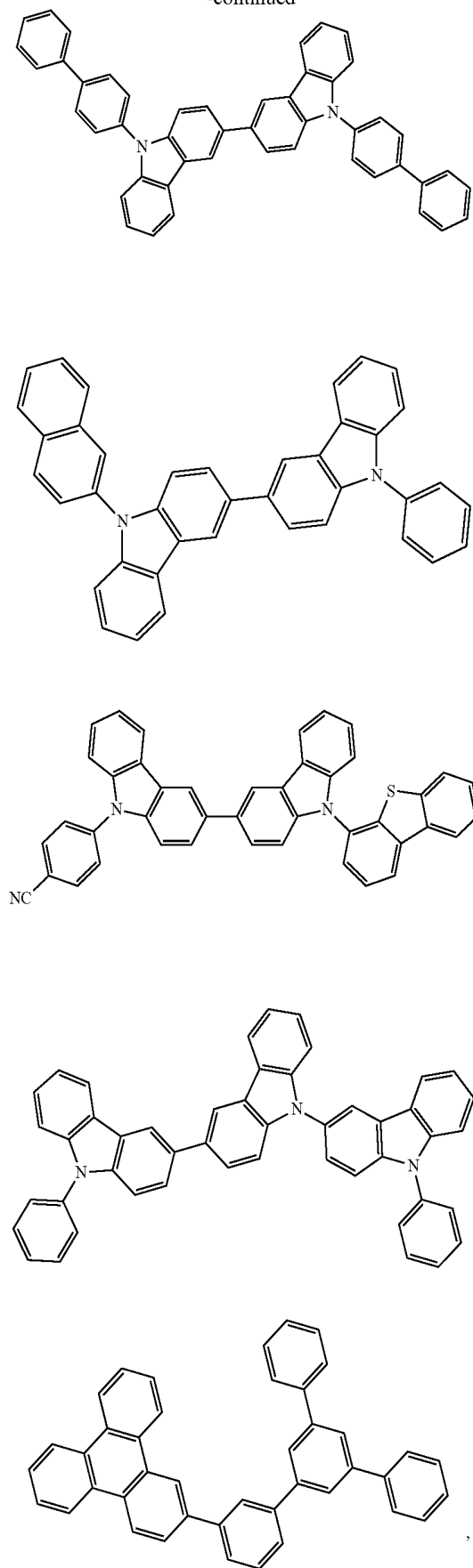
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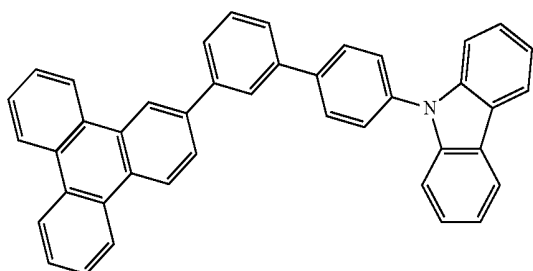
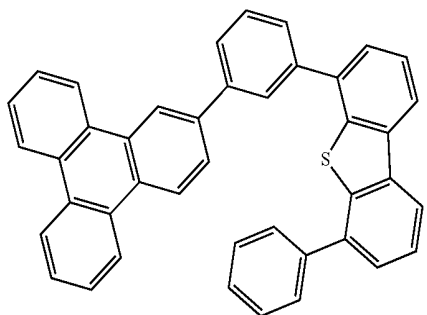
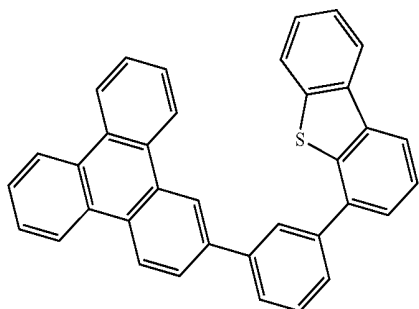
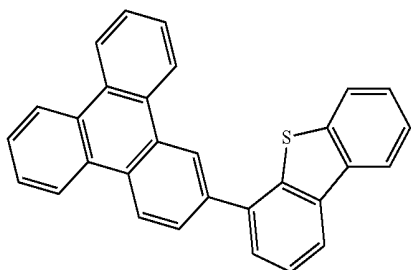
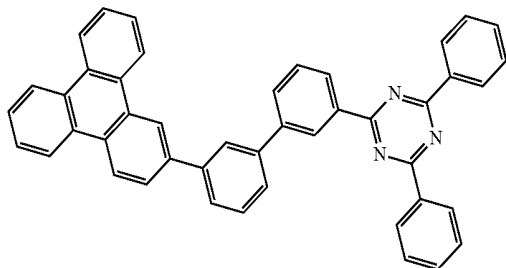
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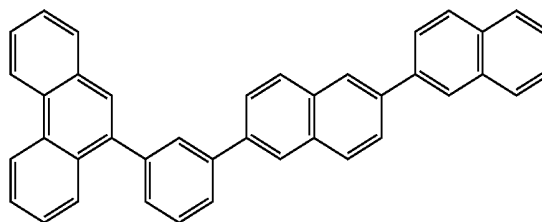
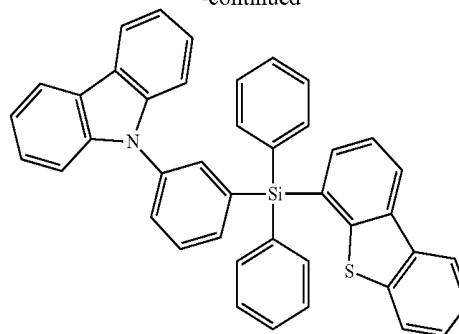
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and combinations thereof.

Additional information on possible hosts is provided below.

[0126] In yet another aspect of the present disclosure, a formulation that comprises the novel compound disclosed herein is described. The formulation can include one or more components selected from the group consisting of a solvent, a host, a hole injection material, hole transport material, electron blocking material, hole blocking material, and an electron transport material, disclosed herein.

Combination with Other Materials

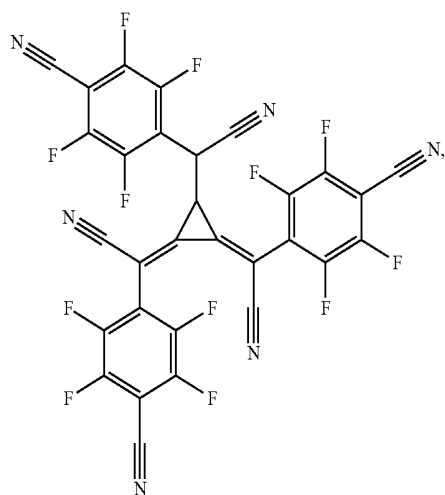
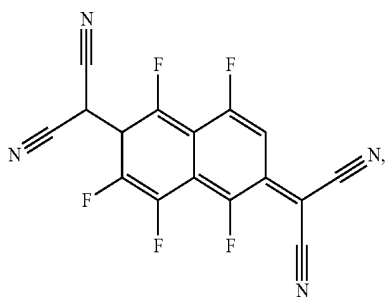
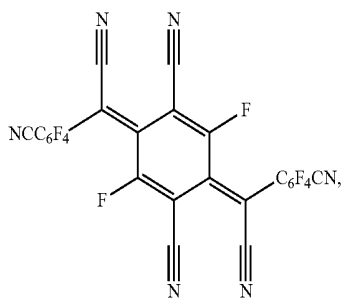
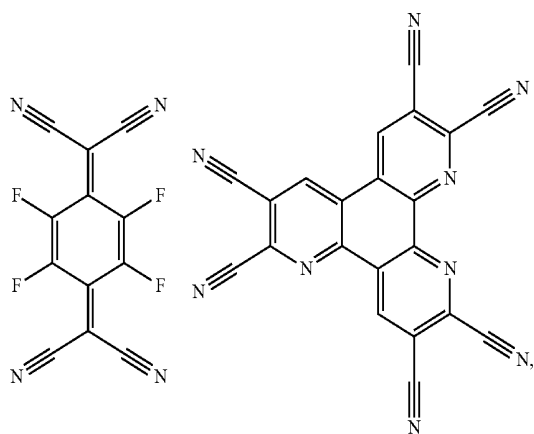
[0127] The materials described herein as useful for a particular layer in an organic light emitting device may be used in combination with a wide variety of other materials present in the device. For example, emissive dopants disclosed herein may be used in conjunction with a wide variety of hosts, transport layers, blocking layers, injection layers, electrodes and other layers that may be present. The materials described or referred to below are non-limiting examples of materials that may be useful in combination with the compounds disclosed herein, and one of skill in the art can readily consult the literature to identify other materials that may be useful in combination.

Conductivity Dopants:

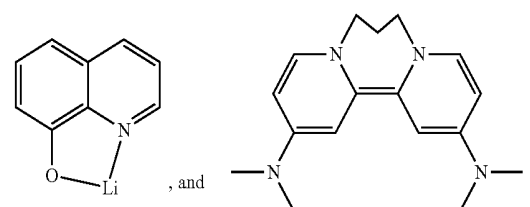
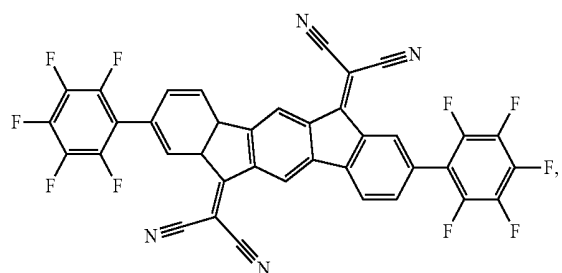
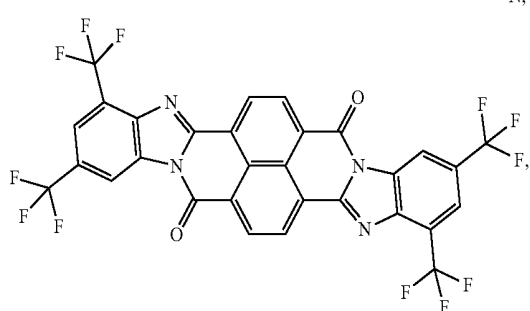
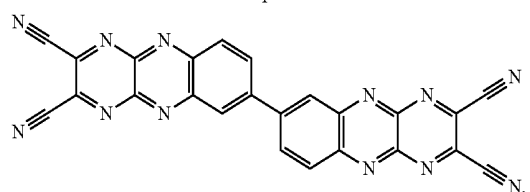
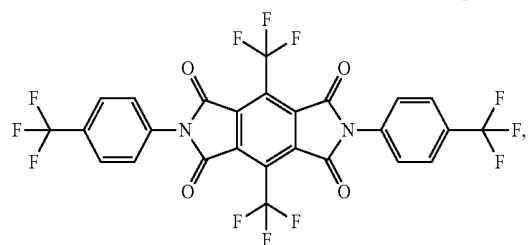
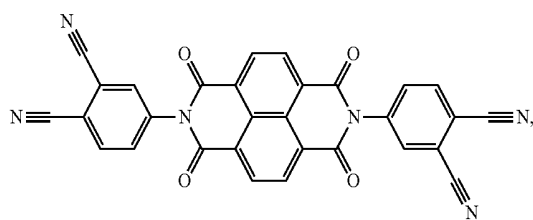
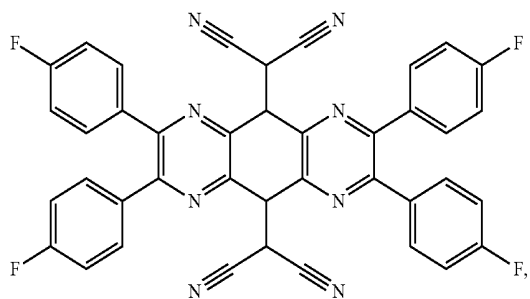
[0128] A charge transport layer can be doped with conductivity dopants to substantially alter its density of charge carriers, which will in turn alter its conductivity. The conductivity is increased by generating charge carriers in the matrix material, and depending on the type of dopant, a change in the Fermi level of the semiconductor may also be achieved. Hole-transporting layer can be doped by p-type conductivity dopants and n-type conductivity dopants are used in the electron-transporting layer.

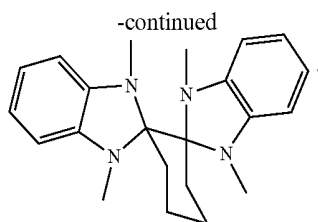
[0129] Non-limiting examples of the conductivity dopants that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: EP01617493, EP01968131, EP2020694, EP2684932, US20050139810, US20070160905, US20090167167, US2010288362, WO06081780, WO2009003455, WO2009008277,

WO2009011327, WO2014009310, US2007252140,
US2015060804, US20150123047, and US2012146012.



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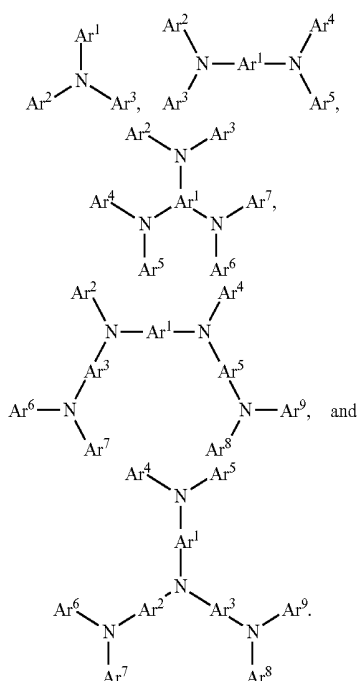




HIL/HTL:

[0130] A hole injecting/transporting material to be used in the present invention is not particularly limited, and any compound may be used as long as the compound is typically used as a hole injecting/transporting material. Examples of the material include, but are not limited to: a phthalocyanine or porphyrin derivative; an aromatic amine derivative; an indolocarbazole derivative; a polymer containing fluorohydrocarbon; a polymer with conductivity dopants; a conducting polymer, such as PEDOT/PSS; a self-assembly monomer derived from compounds such as phosphonic acid and silane derivatives; a metal oxide derivative, such as MoO_x ; a p-type semiconducting organic compound, such as 1,4,5,8,9,12-Hexaazatriphenylenehexacarbonitrile; a metal complex, and a cross-linkable compounds.

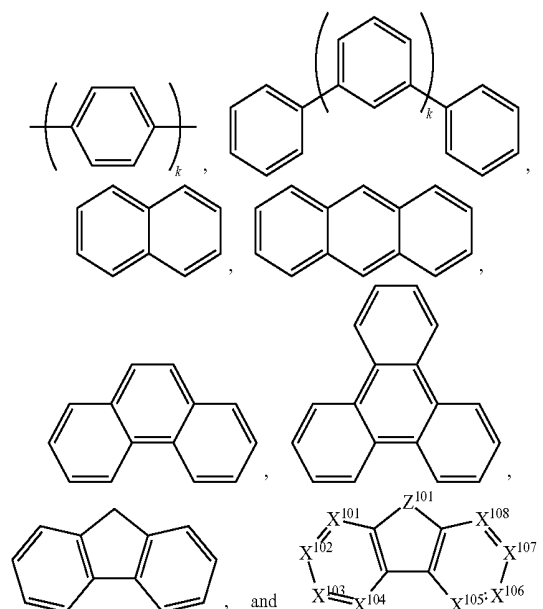
[0131] Examples of aromatic amine derivatives used in HIL or HTL include, but not limit to the following general structures:



[0132] Each of Ar^1 to Ar^9 is selected from the group consisting of aromatic hydrocarbon cyclic compounds such as benzene, biphenyl, triphenyl, triphenylene, naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, and azulene; the group consisting of aromatic heterocyclic compounds such as dibenzothio-
 phene, dibenzofuran, dibenzoselenophene, furan, thiophene, benzofuran, benzothiophene, benzoselenophene, carbazole,

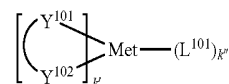
indolocarbazole, pyridylindole, pyrrolodipyridine, pyrazole, imidazole, triazole, oxazole, thiazole, oxadiazole, oxatriazole, dioxazole, thiadiazole, pyridine, pyridazine, pyrimidine, pyrazine, triazine, oxazine, oxathiazine, oxadiazine, indole, benzimidazole, indazole, indoxazine, benzoxazole, benzisoxazole, benzothiazole, quinoline, isoquinoline, cinnoline, quinazoline, quinoxaline, naphthyridine, phthalazine, pteridine, xanthene, acridine, phenazine, phenothiazine, phenoxazine, benzofuopyridine, furodipyridine, benzothienopyridine, thienodipyridine, benzoselenophenopyridine, and selenophenodipyridine; and the group consisting of 2 to 10 cyclic structural units which are groups of the same type or different types selected from the aromatic hydrocarbon cyclic group and the aromatic heterocyclic group and are bonded to each other directly or via at least one of oxygen atom, nitrogen atom, sulfur atom, silicon atom, phosphorus atom, boron atom, chain structural unit and the aliphatic cyclic group. Each Ar may be unsubstituted or may be substituted by a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acids, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof.

[0133] In one aspect, Ar^1 to Ar^9 is independently selected from the group consisting of:



wherein k is an integer from 1 to 20; X^{101} to X^{108} is C (including CH) or N; Z^{101} is NAr¹, O, or S; Ar¹ has the same group defined above.

[0134] Examples of metal complexes used in HIL or HTL include, but are not limited to the following general formula:

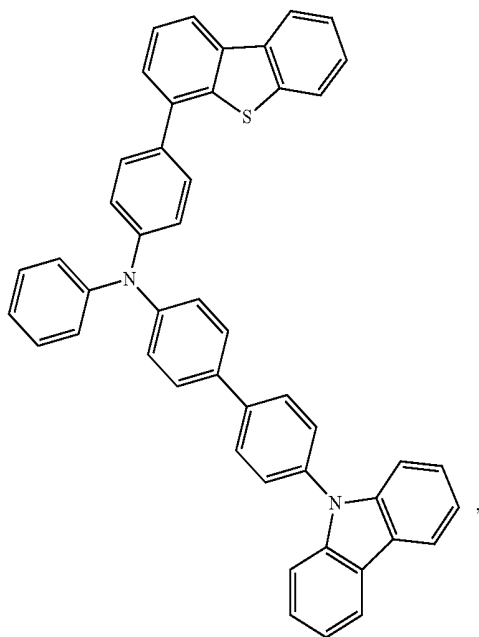
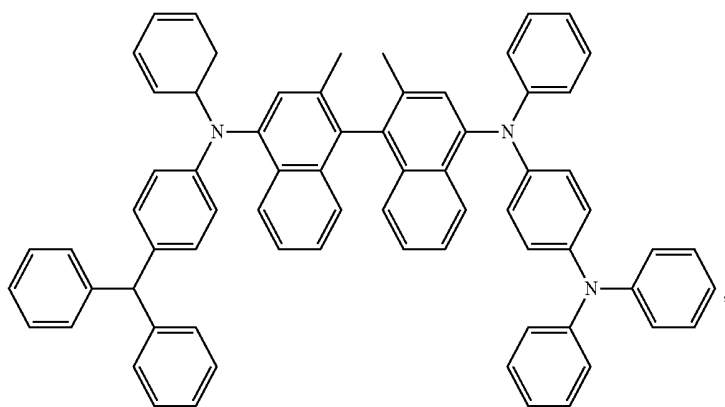


wherein Met is a metal, which can have an atomic weight greater than 40; ($Y^{101}-Y^{102}$) is a bidentate ligand, Y^{101} and Y^{102} are independently selected from C, N, O, P, and S; L^{101} is an ancillary ligand; k' is an integer value from 1 to the maximum number of ligands that may be attached to the metal; and $k'+k''$ is the maximum number of ligands that may be attached to the metal.

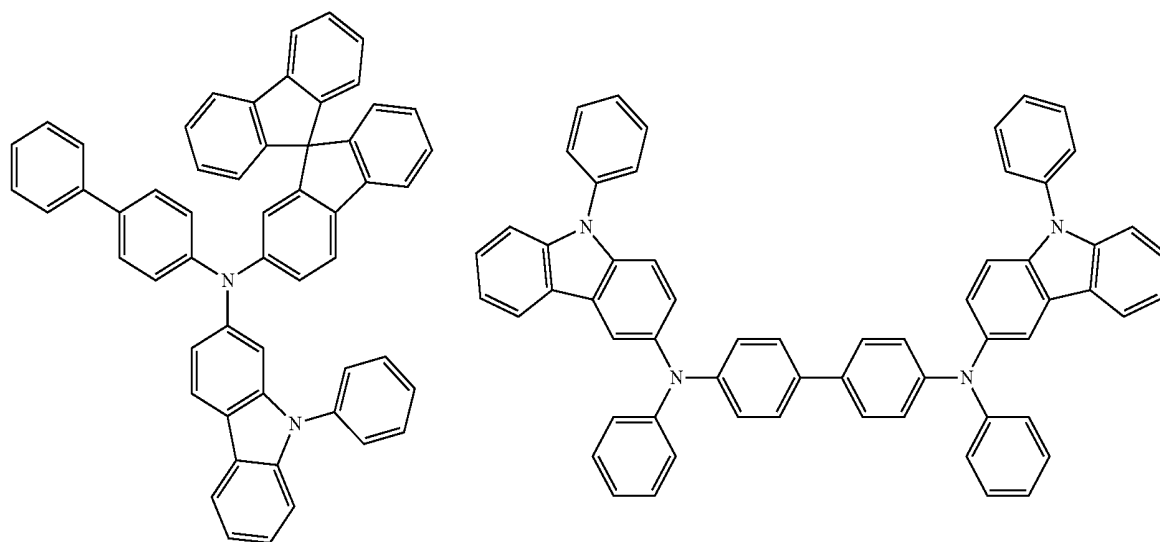
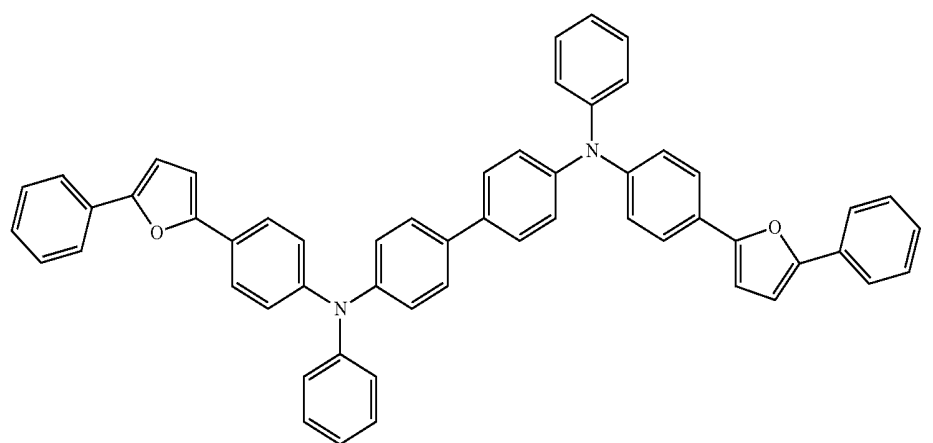
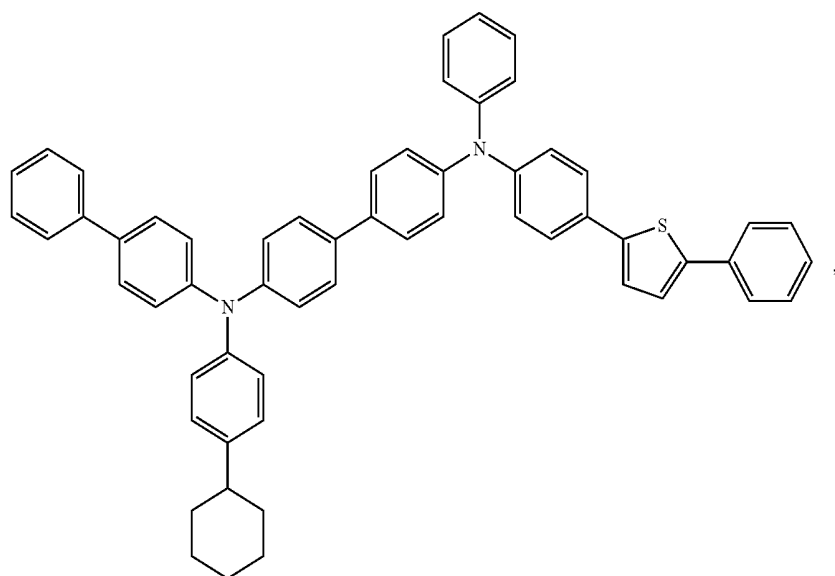
[0135] In one aspect, ($Y^{101}-Y^{102}$) is a 2-phenylpyridine derivative. In another aspect, ($Y^{101}-Y^{102}$) is a carbene ligand. In another aspect, Met is selected from Ir, Pt, Os, and Zn. In a further aspect, the metal complex has a smallest oxidation potential in solution vs. Fc+/Fc couple less than about 0.6 V.

[0136] Non-limiting examples of the HIL and HTL materials that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: CN102702075, DE102012005215, EP01624500, EP01698613, EP01806334, EP01930964, EP01972613, EP01997799, EP02011790, EP02055700, EP02055701, EP1725079, EP2085382, EP2660300, EP650955, JP07-073529,

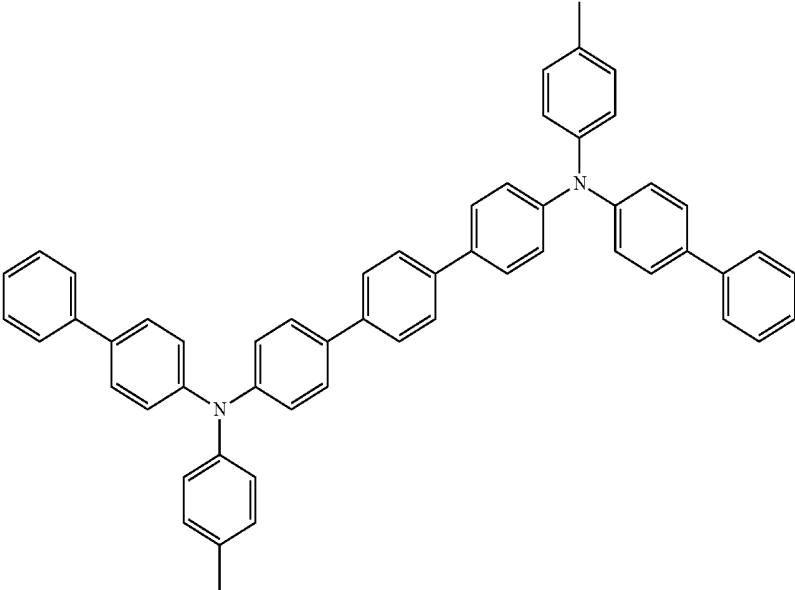
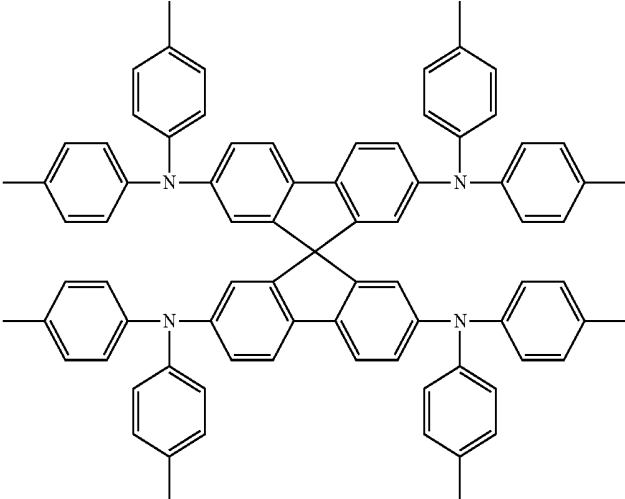
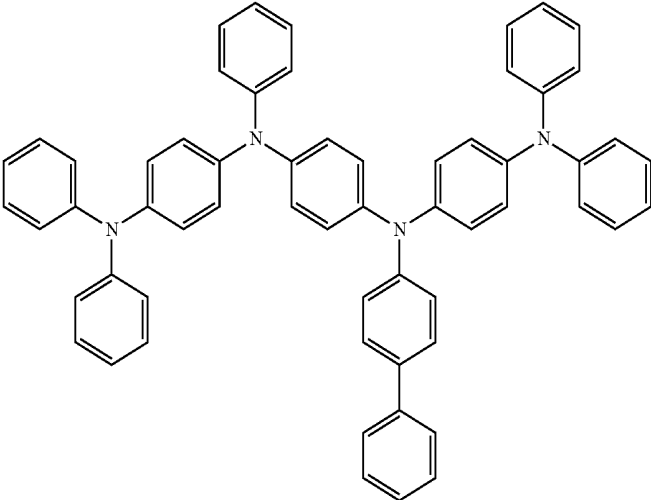
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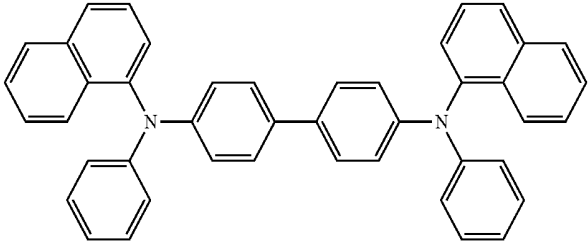
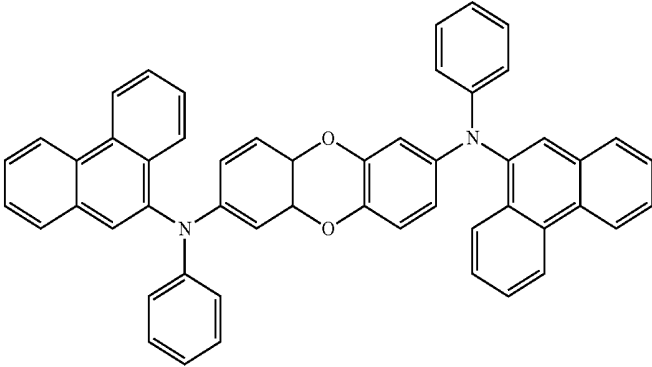
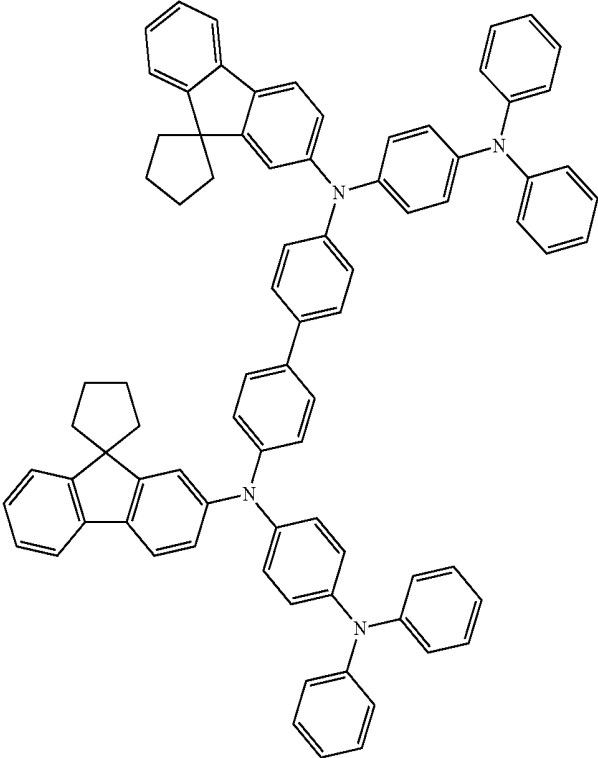
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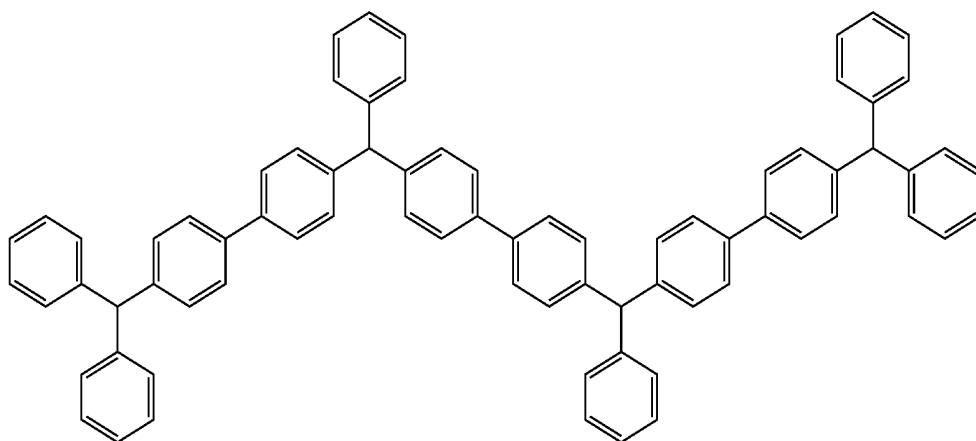
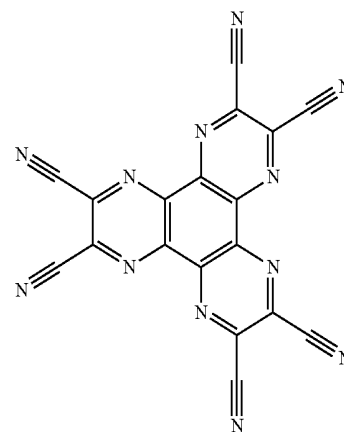
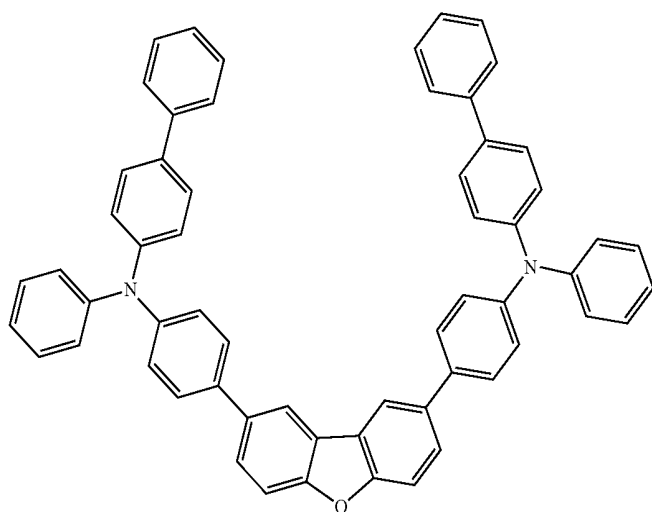
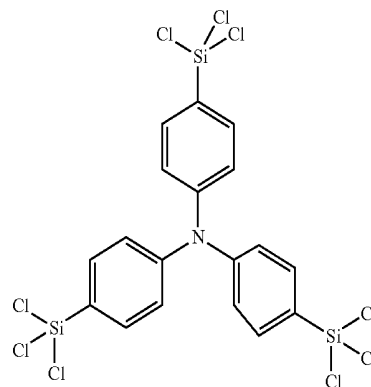
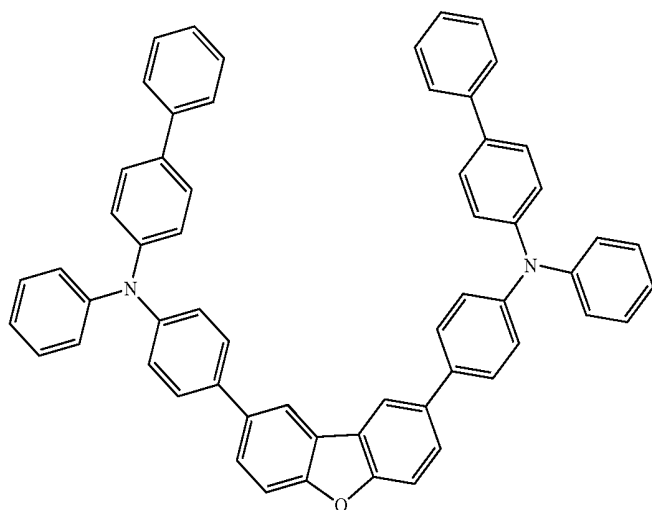


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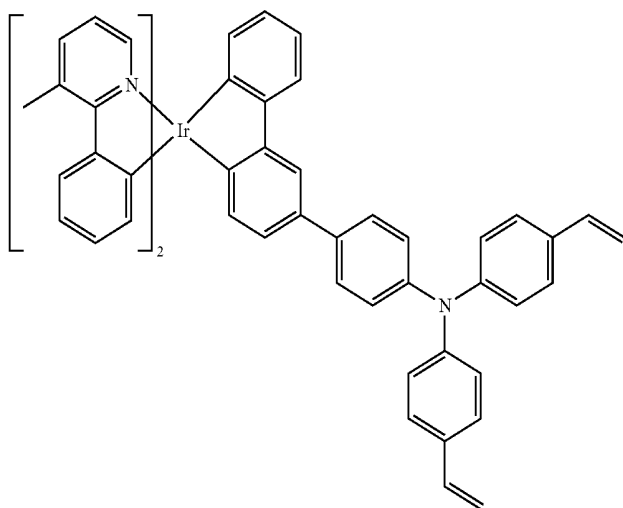
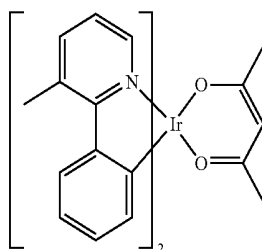
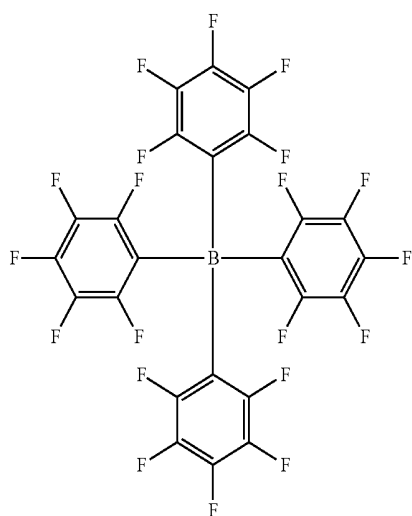
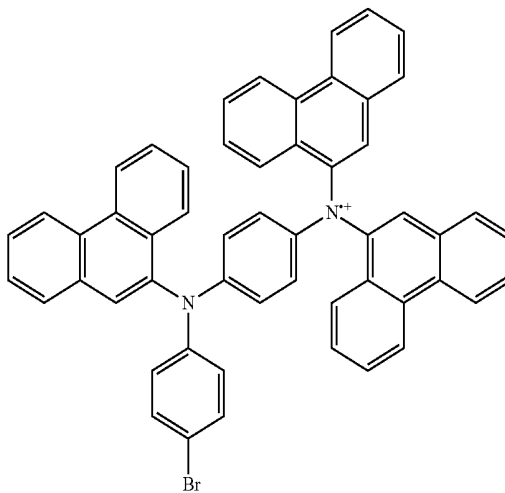
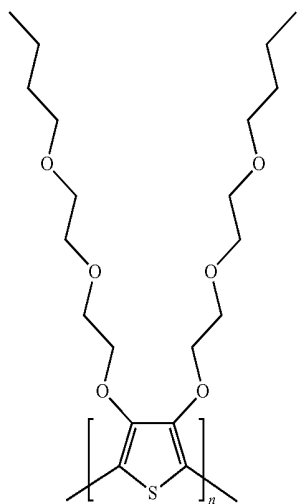


+MoO₃

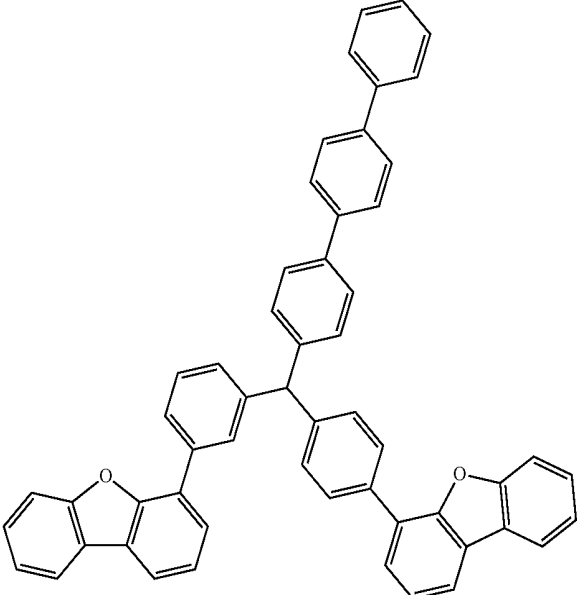
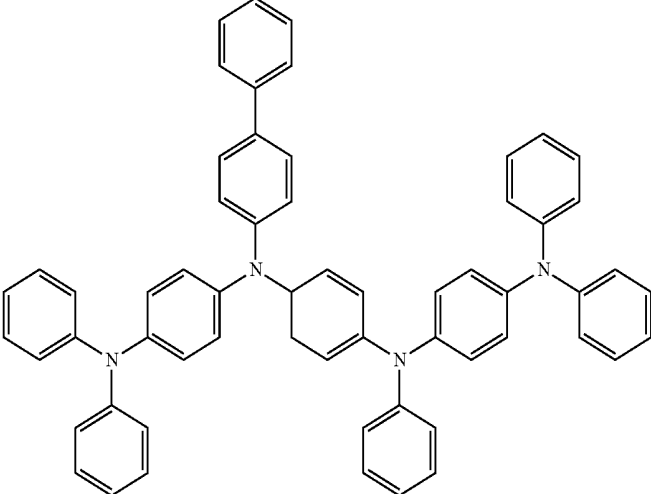
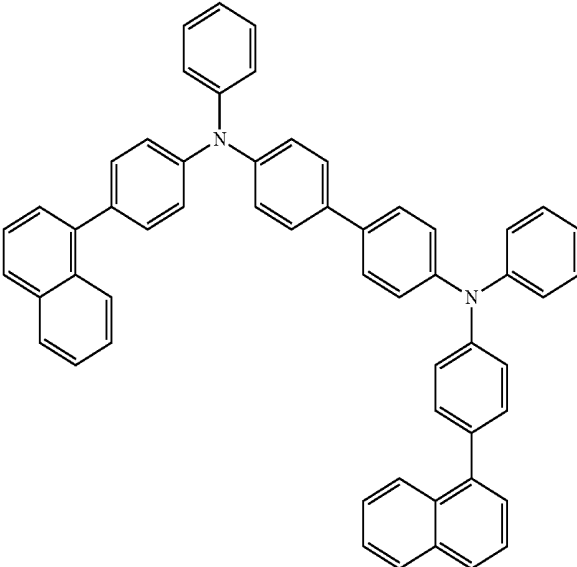
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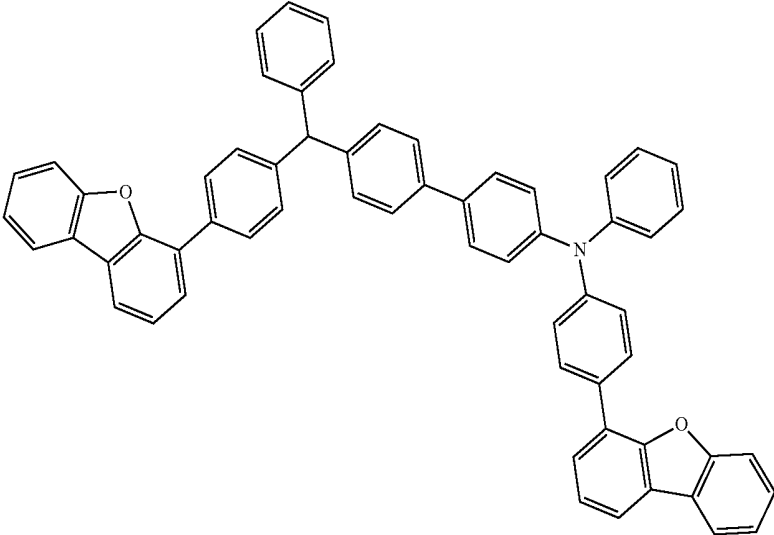
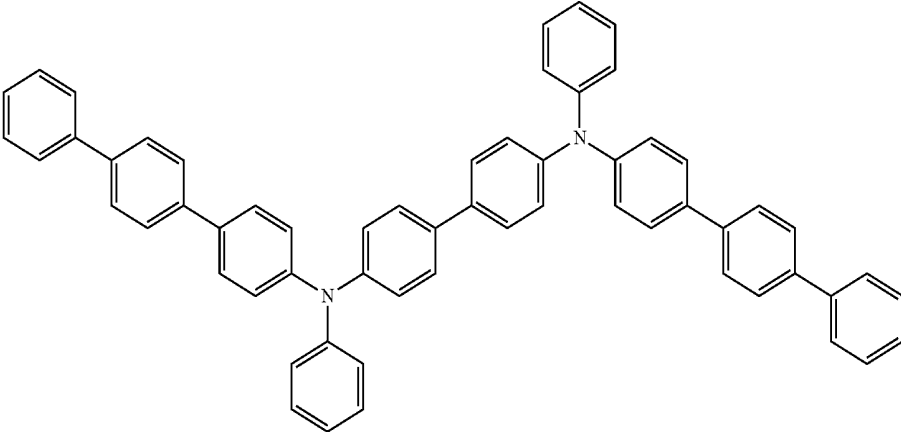
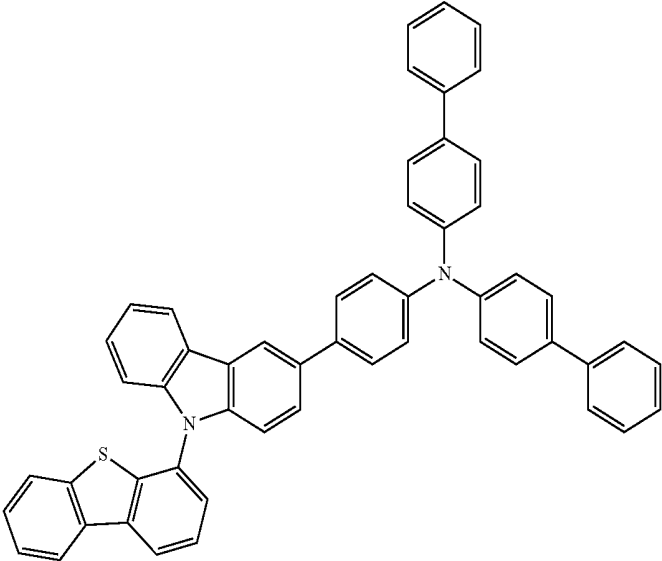
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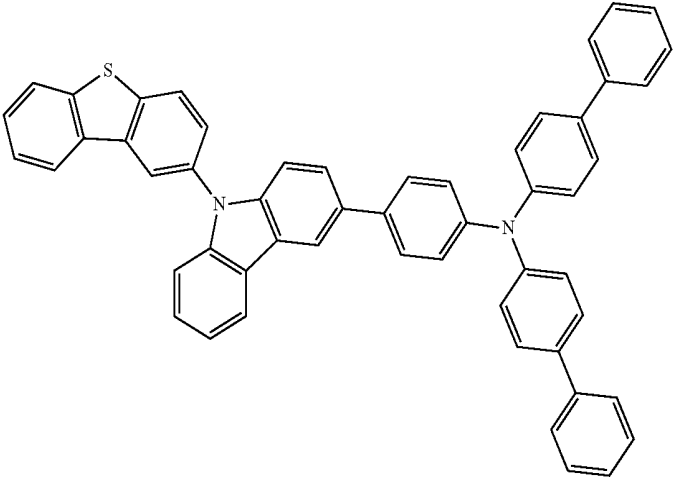
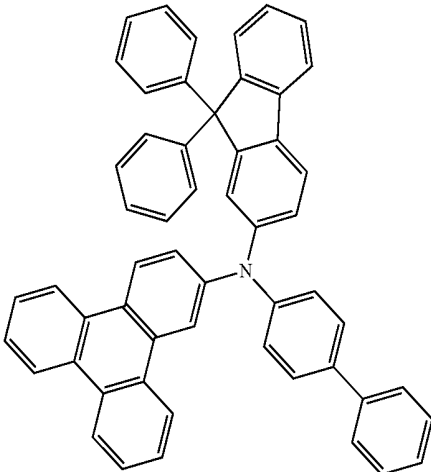
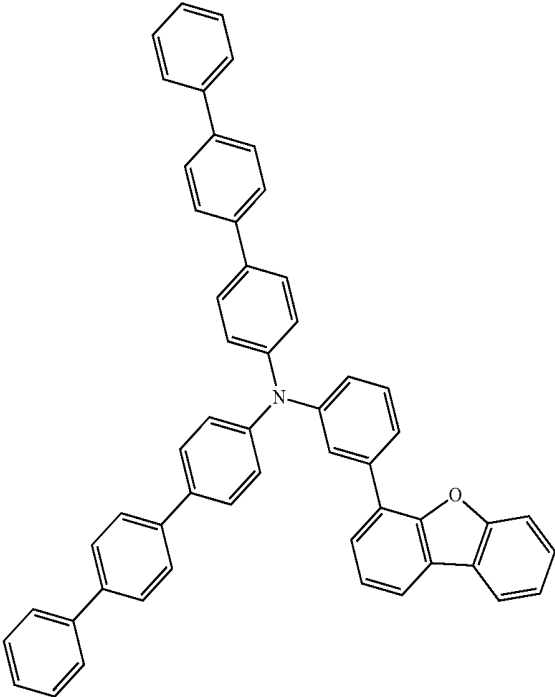
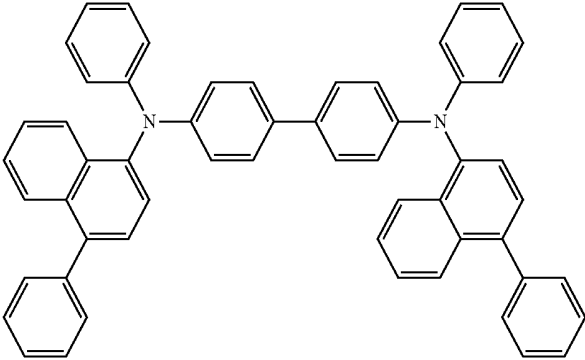
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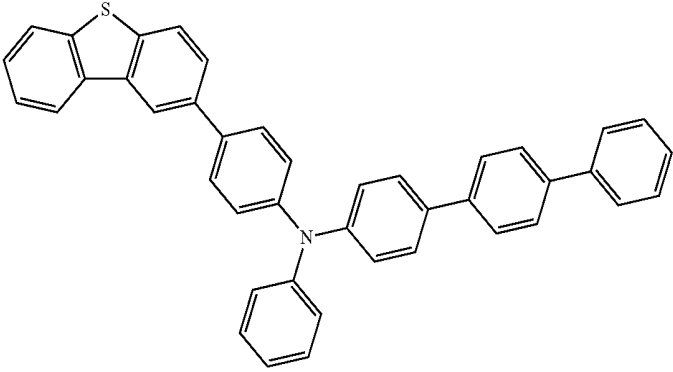
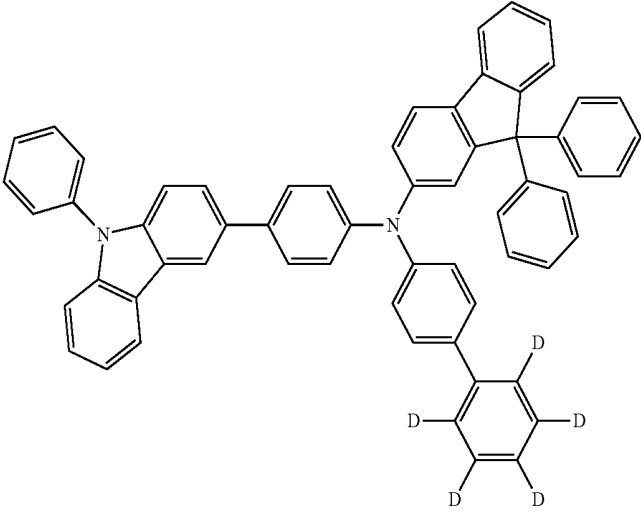
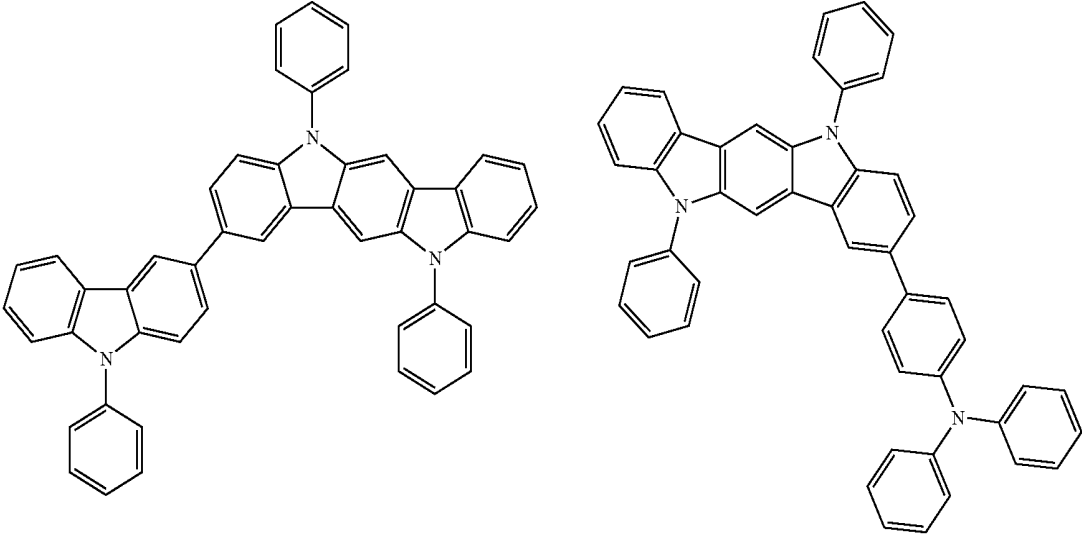
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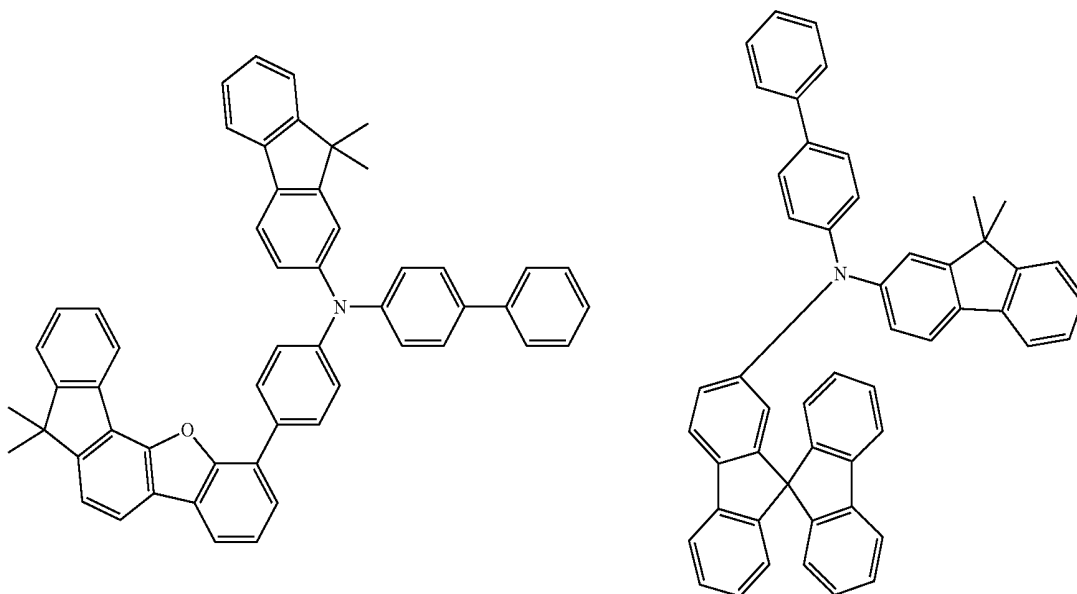
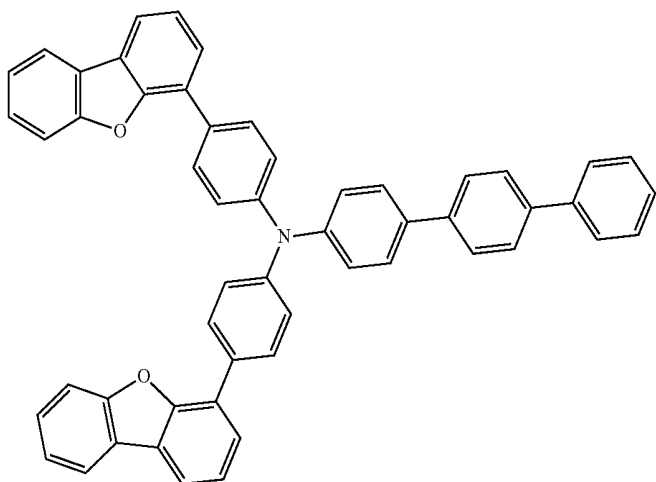
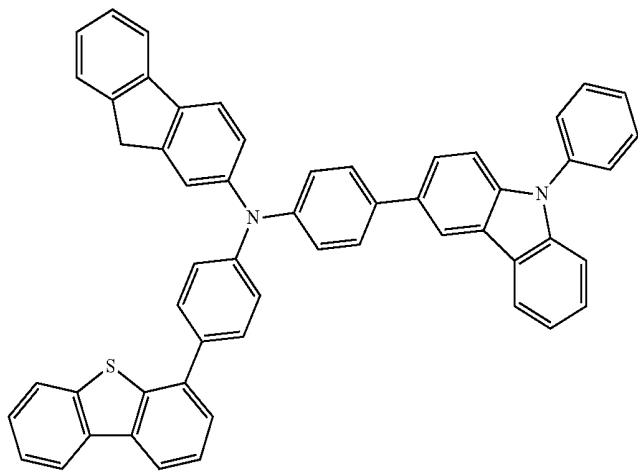
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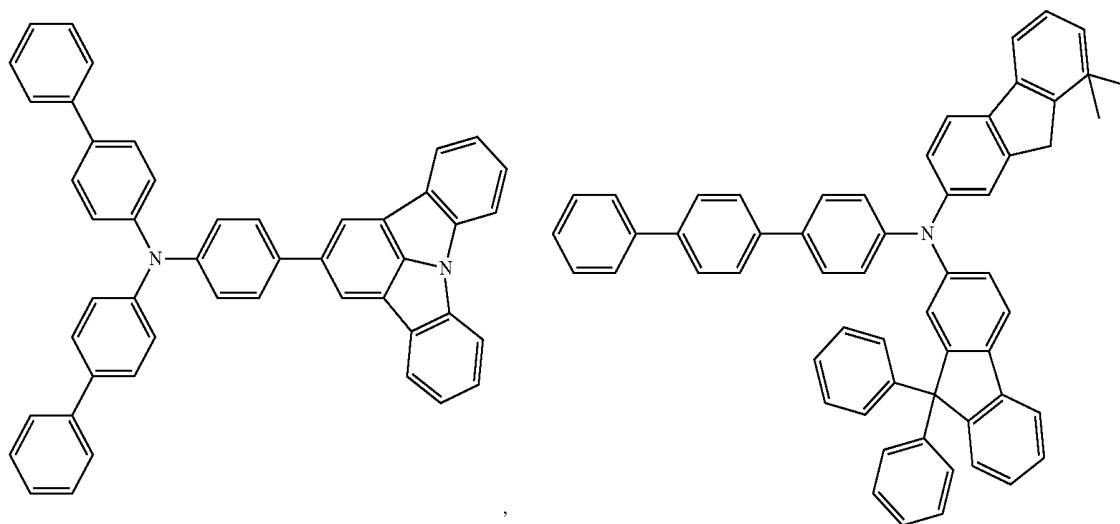
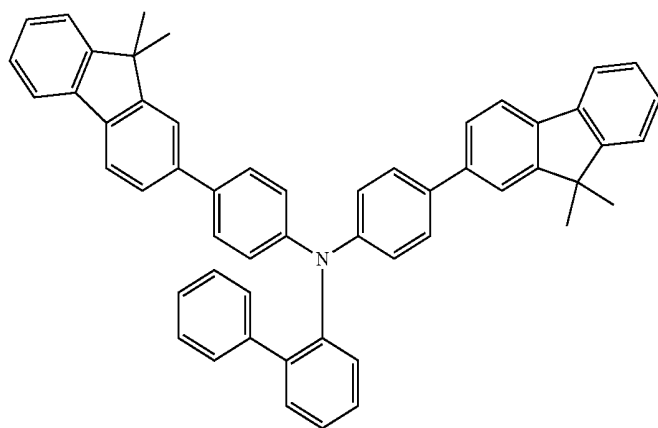
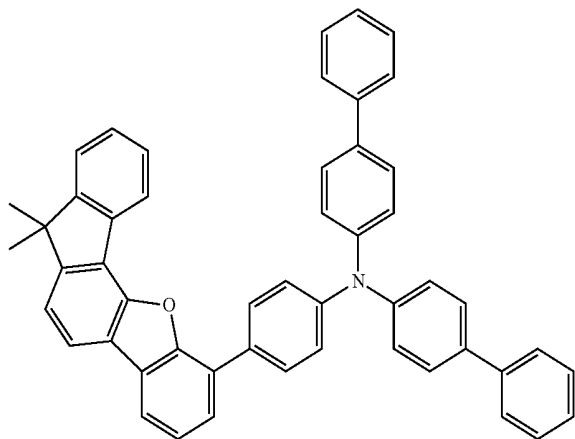
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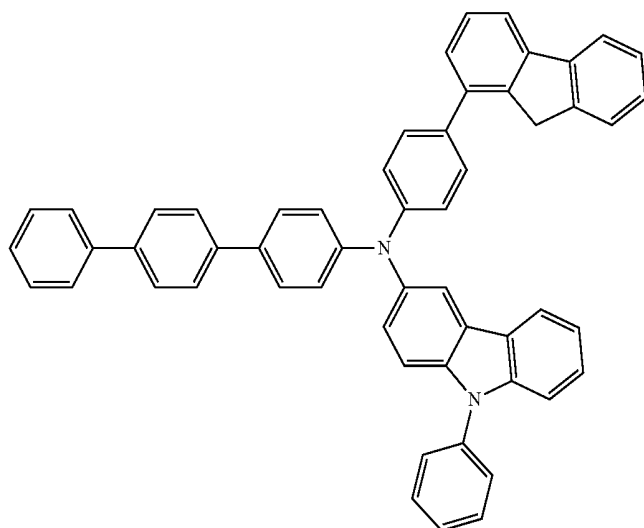
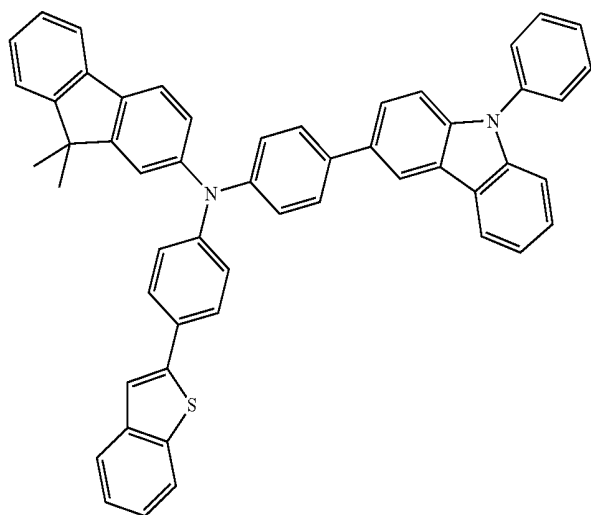
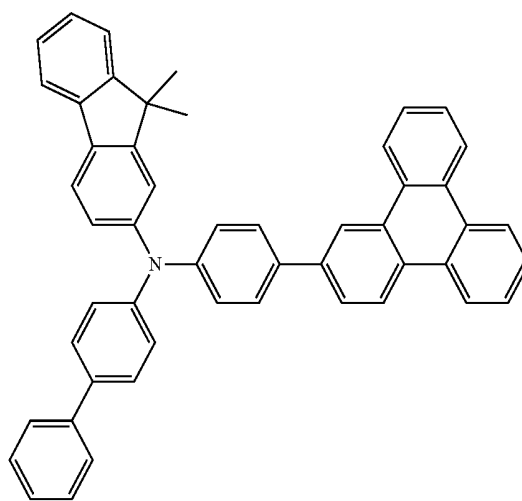
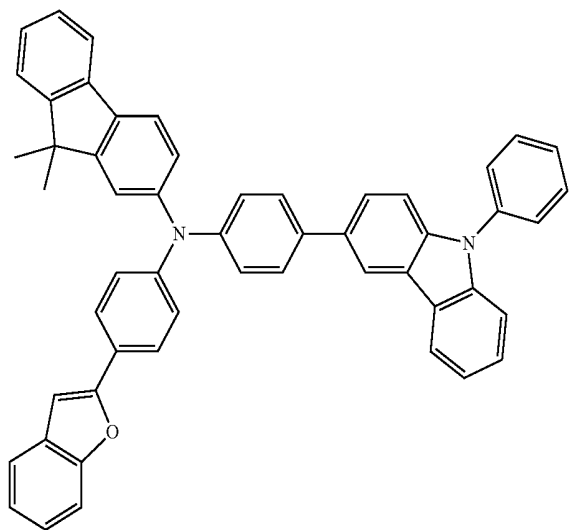
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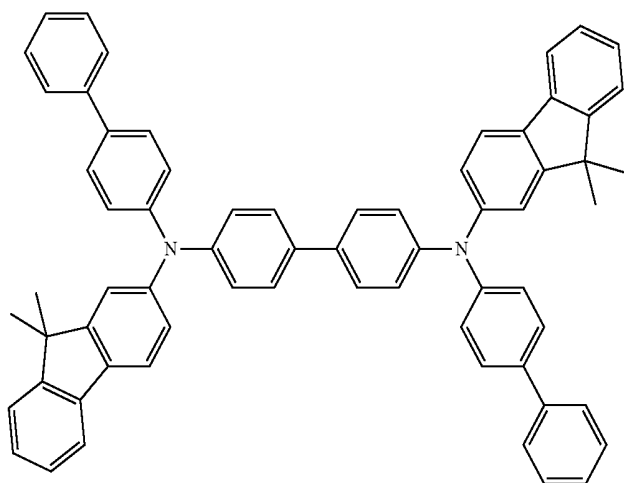
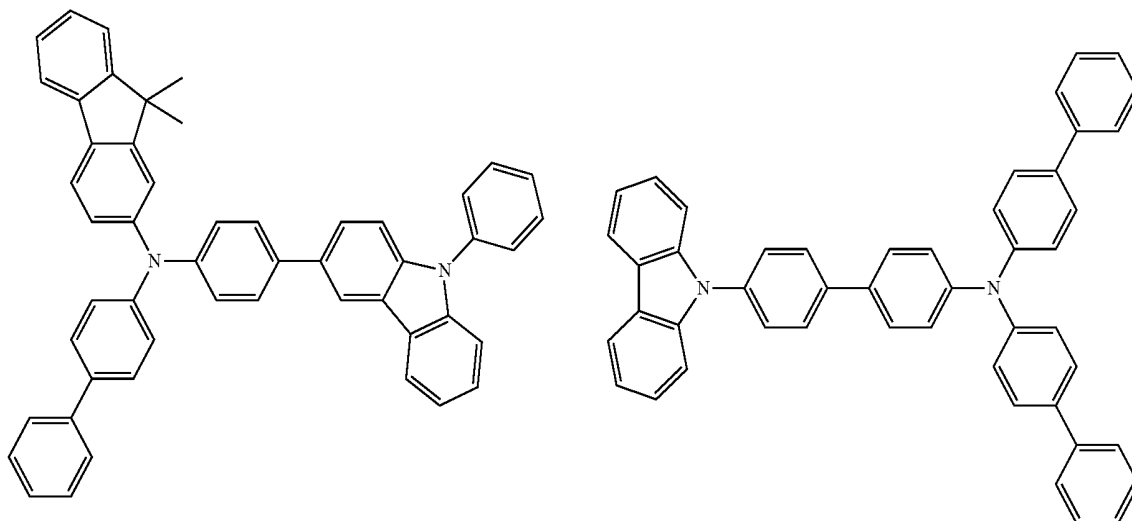
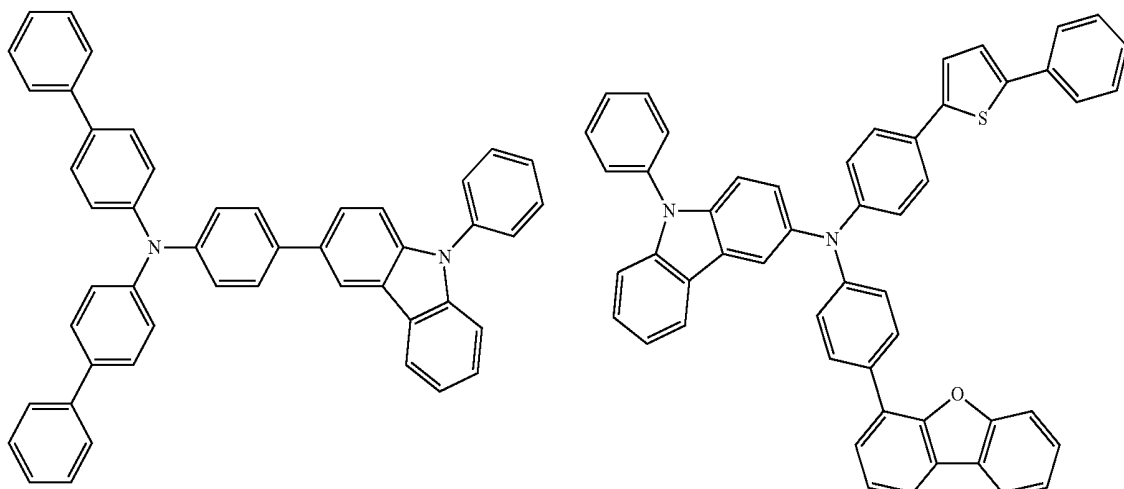
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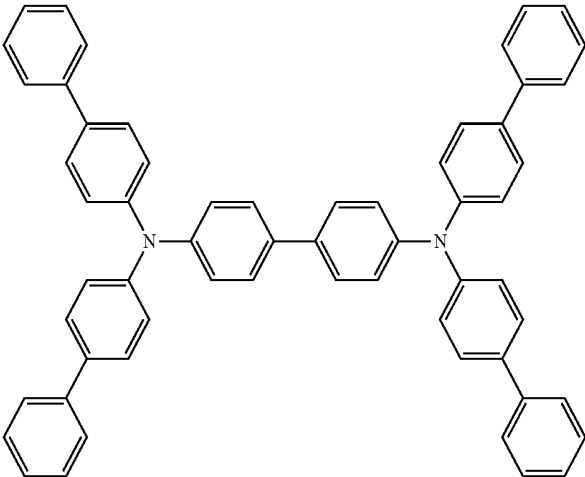
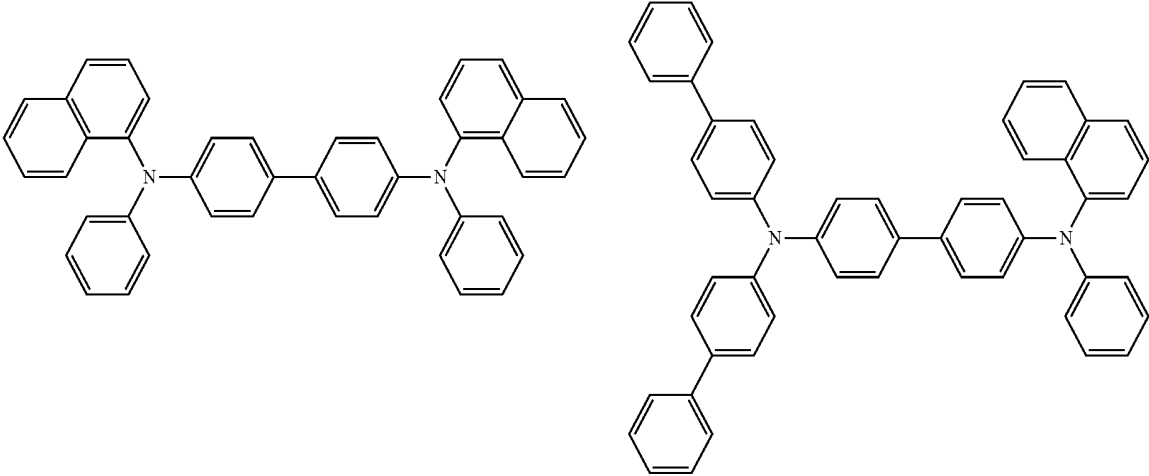
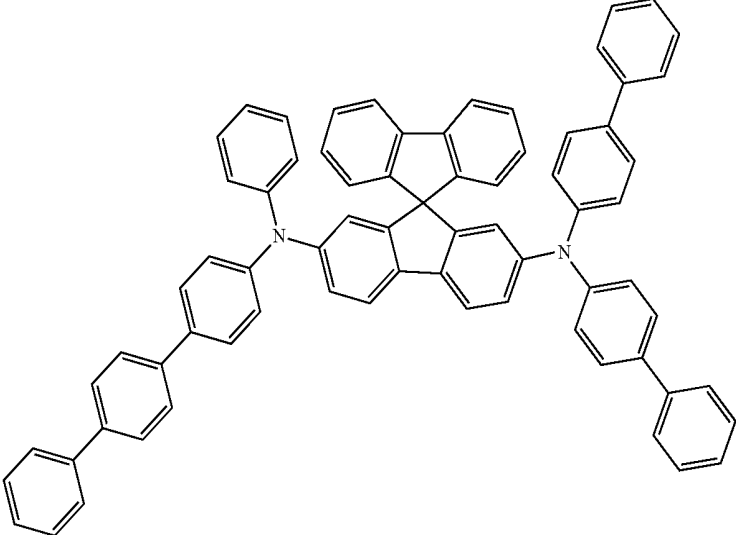
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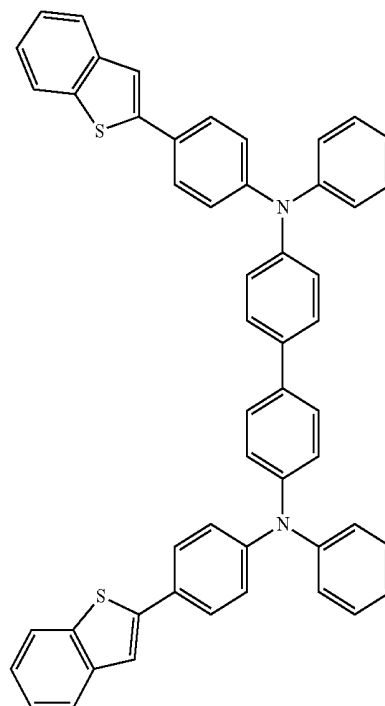
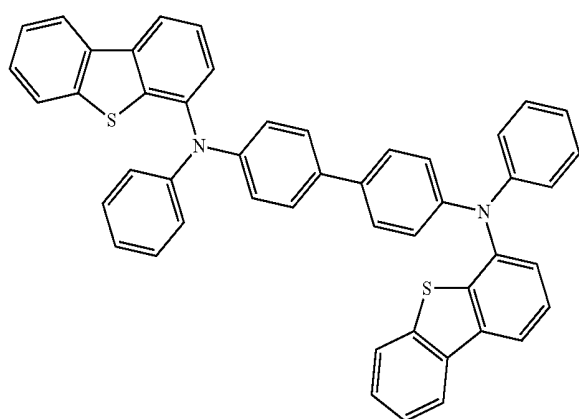
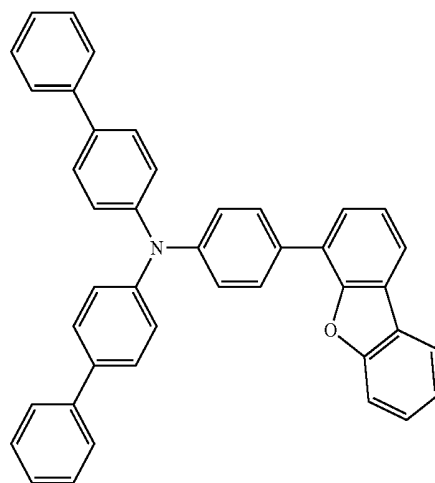
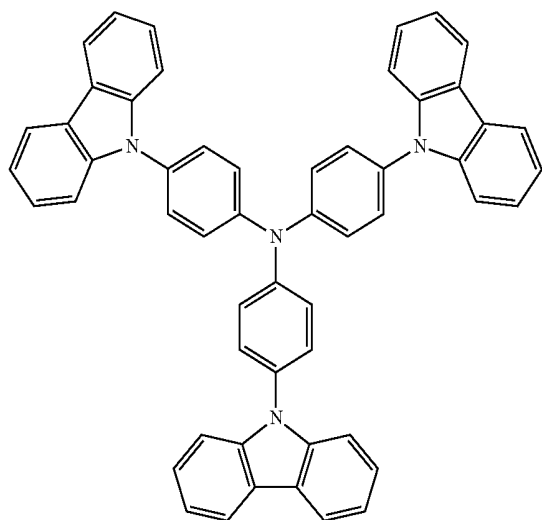
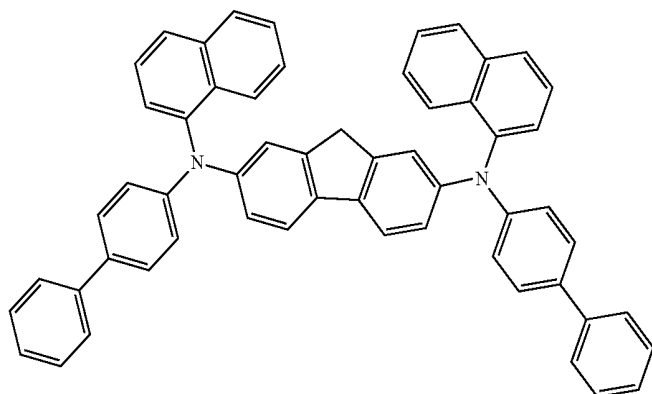
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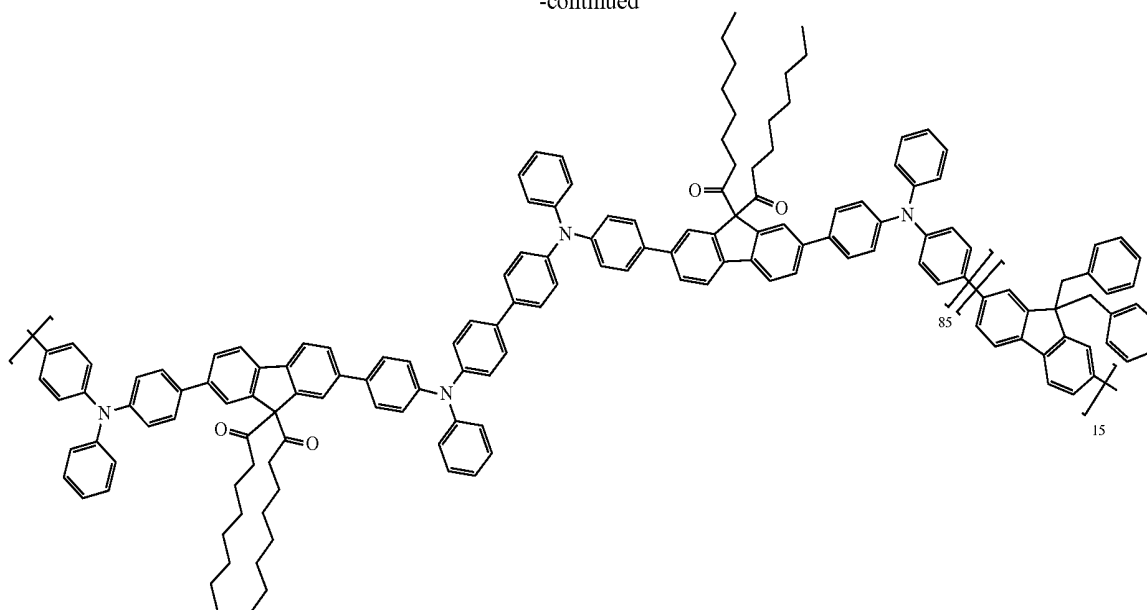


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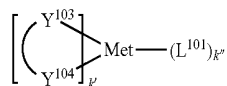
EBL:

[0137] An electron blocking layer (EBL) may be used to reduce the number of electrons and/or excitons that leave the emissive layer. The presence of such a blocking layer in a device may result in substantially higher efficiencies, and/or longer lifetime, as compared to a similar device lacking a blocking layer. Also, a blocking layer may be used to confine emission to a desired region of an OLED. In some embodiments, the EBL material has a higher LUMO (closer to the vacuum level) and/or higher triplet energy than the emitter closest to the EBL interface. In some embodiments, the EBL material has a higher LUMO (closer to the vacuum level) and/or higher triplet energy than one or more of the hosts closest to the EBL interface. In one aspect, the compound used in EBL contains the same molecule or the same functional groups used as one of the hosts described below.

Host:

[0138] The light emitting layer of the organic EL device of the present invention preferably contains at least a metal complex as light emitting material, and may contain a host material using the metal complex as a dopant material. Examples of the host material are not particularly limited, and any metal complexes or organic compounds may be used as long as the triplet energy of the host is larger than that of the dopant. Any host material may be used with any dopant so long as the triplet criteria is satisfied.

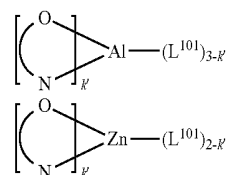
[0139] Examples of metal complexes used as host are preferred to have the following general formula:



wherein Met is a metal; (Y¹⁰³-Y¹⁰⁴) is a bidentate ligand, Y¹⁰³ and Y¹⁰⁴ are independently selected from C, N, O, P, and S; L¹⁰¹ is another ligand; k' is an integer value from

1 to the maximum number of ligands that may be attached to the metal; and k'+k'' is the maximum number of ligands that may be attached to the metal.

[0140] In one aspect, the metal complexes are:



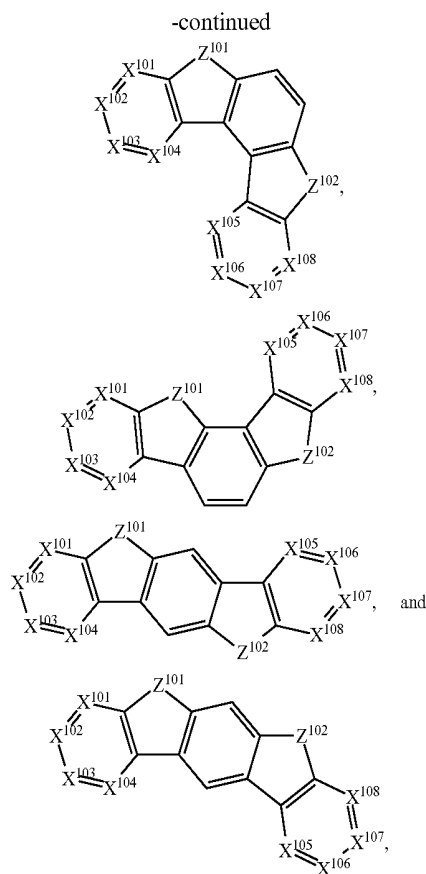
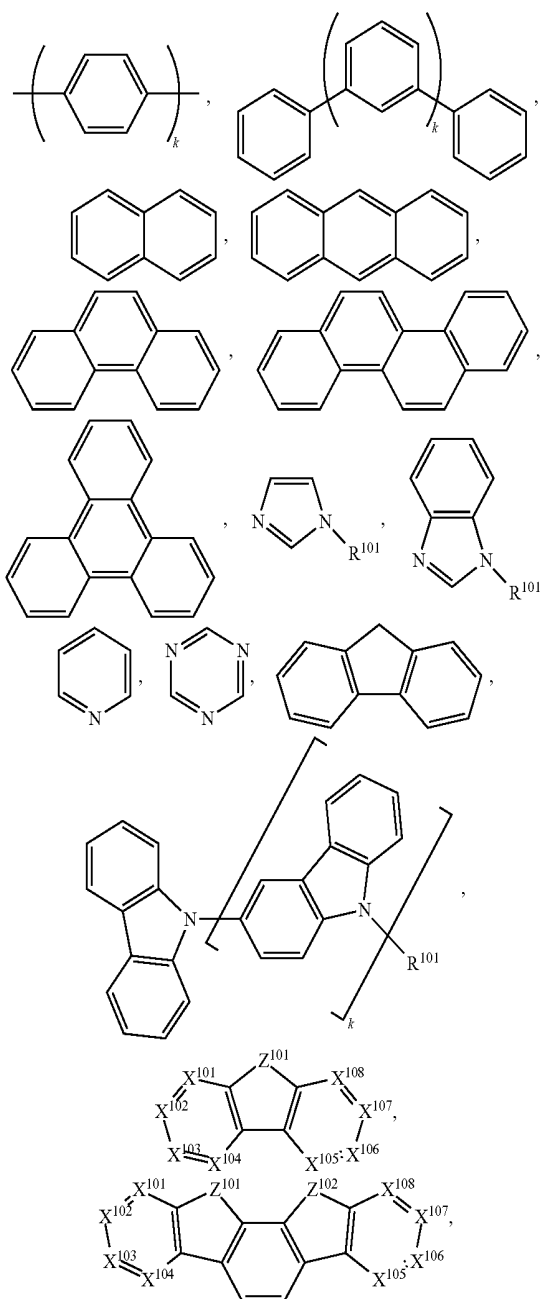
wherein (O—N) is a bidentate ligand, having metal coordinated to atoms O and N.

[0141] In another aspect, Met is selected from Ir and Pt. In a further aspect, (Y¹⁰³-Y¹⁰⁴) is a carbene ligand.

[0142] Examples of other organic compounds used as host are selected from the group consisting of aromatic hydrocarbon cyclic compounds such as benzene, biphenyl, triphenyl, triphenylene, tetraphenylene, naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, and azulene; the group consisting of aromatic heterocyclic compounds such as dibenzothiophene, dibenzofuran, dibenzoselenophene, furan, thiophene, benzofuran, benzothiophene, benzoselenophene, carbazole, indolocarbazole, pyridylindole, pyrrolopyridine, pyrazole, imidazole, triazole, oxazole, thiazole, oxadiazole, oxatriazole, dioxazole, thiadiazole, pyridine, pyridazine, pyrimidine, pyrazine, triazine, oxazine, oxathiazine, oxadiazine, indole, benzimidazole, indazole, indoxazine, benzoxazole, benzisoxazole, benzothiazole, quinoline, isoquinoline, cinoline, quinazoline, quinoxaline, naphthyridine, phthalazine, pteridine, xanthene, acridine, phenazine, phenothiazine, phenoxazine, benzofuroypyridine, furodipyridine, benzothienopyridine, thienodipyridine, benzoselenophenopyridine, and selenophenodipyridine; and the group consisting of 2 to 10 cyclic structural units which are groups of

the same type or different types selected from the aromatic hydrocarbon cyclic group and the aromatic heterocyclic group and are bonded to each other directly or via at least one of oxygen atom, nitrogen atom, sulfur atom, silicon atom, phosphorus atom, boron atom, chain structural unit and the aliphatic cyclic group. Each option within each group may be unsubstituted or may be substituted by a substituent selected from the group consisting of deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acids, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof.

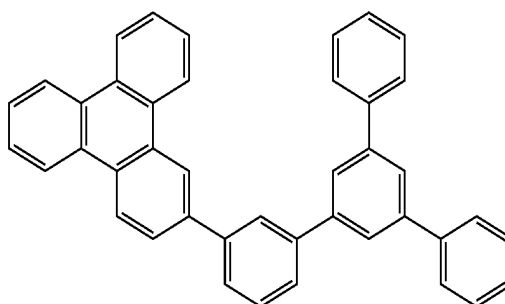
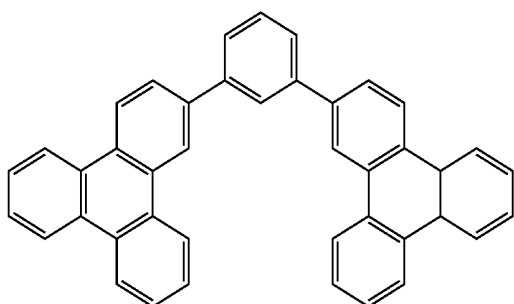
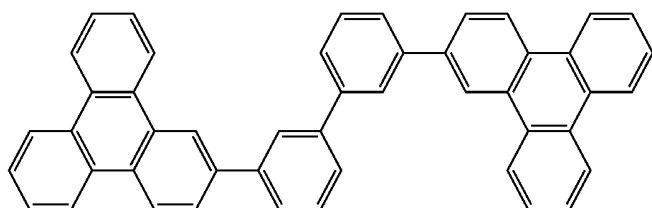
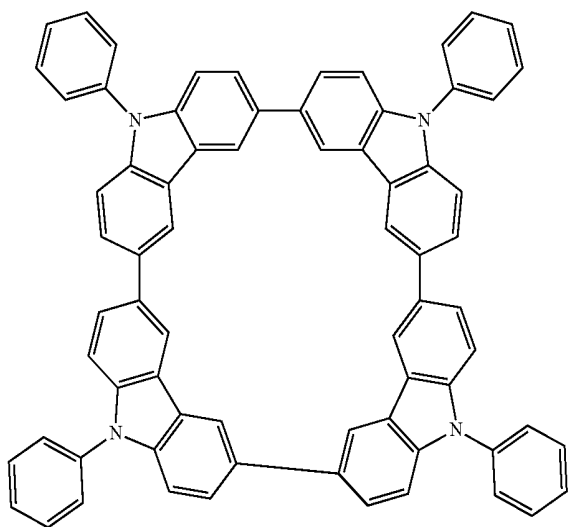
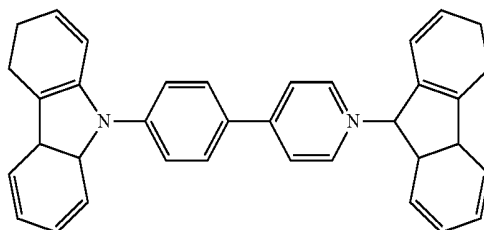
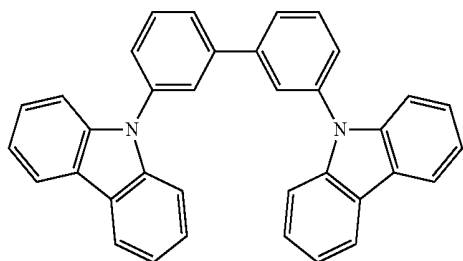
[0143] In one aspect, the host compound contains at least one of the following groups in the molecule:



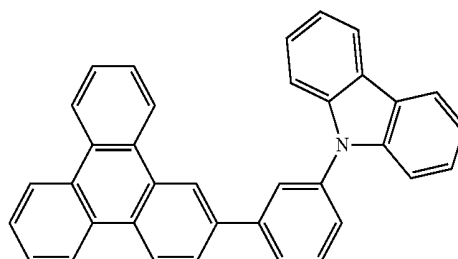
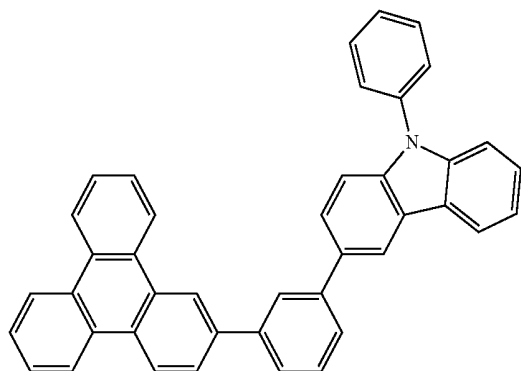
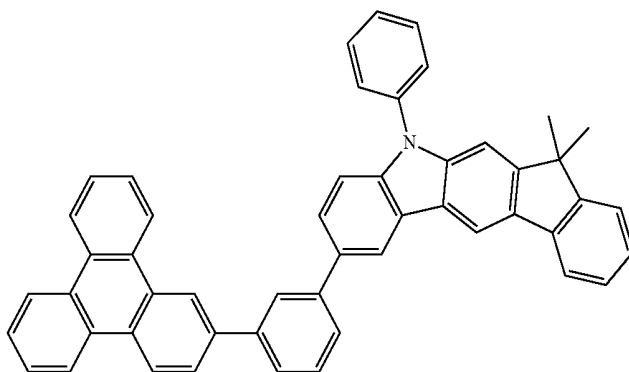
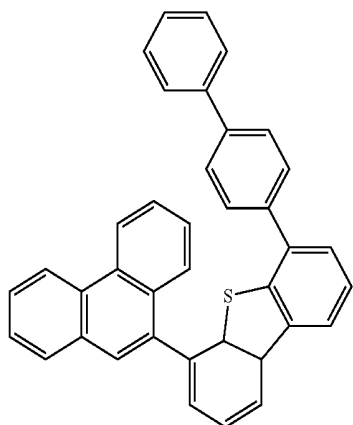
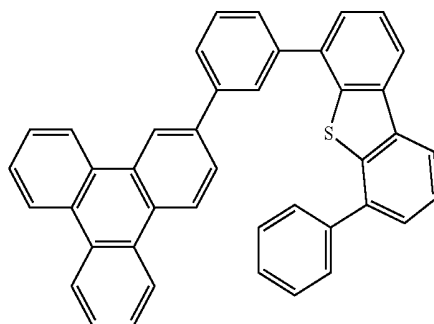
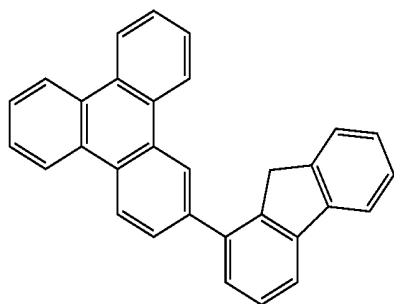
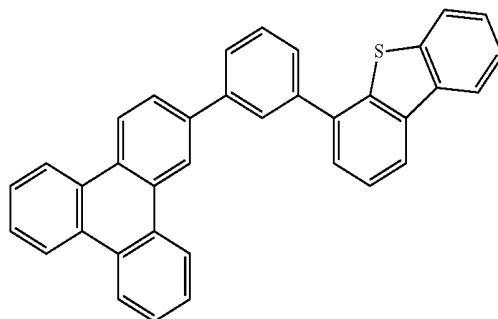
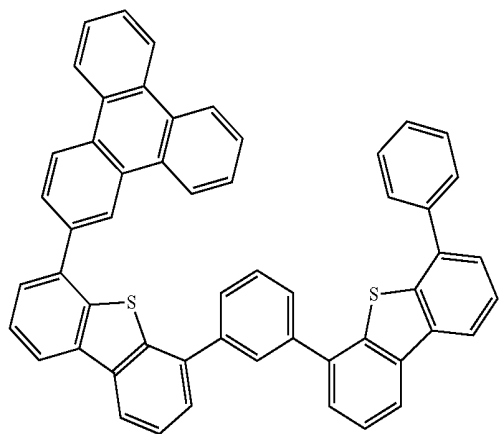
wherein R^{101} is selected from the group consisting of hydrogen, deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acids, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof, and when it is aryl or heteroaryl, it has the similar definition as Ar's mentioned above. k is an integer from 0 to 20 or 1 to 20. X^{101} to X^{108} are independently selected from C (including CH) or N. Z^{101} and Z^{102} are independently selected from NR^{101} , O, or S.

[0144] Non-limiting examples of the host materials that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: EP2034538, EP2034538A, EP2757608, JP2007254297, KR20100079458, KR20120088644, KR20120129733, KR20130115564, TW201329200, US20030175553, US20050238919, US20060280965, US20090017330, US20090030202, US20090167162, US20090302743, US20090309488, US20100012931, US20100084966, US20100187984, US2010187984, US2012075273, US2012126221, US2013009543, US2013105787, US2013175519, US2014001446, US20140183503, US20140225088, US2014034914, U.S. Pat. No. 7,154,114, WO2001039234, WO2004093207, WO2005014551, WO2005089025, WO2006072002, WO2006114966, WO2007063754, WO2008056746, WO2009003898,

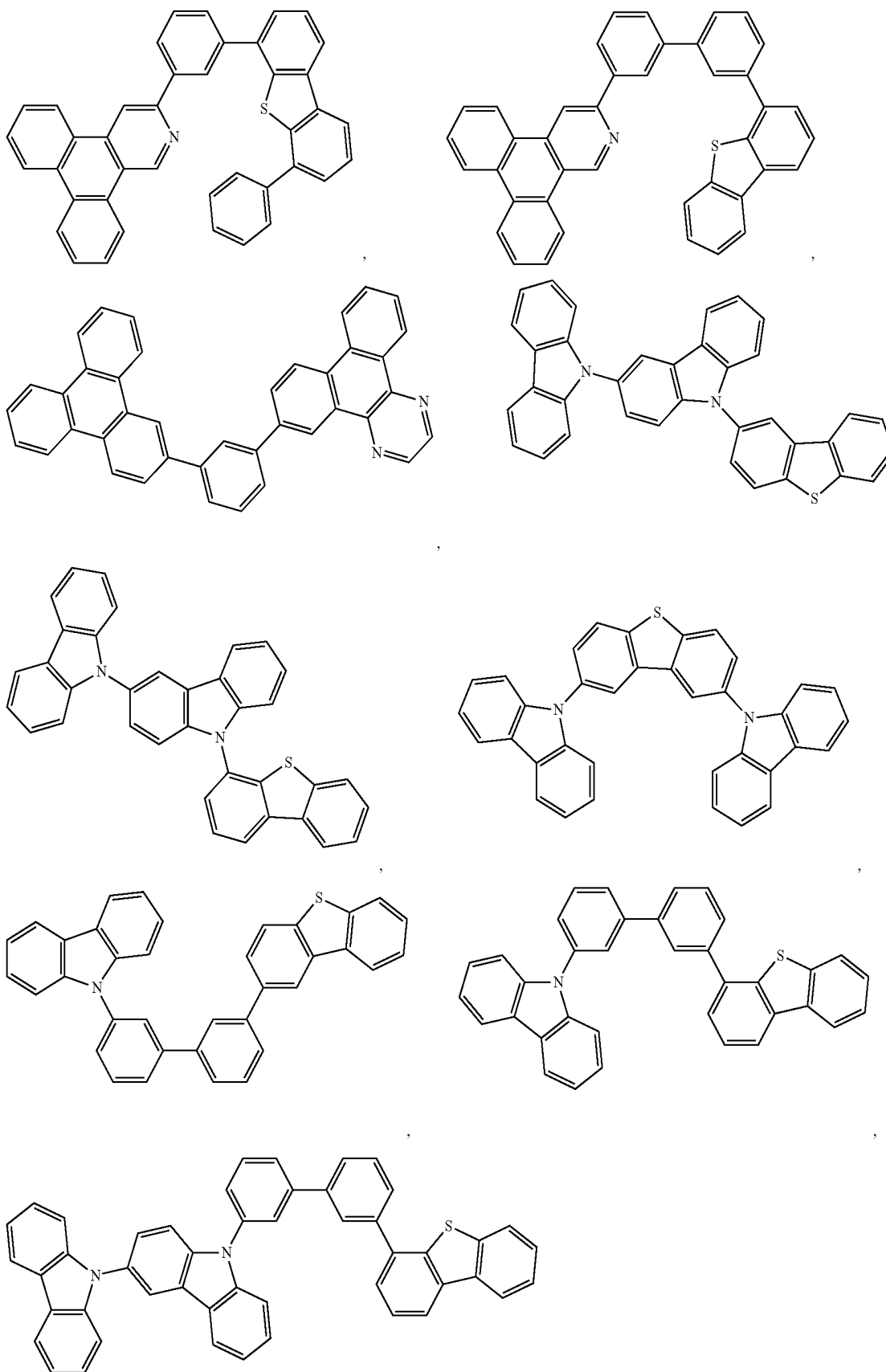
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WO2010107244, WO2011081423, WO2011081431, US20170263869, US20160163995, U.S. Pat. No. 9,466,
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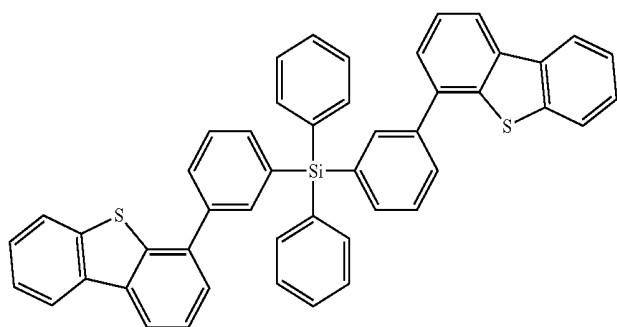
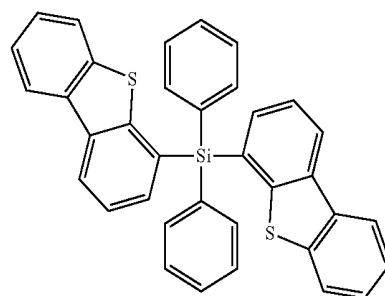
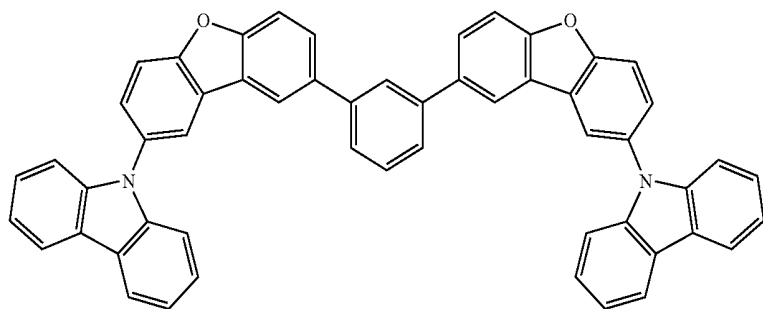
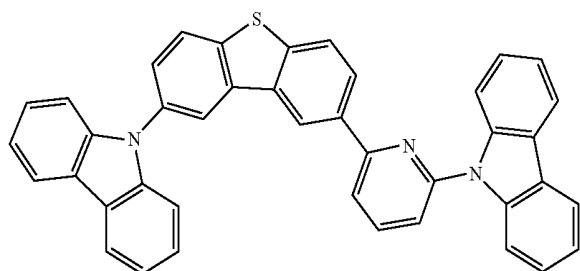
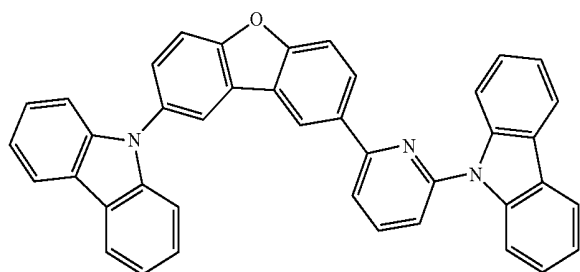
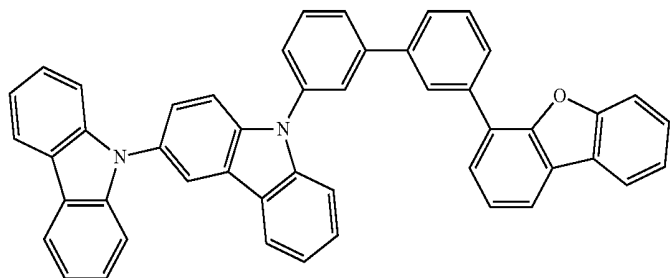
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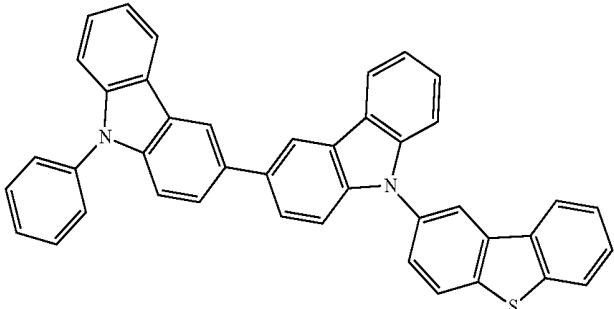
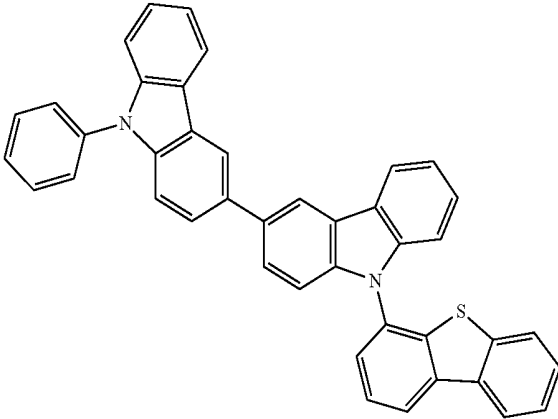
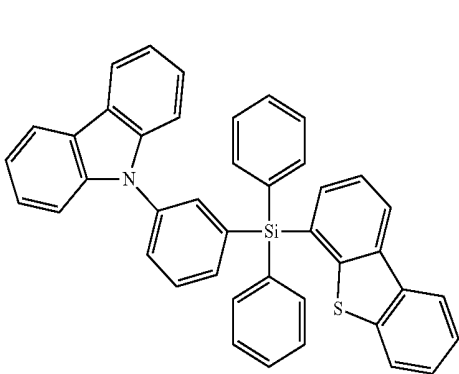
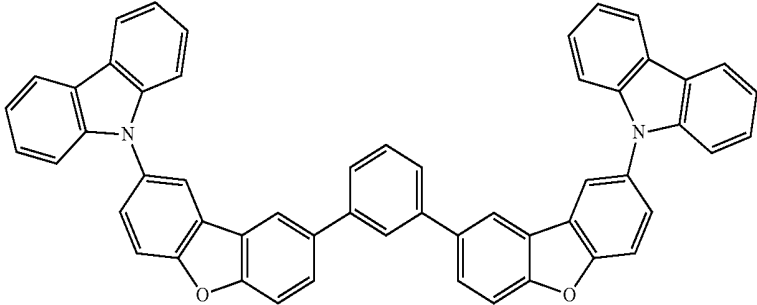
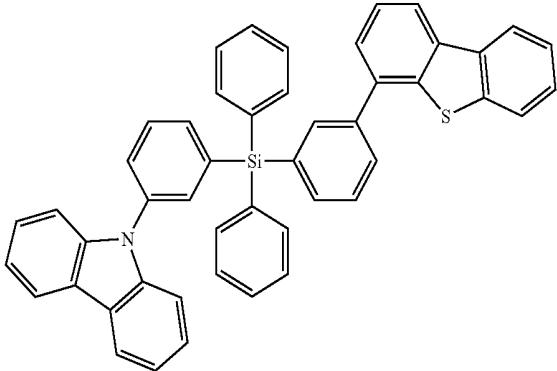
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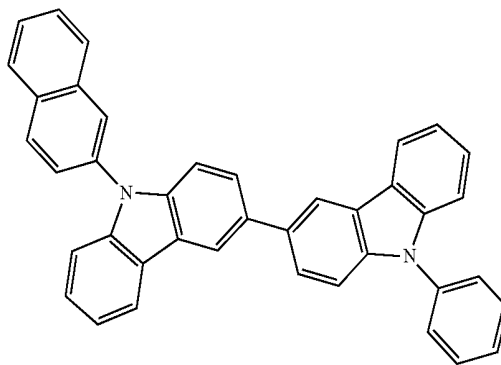
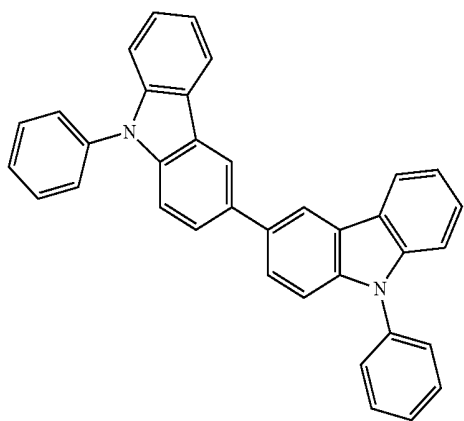
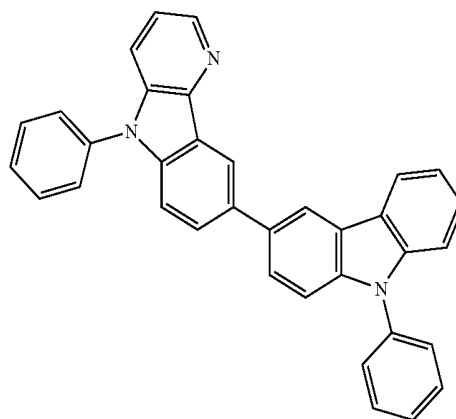
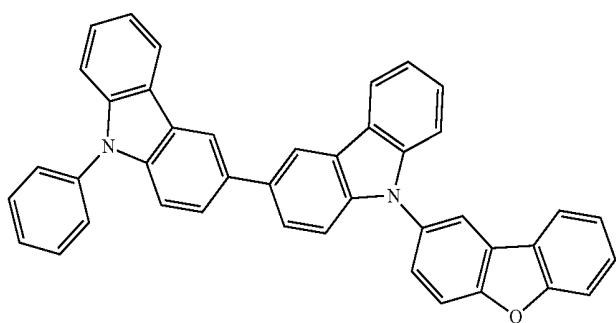
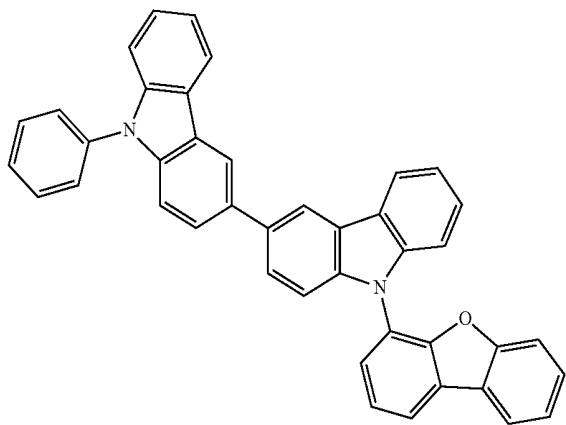
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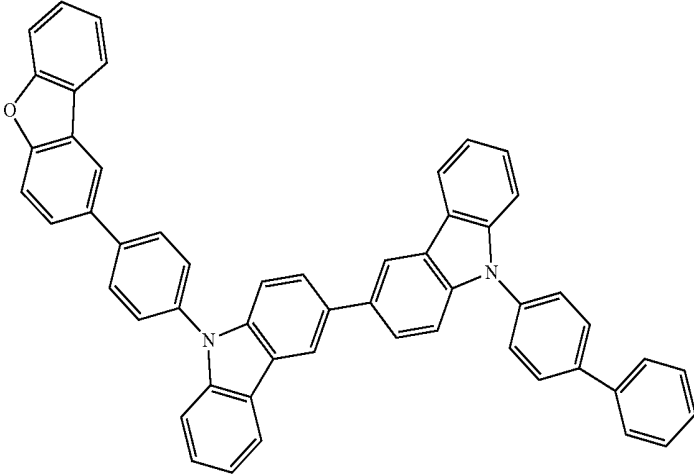
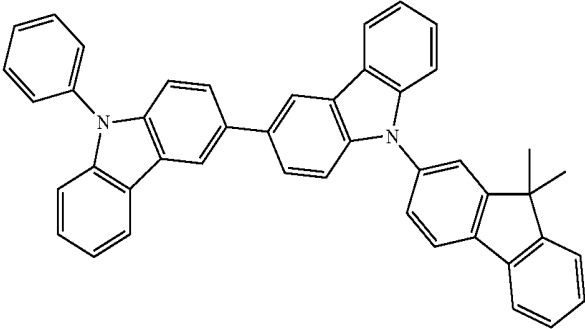
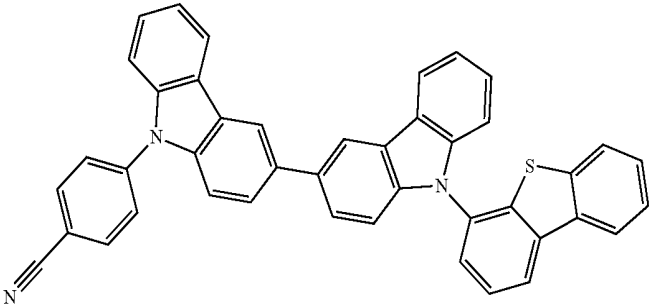
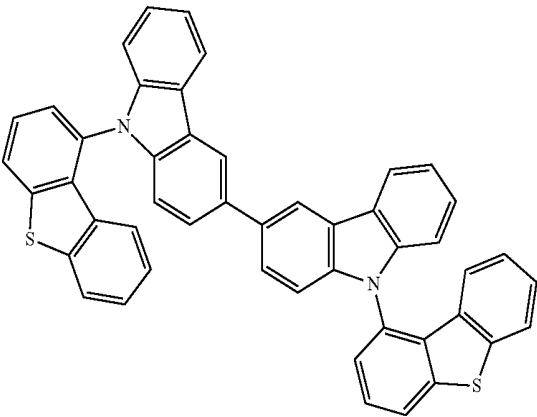
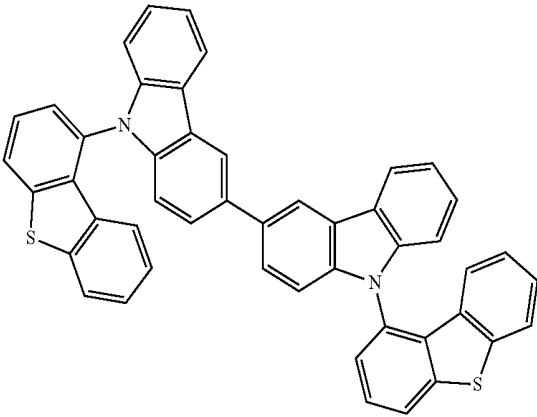
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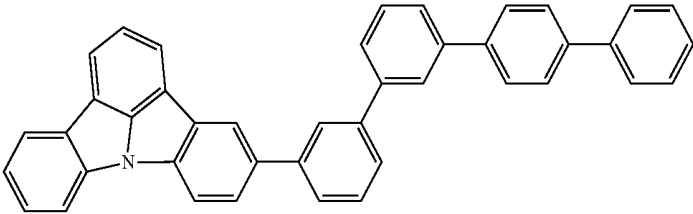
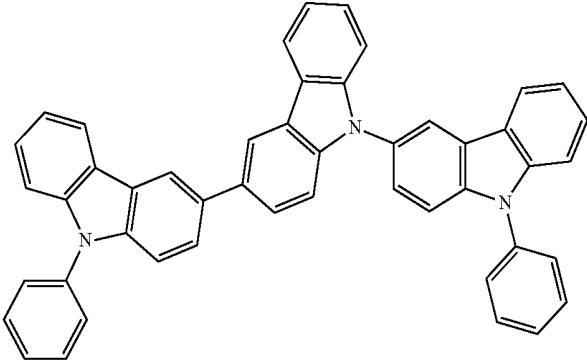
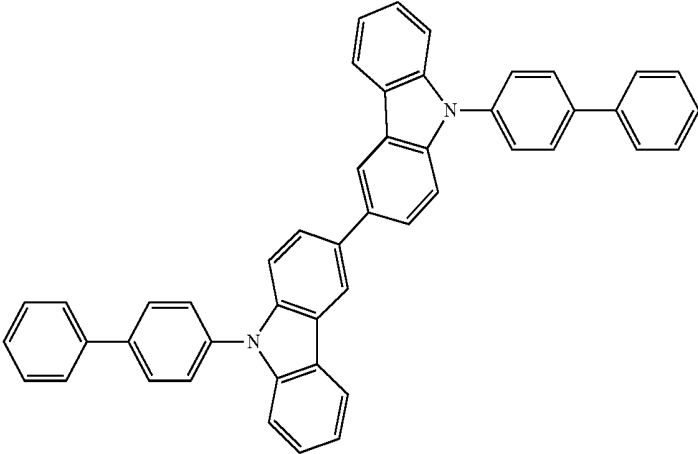
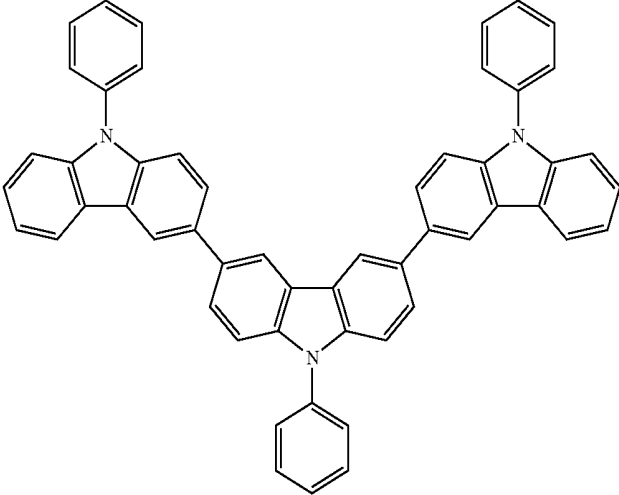
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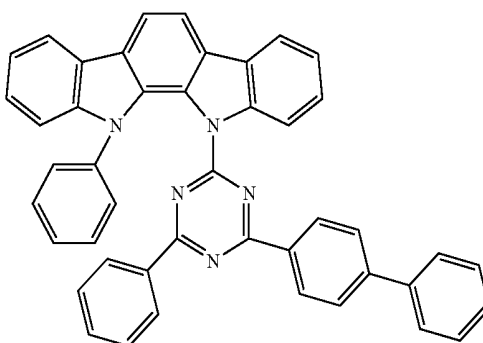
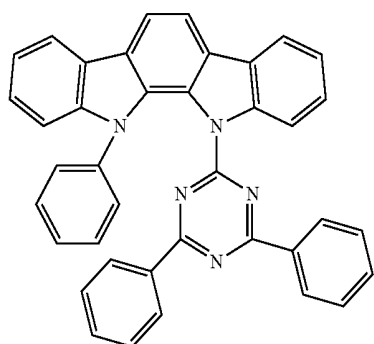
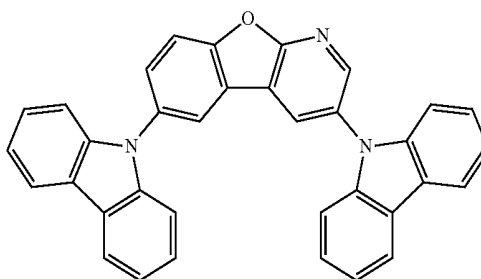
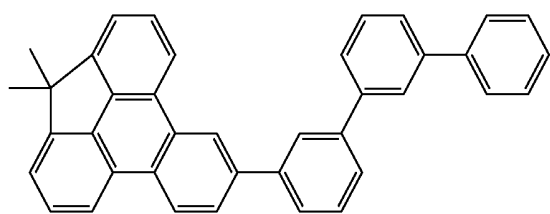
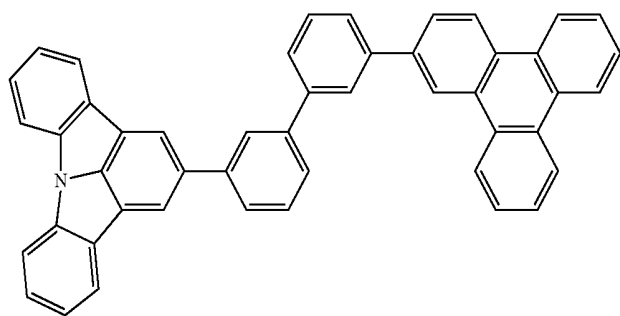
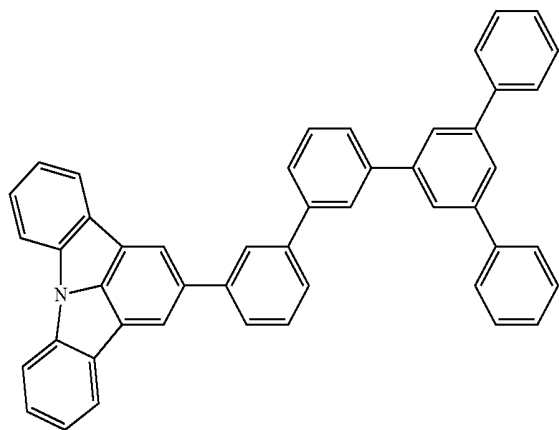
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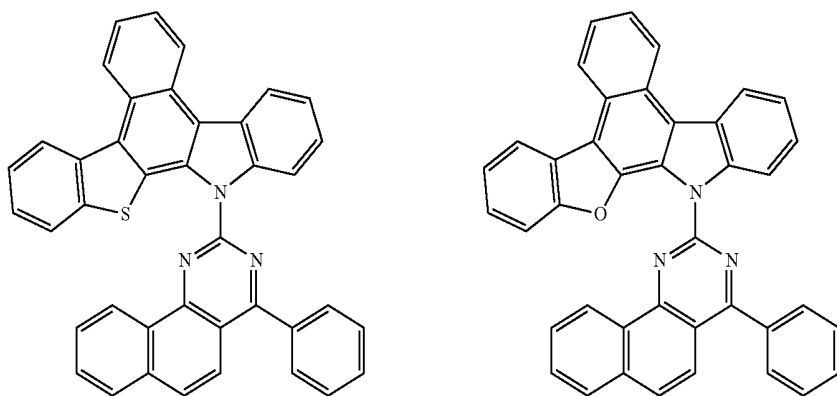
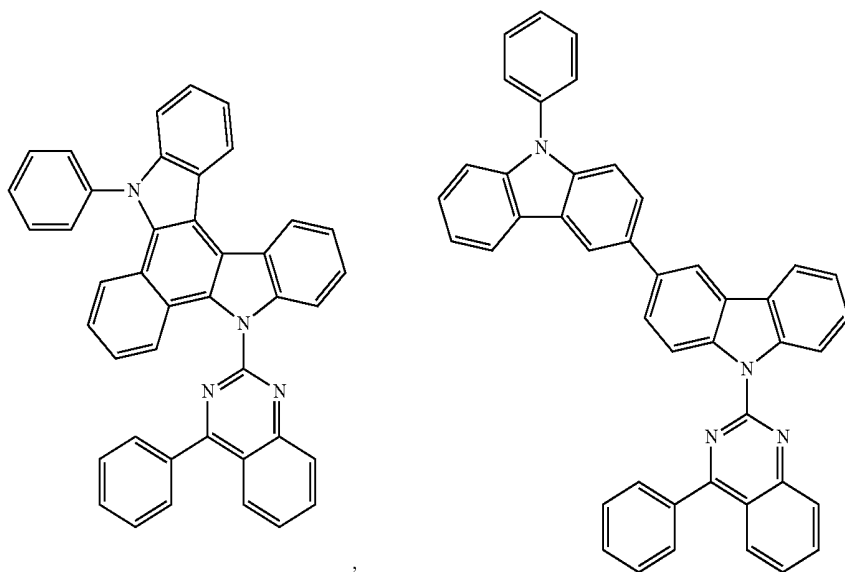
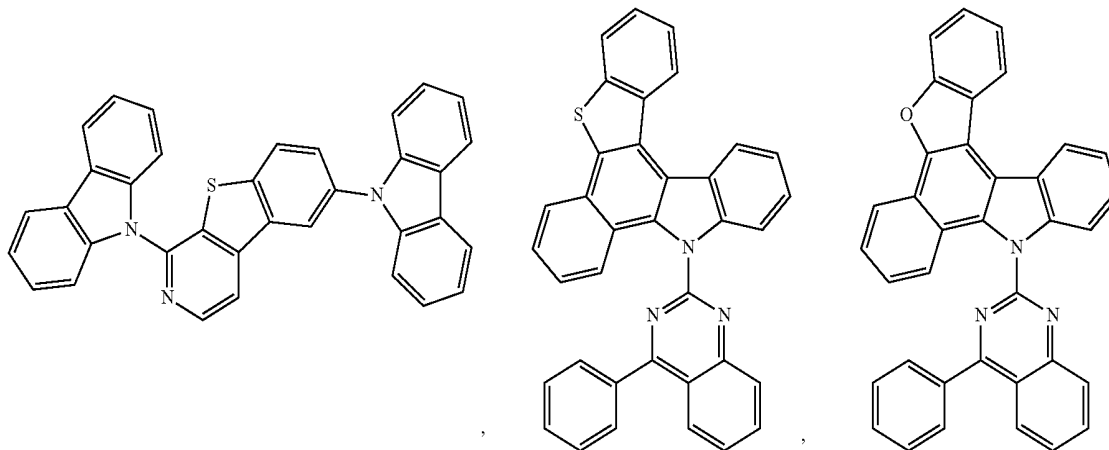
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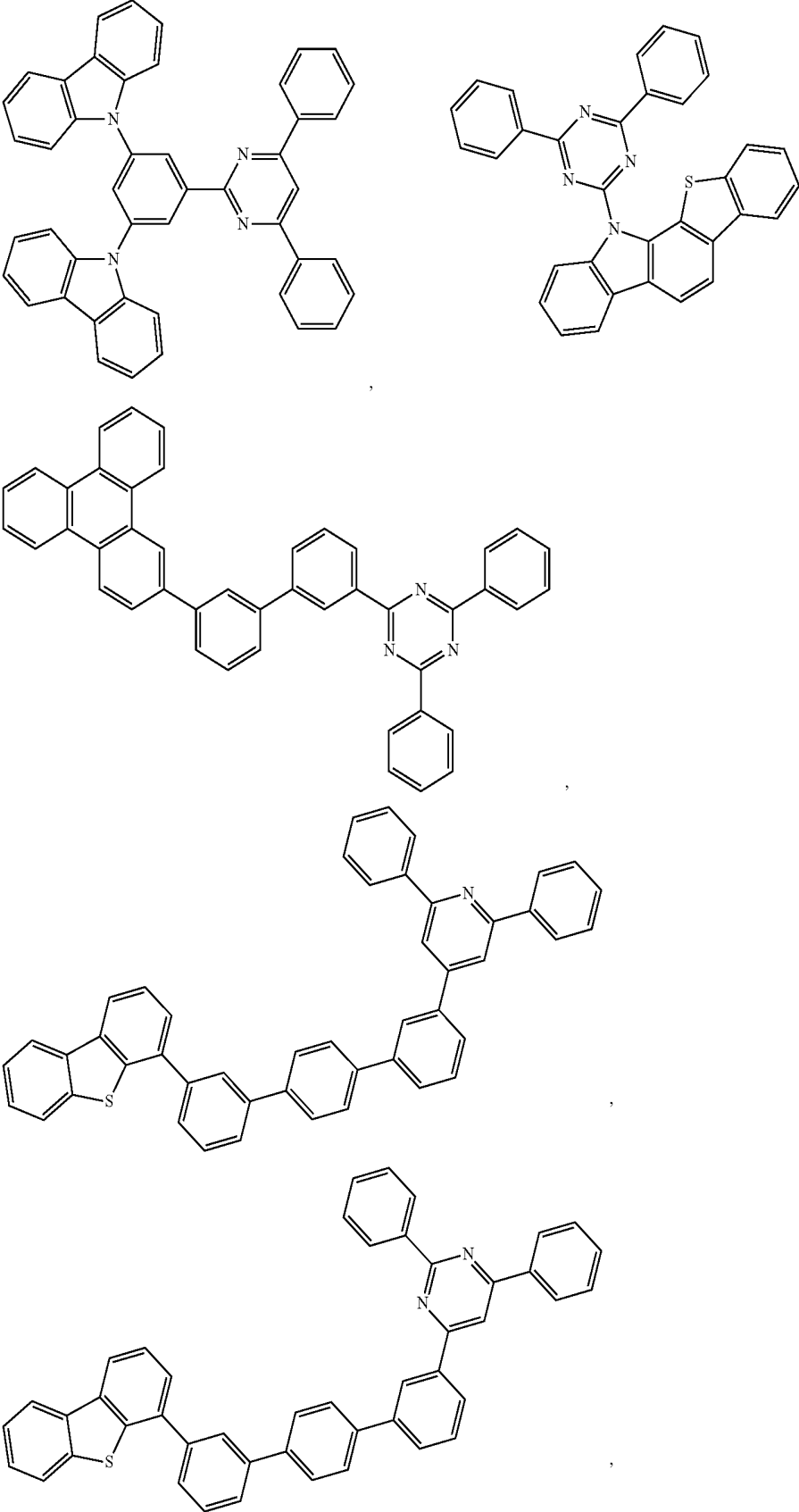
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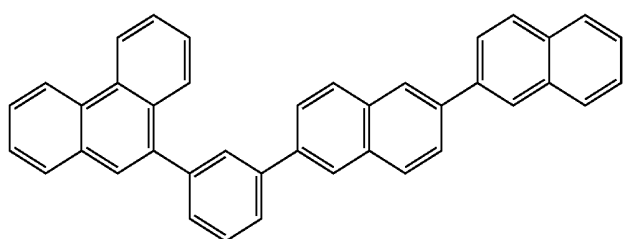
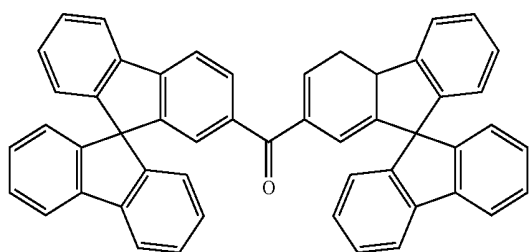
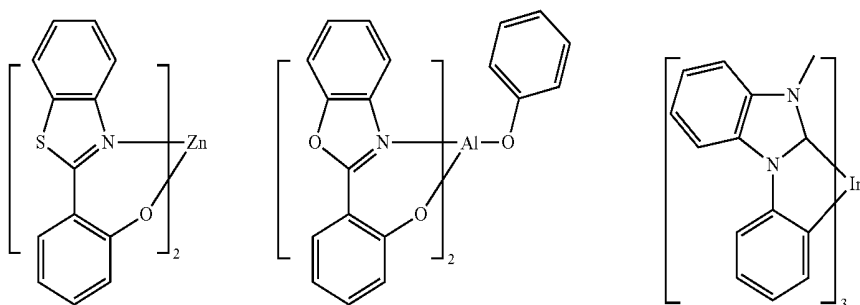
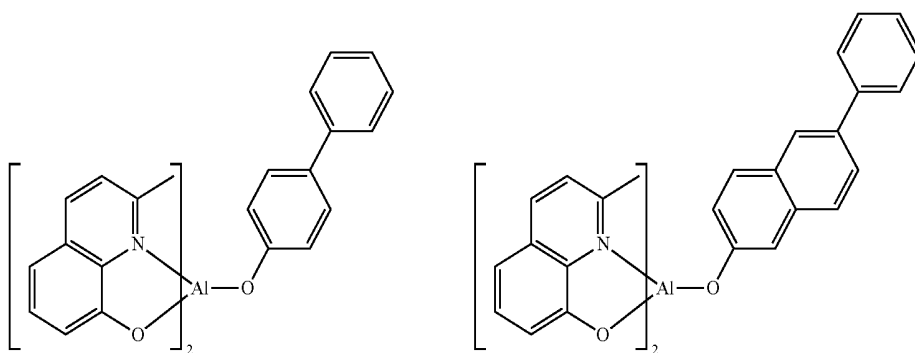
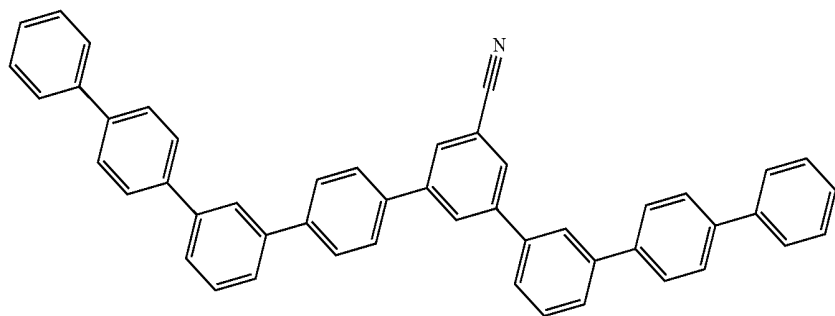
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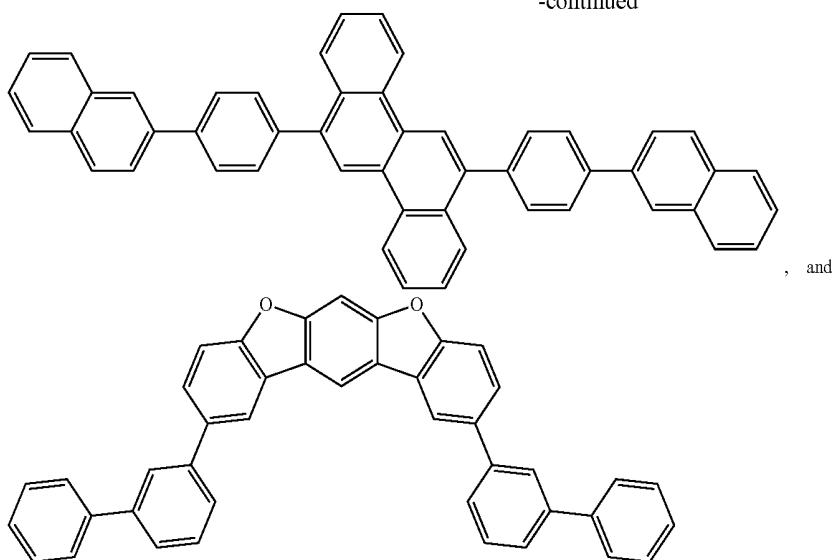
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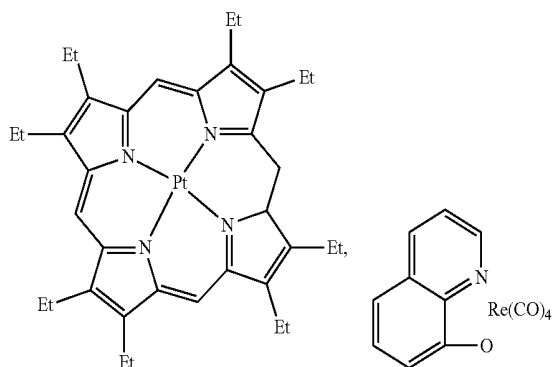


Additional Emitters:

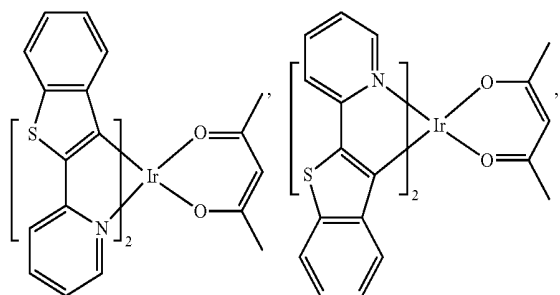
[0145] One or more additional emitter dopants may be used in conjunction with the compound of the present disclosure. Examples of the additional emitter dopants are not particularly limited, and any compounds may be used as long as the compounds are typically used as emitter materials. Examples of suitable emitter materials include, but are not limited to, compounds which can produce emissions via phosphorescence, fluorescence, thermally activated delayed fluorescence, i.e., TADF (also referred to as E-type delayed fluorescence), triplet-triplet annihilation, or combinations of these processes.

[0146] Non-limiting examples of the emitter materials that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: CN103694277, CN1696137, EB01238981, EP01239526, EP01961743, EP1239526, EP1244155, EP1642951, EP1647554, EP1841834, EP1841834B, EP2062907, EP2730583, JP2012074444, JP2013110263, JP4478555, KR1020090133652, KR20120032054, KR20130043460, TW201332980, U.S. Ser. No. 06/699,599, U.S. Ser. No. 06/916,554, US20010019782, US20020034656, US20030068526, US20030072964, US20030138657, US20050123788, US20050244673, US2005123791, US2005260449, US20060008670, US20060065890, US20060127696, US20060134459, US20060134462, US20060202194, US20060251923, US20070034863, US20070087321, US20070103060, US20070111026, US20070190359, US20070231600, US2007034863, US2007104979, US2007104980, US2007138437, US2007224450, US2007278936, US20080020237, US20080233410, US20080261076, US20080297033, US200805851, US2008161567, US2008210930, US20090039776, US20090108737, US20090115322, US20090179555, US2009085476, US2009104472, US20100090591, US20100148663, US20100244004, US20100295032, US2010102716, US2010105902, US2010244004, US2010270916, US20110057559, US20110108822, US20110204333, US2011215710,

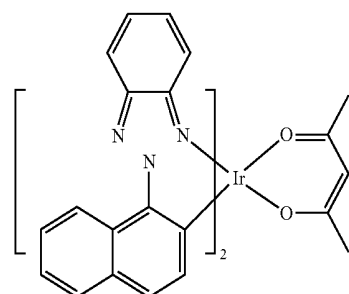
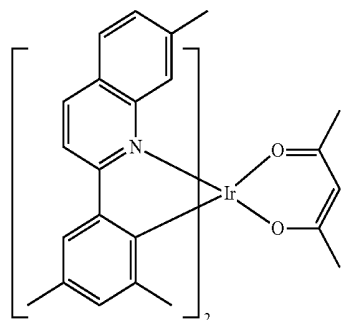
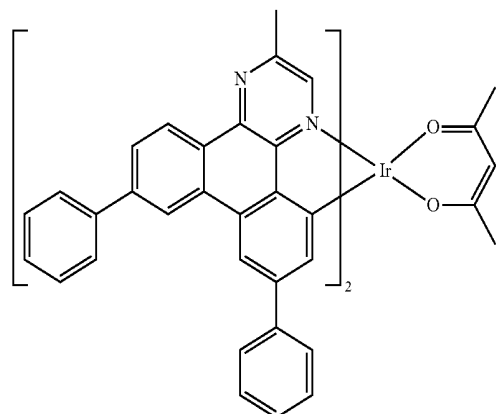
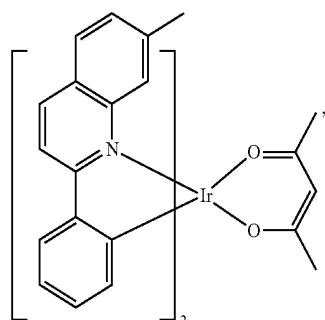
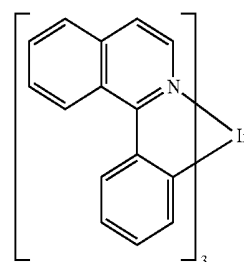
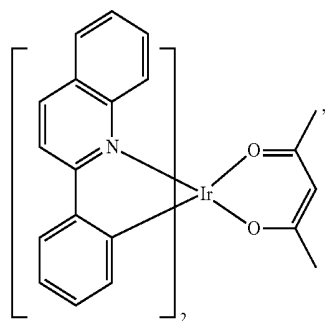
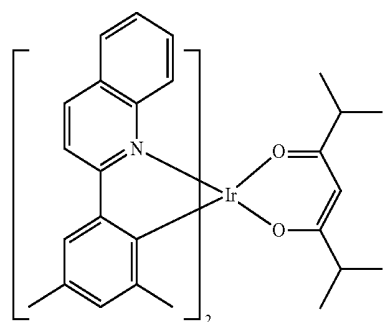
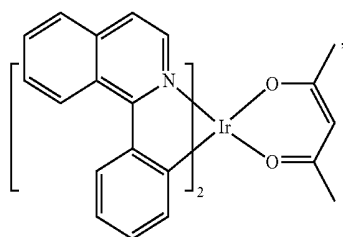
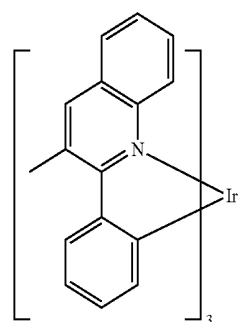
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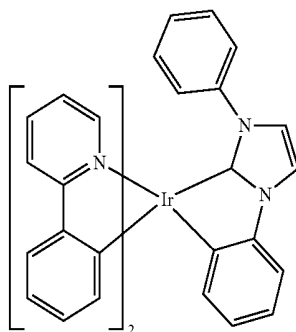
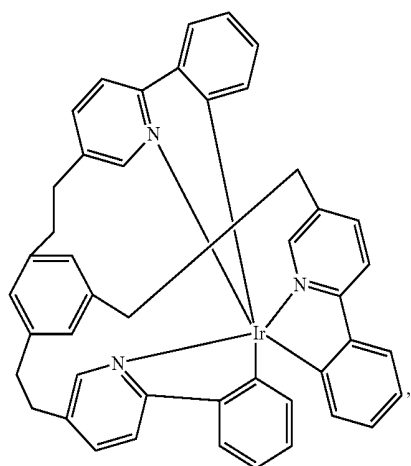
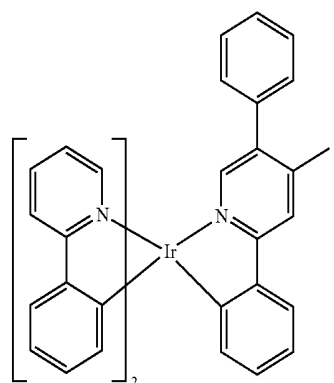
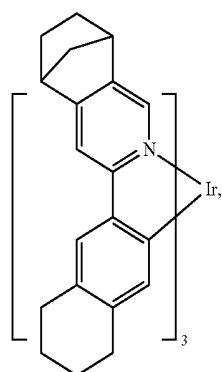
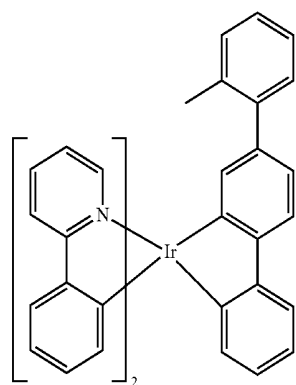
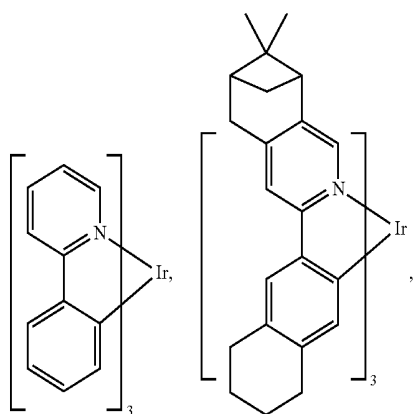
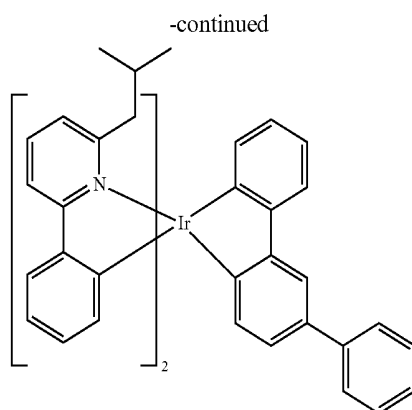
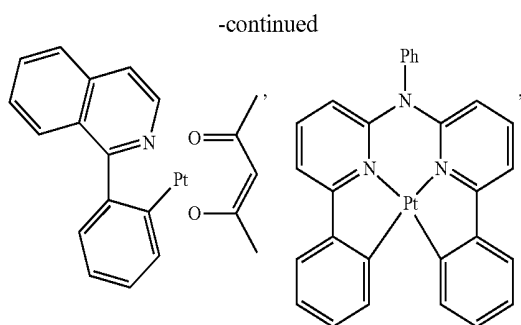


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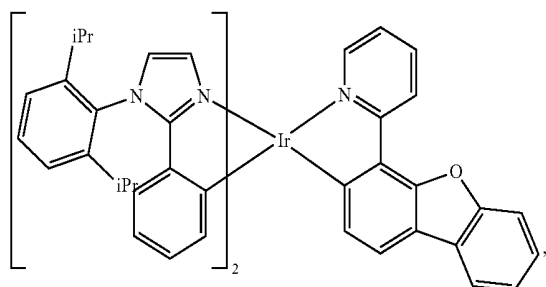
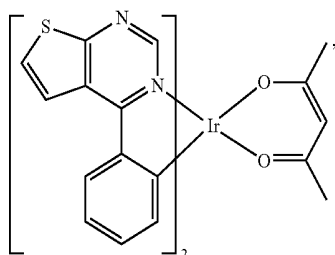
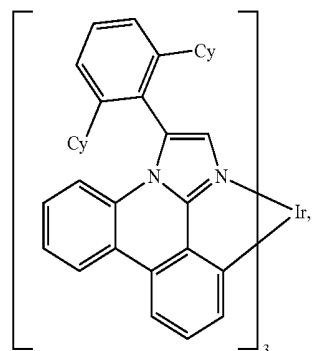
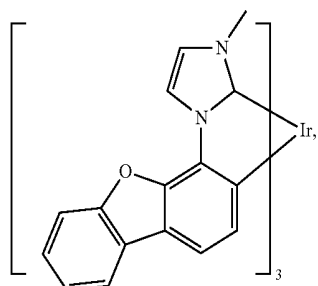
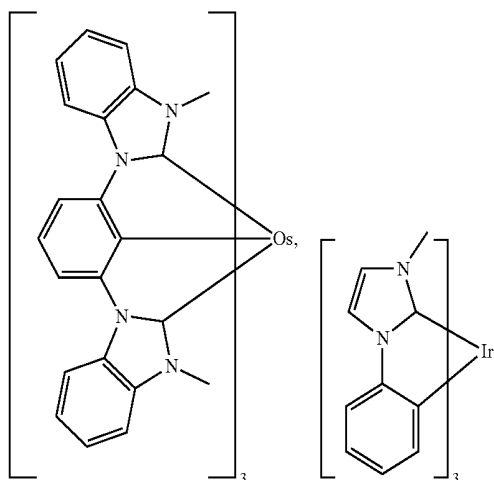


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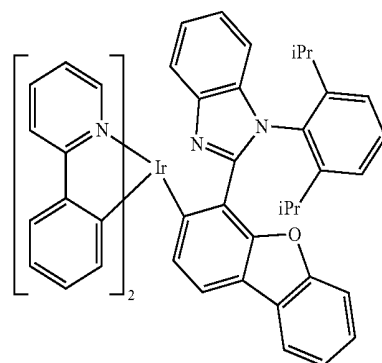
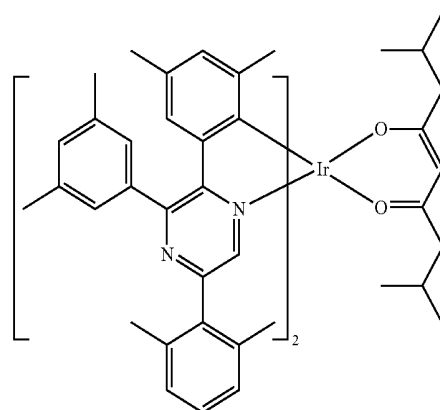
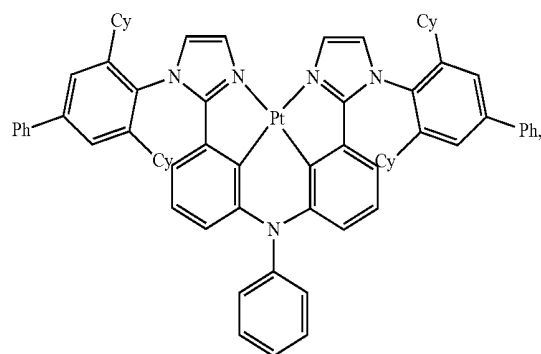
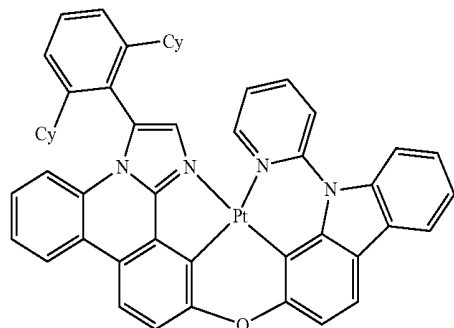


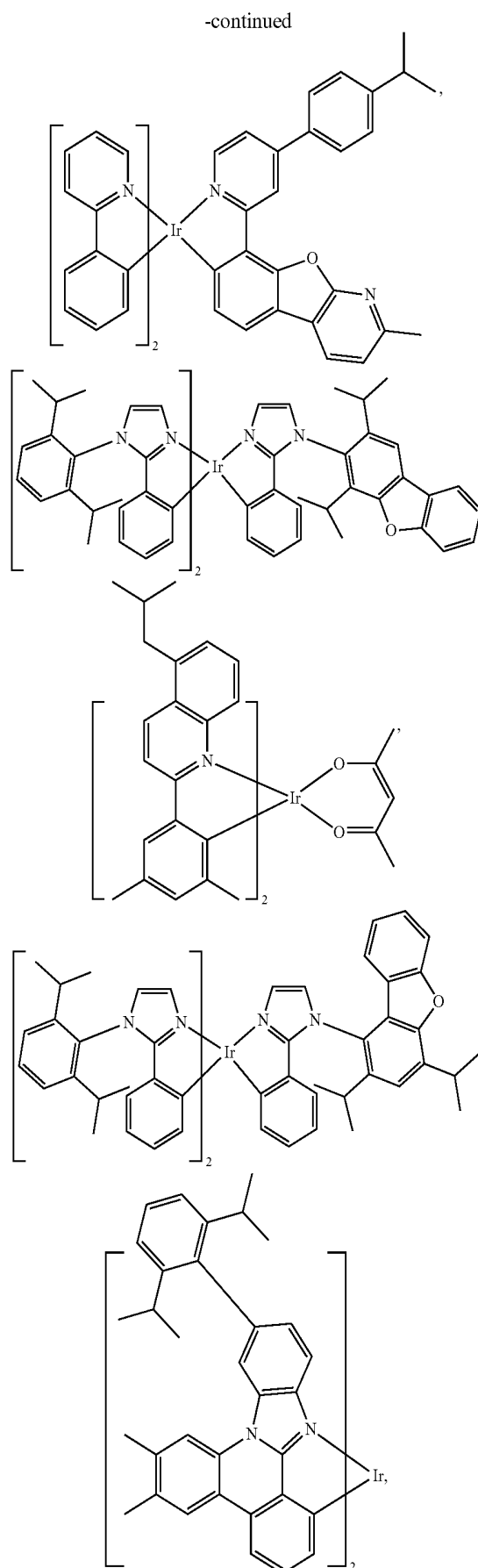
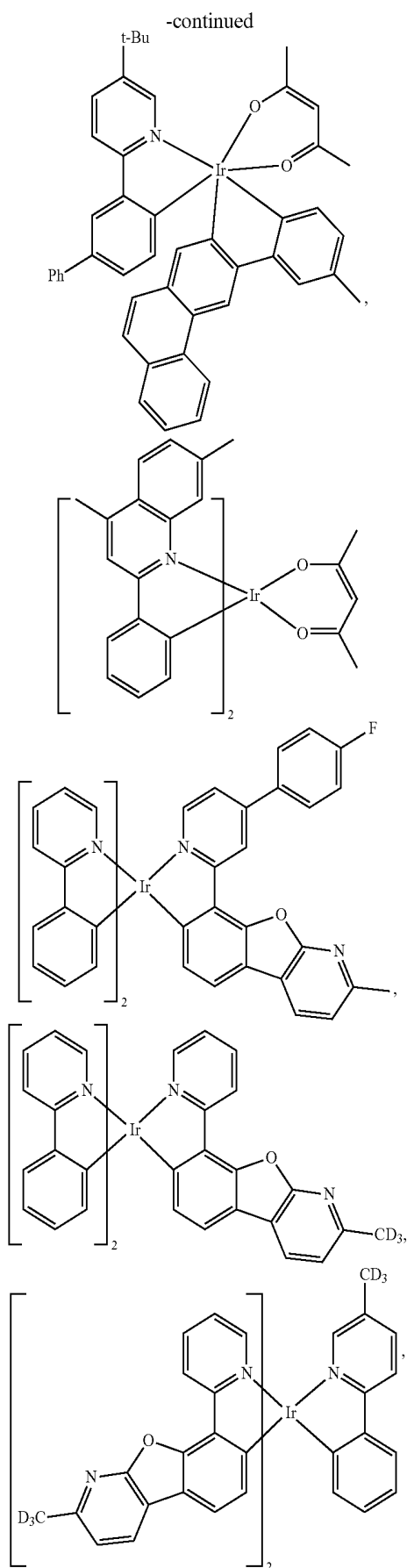


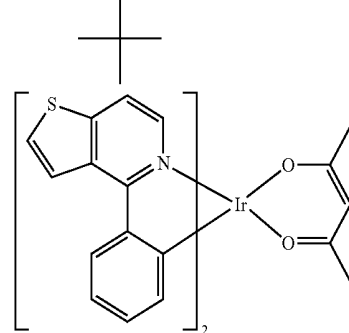
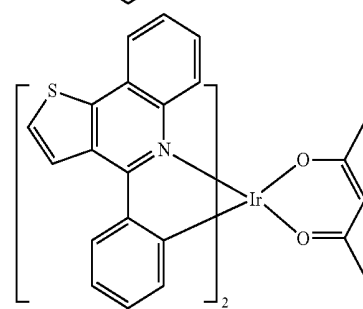
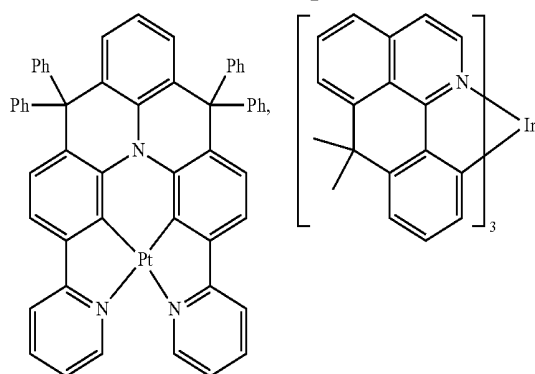
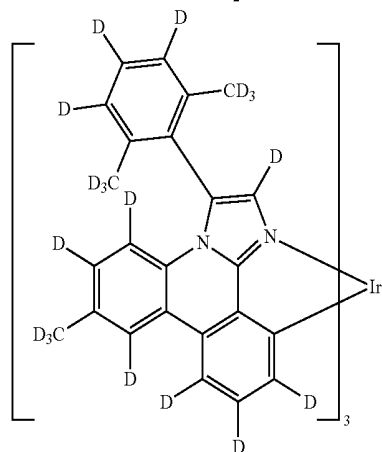
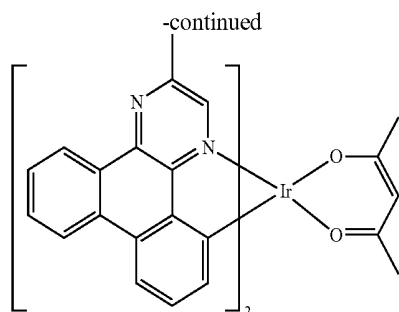
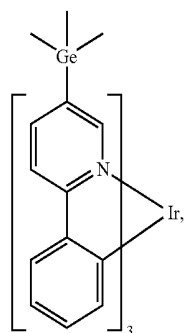
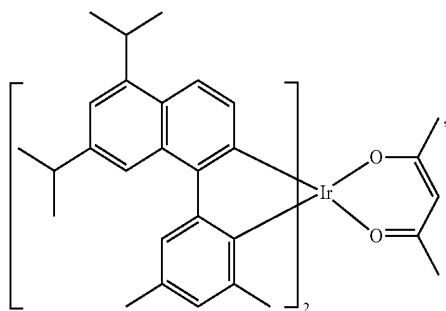
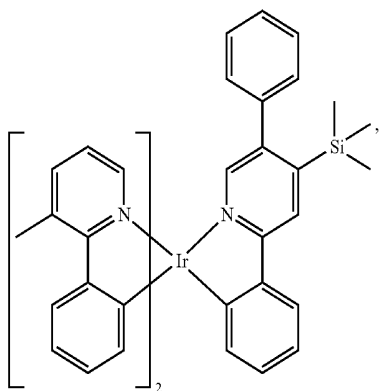
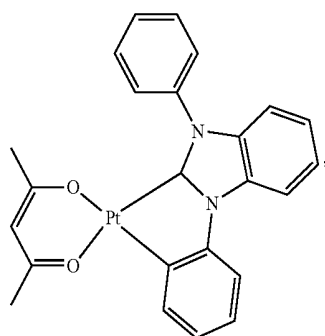
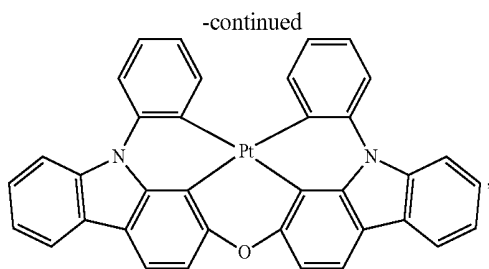
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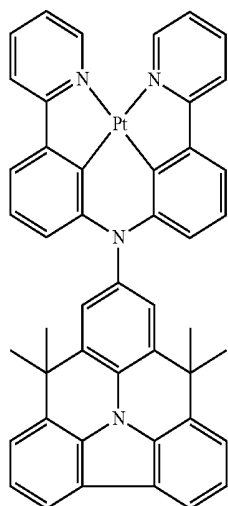
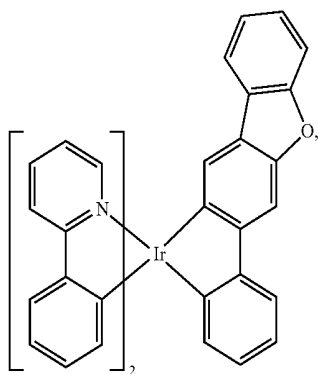
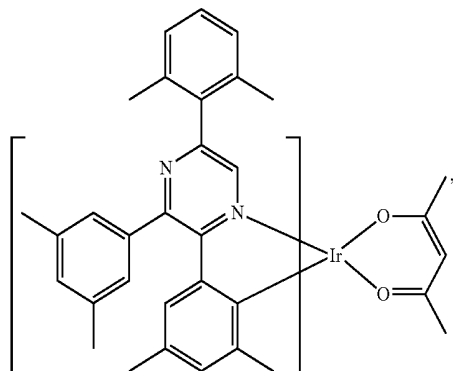
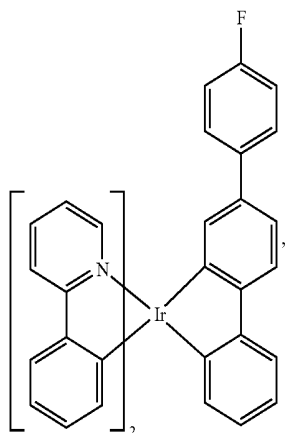
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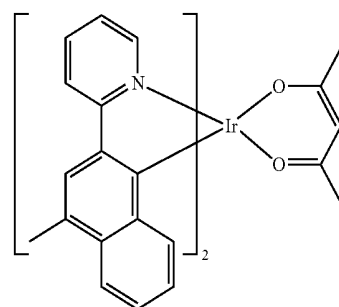
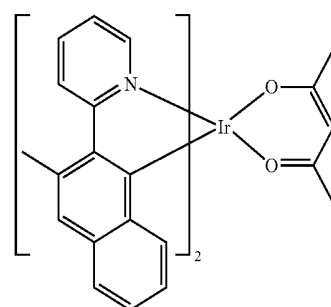
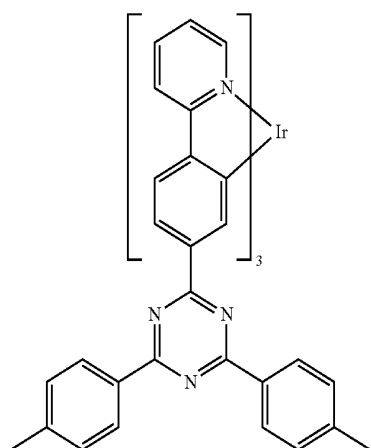
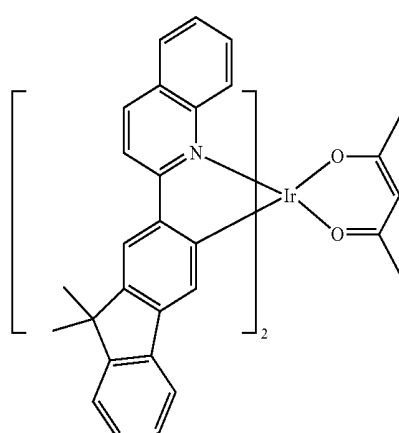




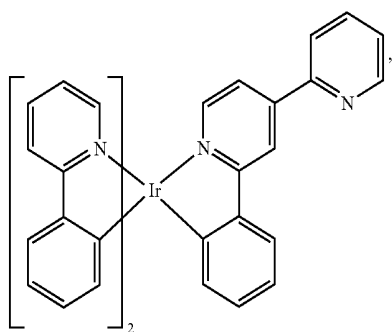
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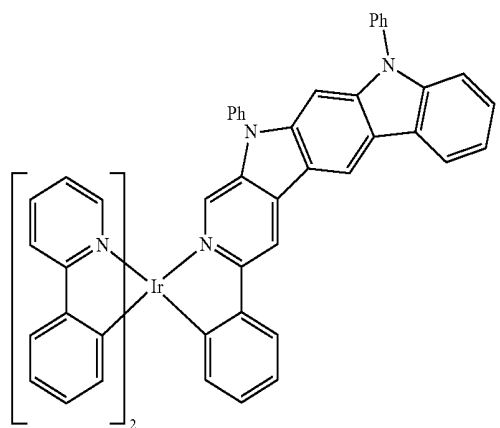
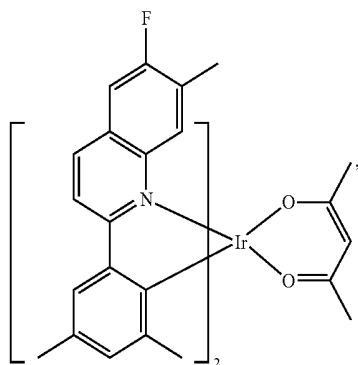
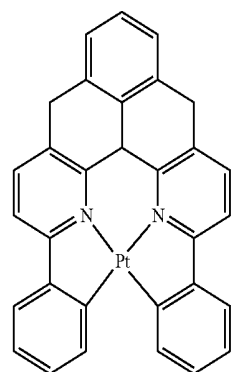
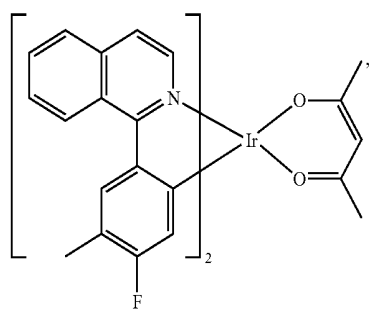
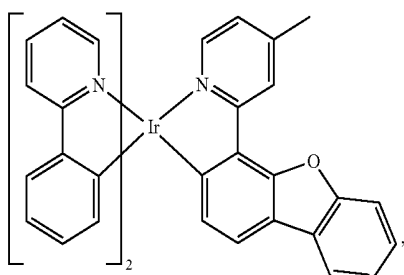
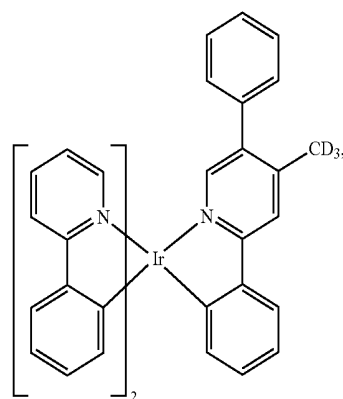
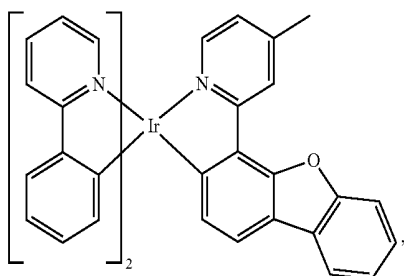
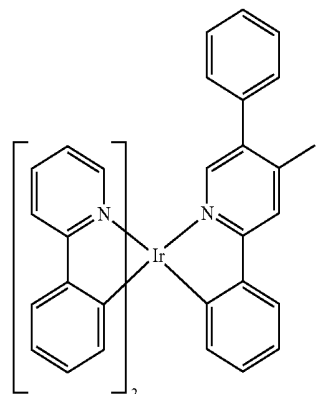
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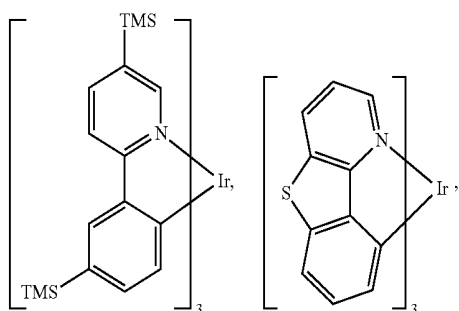
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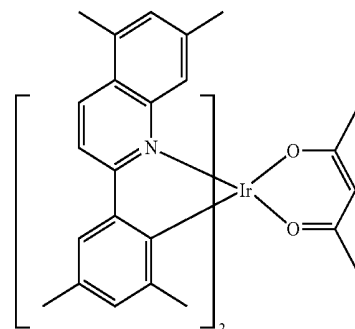
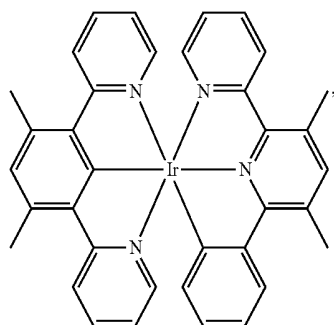
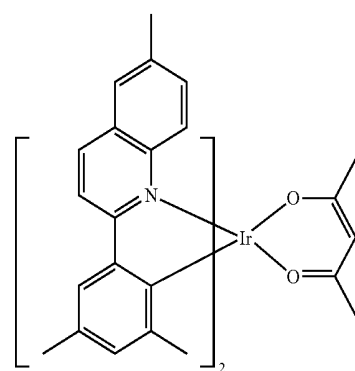
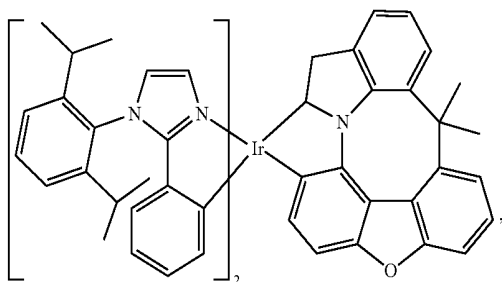
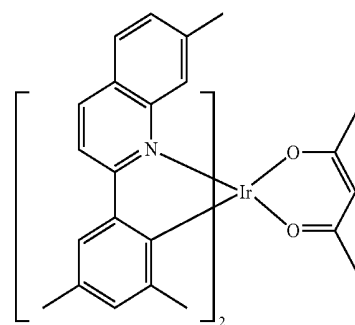
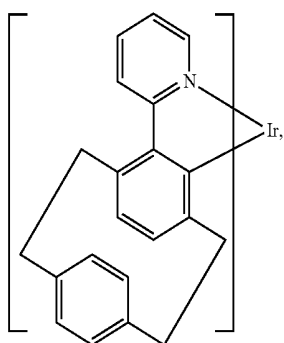
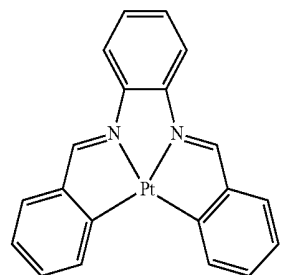
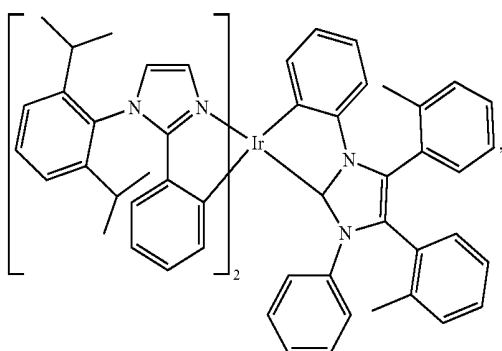
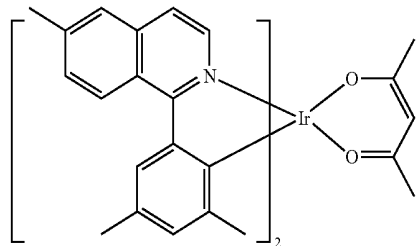
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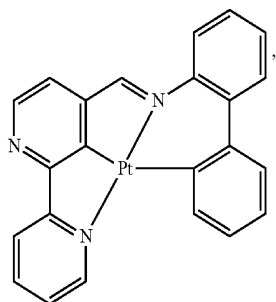
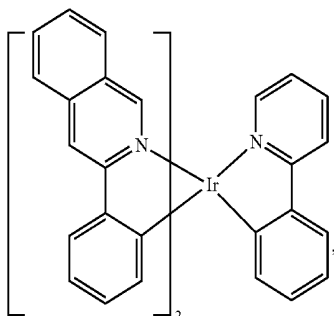
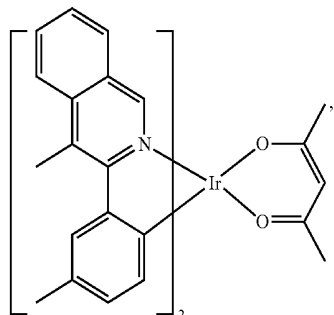
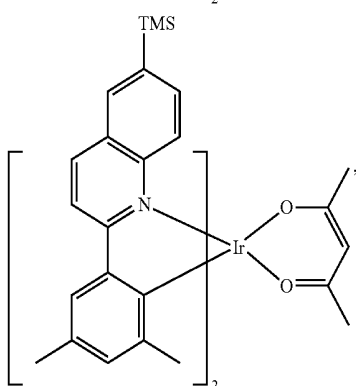
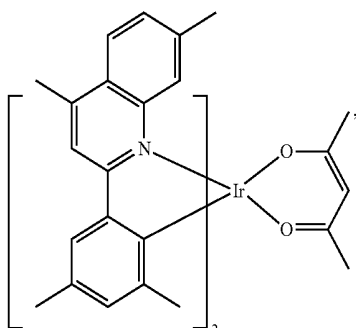
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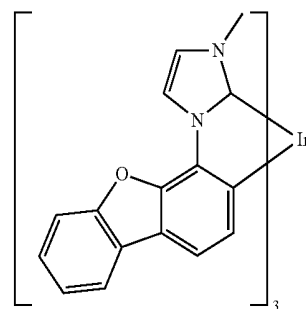
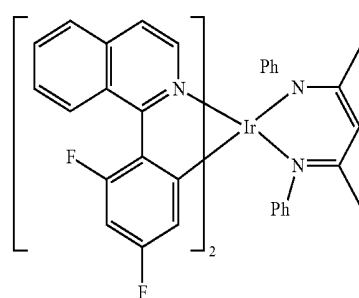
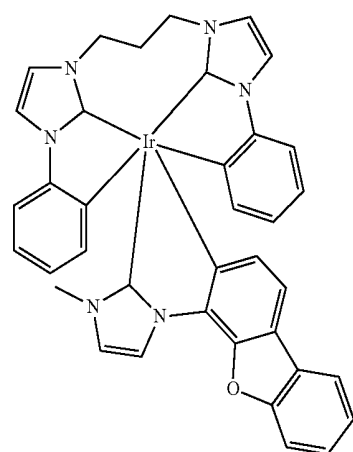
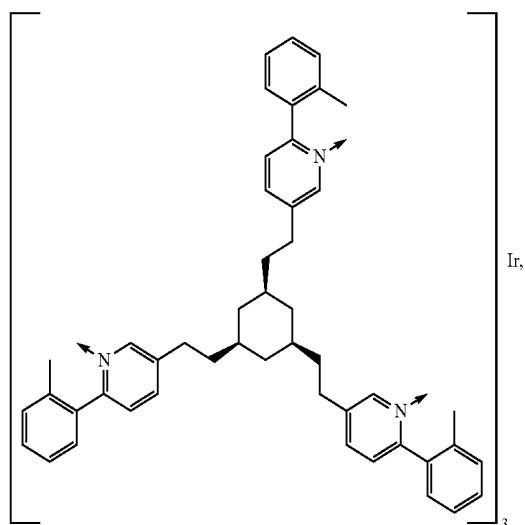
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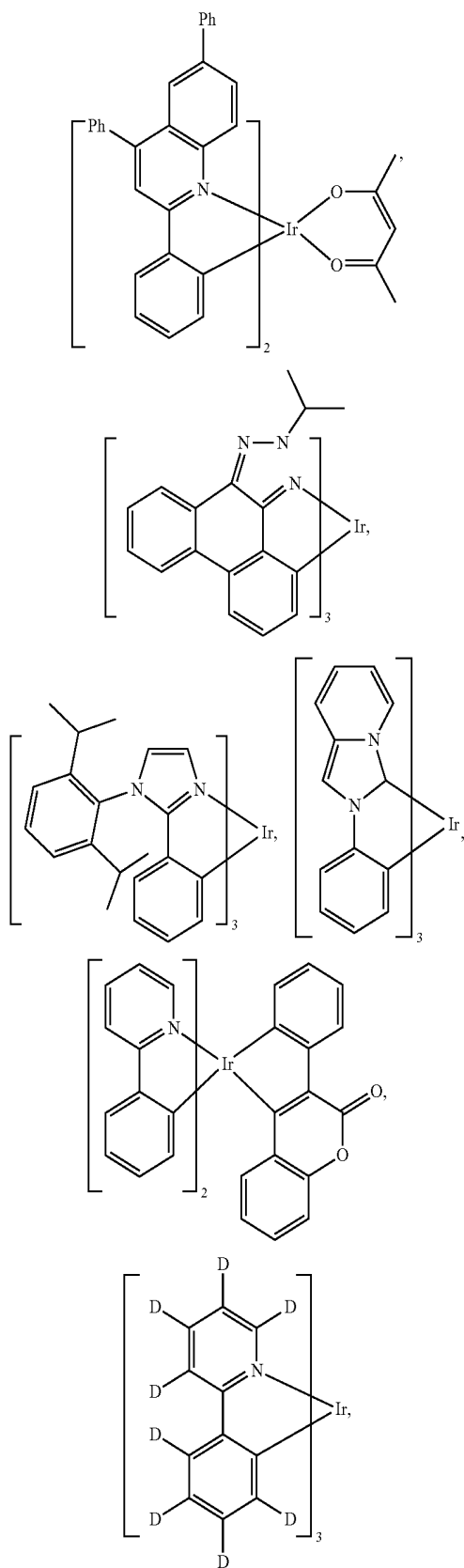
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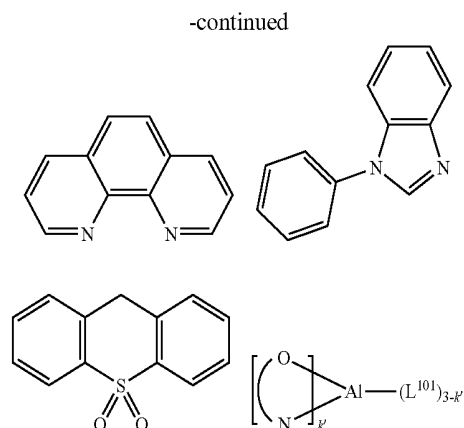
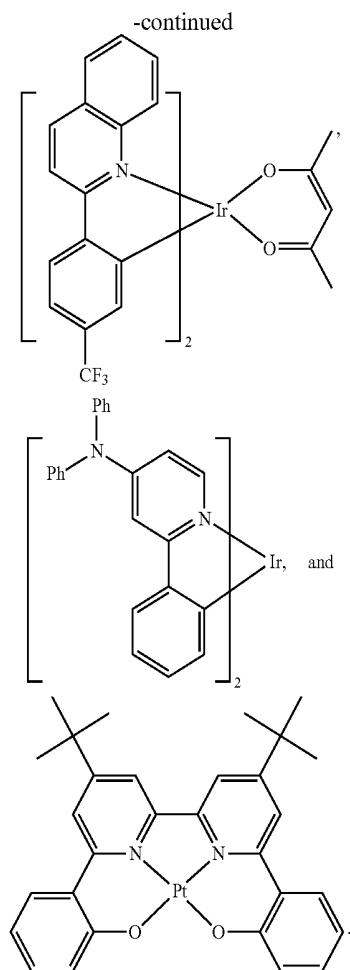


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wherein k is an integer from 1 to 20; L^{101} is another ligand, k' is an integer from 1 to 3.

ETL:

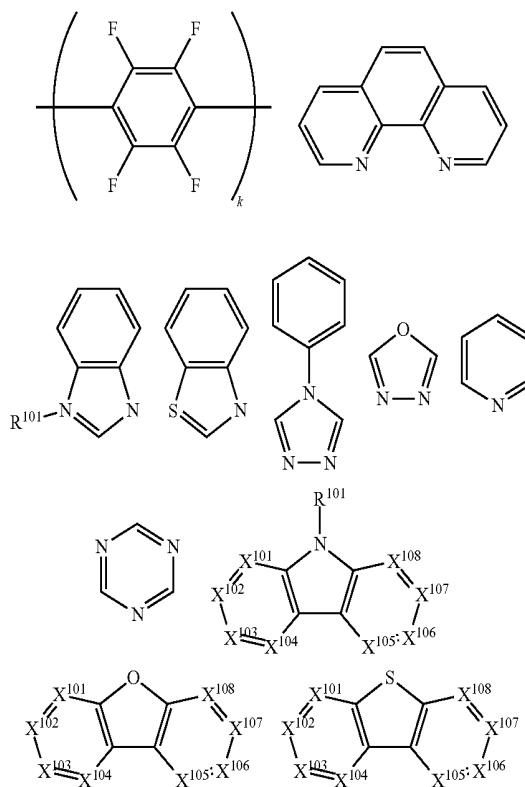
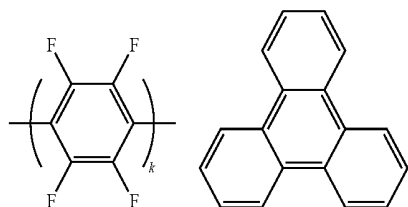
[0150] Electron transport layer (ETL) may include a material capable of transporting electrons. Electron transport layer may be intrinsic (undoped), or doped. Doping may be used to enhance conductivity. Examples of the ETL material are not particularly limited, and any metal complexes or organic compounds may be used as long as they are typically used to transport electrons.

[0151] In one aspect, compound used in ETL contains at least one of the following groups in the molecule:

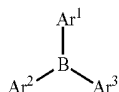
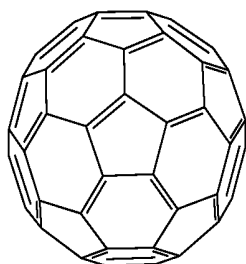
[0147] A hole blocking layer (HBL) may be used to reduce the number of holes and/or excitons that leave the emissive layer. The presence of such a blocking layer in a device may result in substantially higher efficiencies and/or longer lifetime as compared to a similar device lacking a blocking layer. Also, a blocking layer may be used to confine emission to a desired region of an OLED. In some embodiments, the HBL material has a lower HOMO (further from the vacuum level) and/or higher triplet energy than the emitter closest to the HBL interface. In some embodiments, the HBL material has a lower HOMO (further from the vacuum level) and/or higher triplet energy than one or more of the hosts closest to the HBL interface.

[0148] In one aspect, compound used in HBL contains the same molecule or the same functional groups used as host described above.

[0149] In another aspect, compound used in HBL contains at least one of the following groups in the molecule:

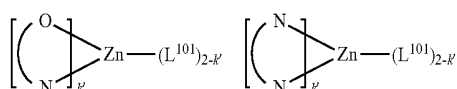
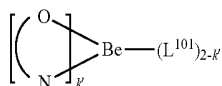
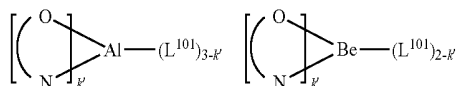


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wherein R^{101} is selected from the group consisting of hydrogen, deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acids, ether, ester, nitrile, isonitrile, sulfinyl, sulfonyl, phosphino, and combinations thereof, when it is aryl or heteroaryl, it has the similar definition as Ar 's mentioned above. Ar^1 to Ar^3 has the similar definition as Ar 's mentioned above. k is an integer from 1 to 20. X^{101} to X^{108} is selected from C (including CH) or N.

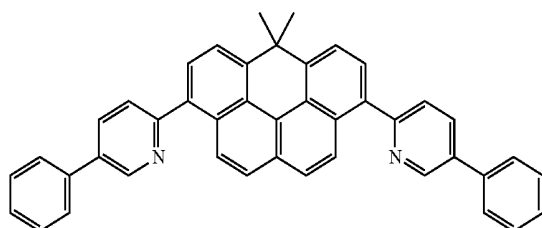
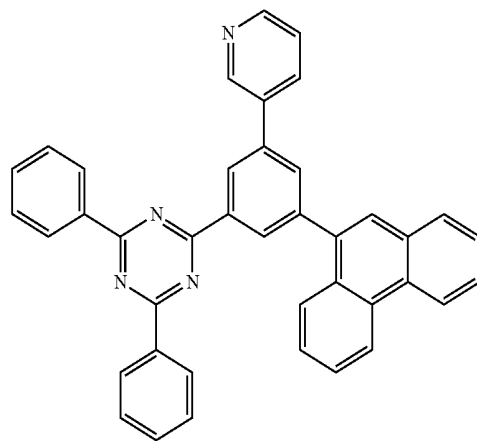
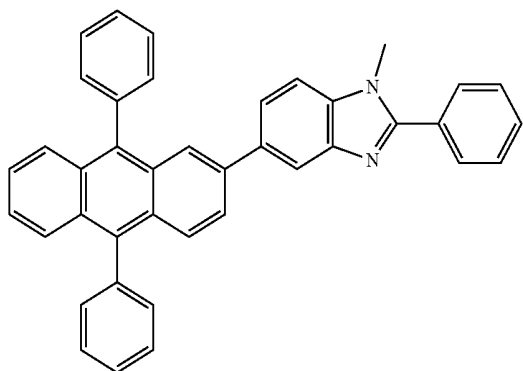
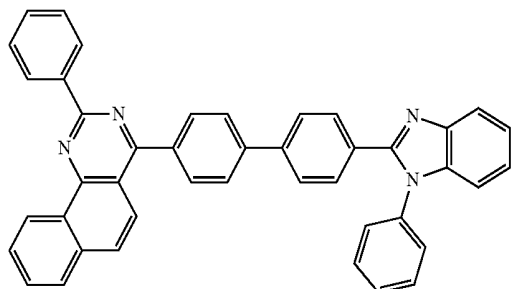
[0152] In another aspect, the metal complexes used in ETL contains, but not limit to the following general formula:



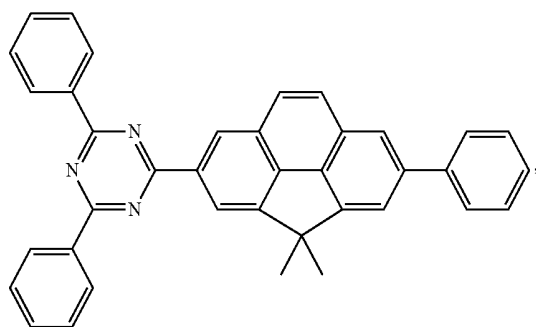
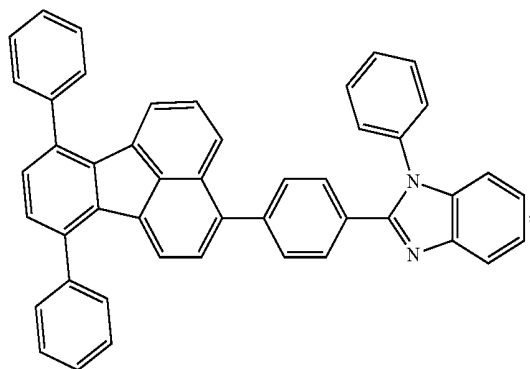
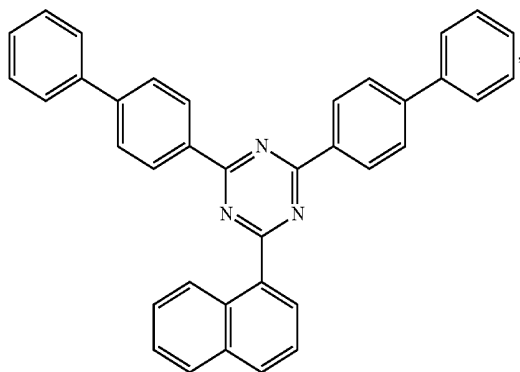
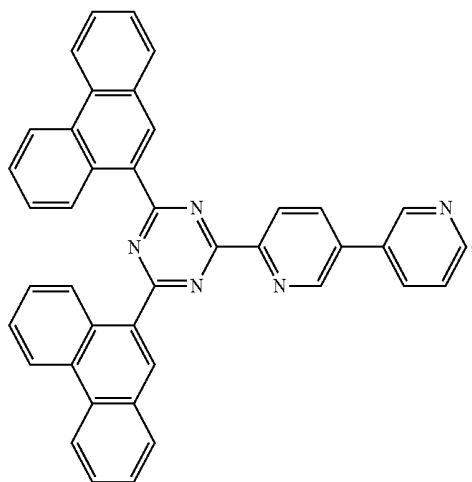
wherein (O—N) or (N—N) is a bidentate ligand, having metal coordinated to atoms O, N or N, N; L^{101} is another ligand; k is an integer value from 1 to the maximum number of ligands that may be attached to the metal.

[0153] Non-limiting examples of the ETL materials that may be used in an OLED in combination with materials disclosed herein are exemplified below together with references that disclose those materials: CN103508940, EP01602648, EP01734038, EP01956007, JP2004-022334, JP2005149918, JP2005-268199, KR0117693, KR20130108183, US20040036077, US20070104977, US2007018155, US20090101870, US20090115316, US20090140637, US20090179554, US2009218940, US2010108990, US2011156017, US2011210320, US2012193612, US2012214993, US2014014925, US2014014927, US20140284580, U.S. Pat. No. 6,656,612, U.S. Pat. No. 8,415,031, WO2003060956, WO2007111263, WO2009148269, WO2010067894, WO2010072300,

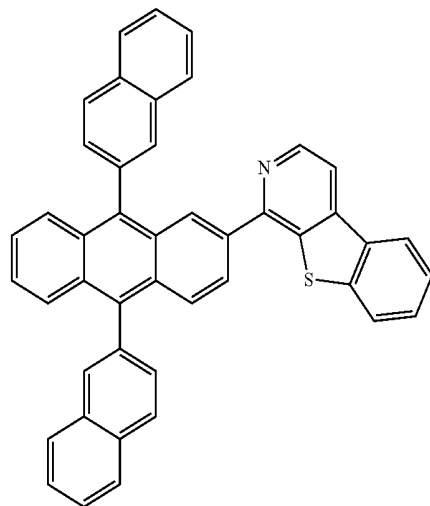
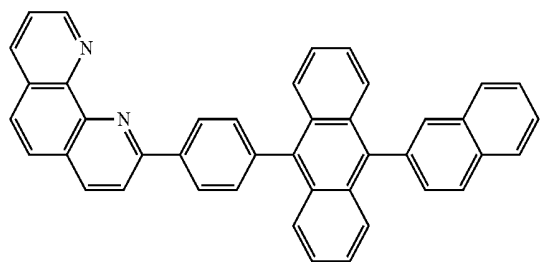
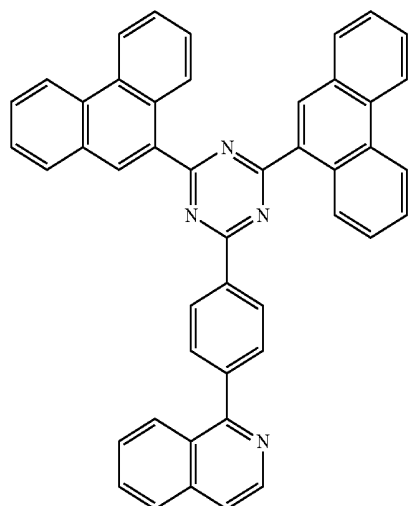
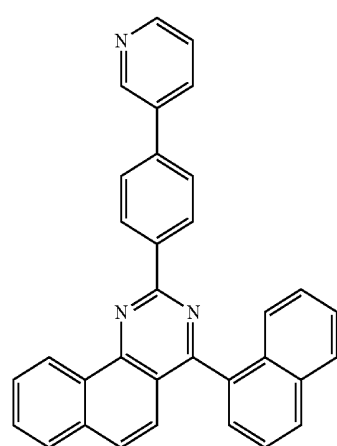
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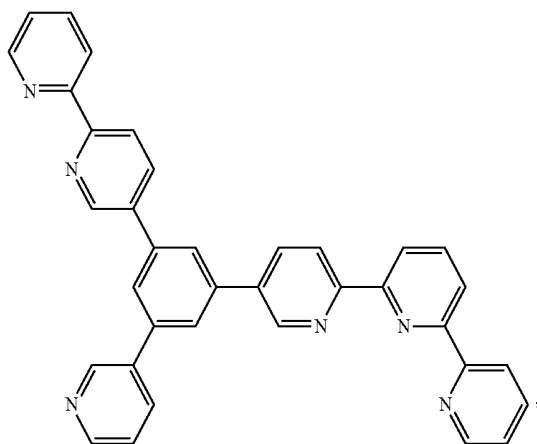
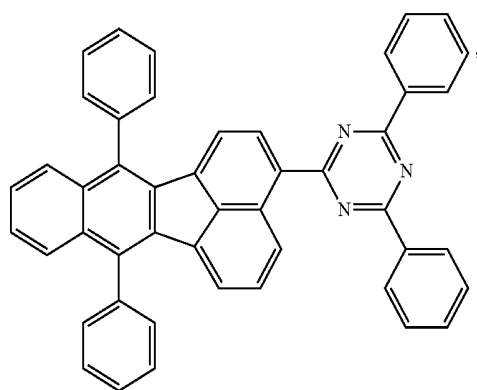
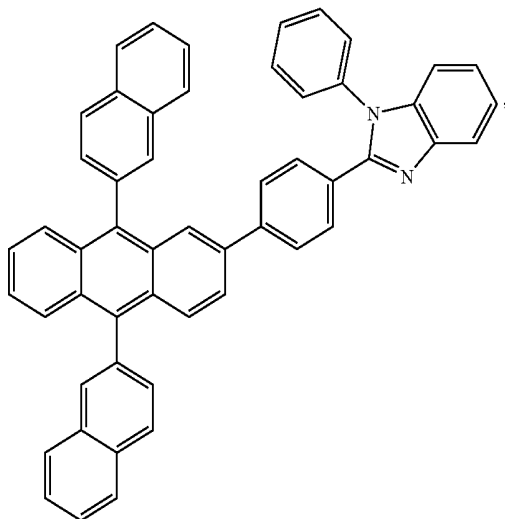
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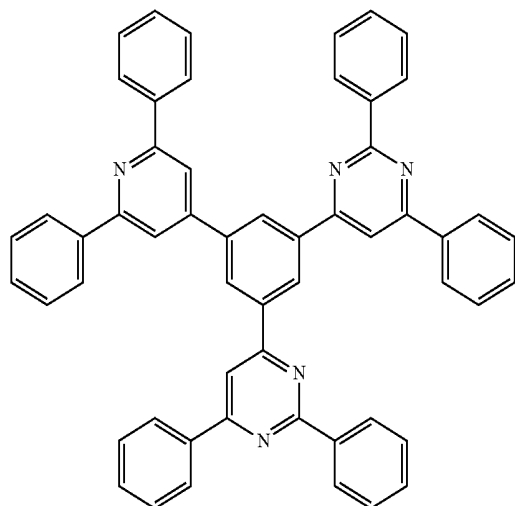
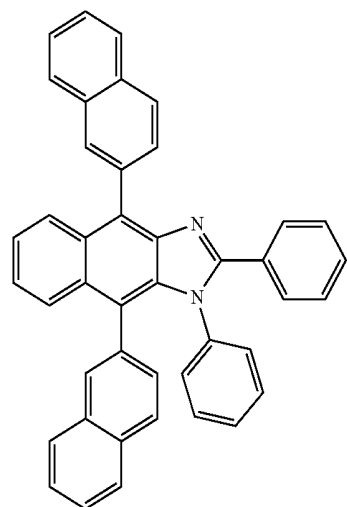
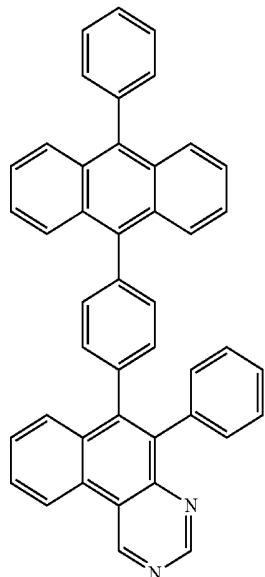
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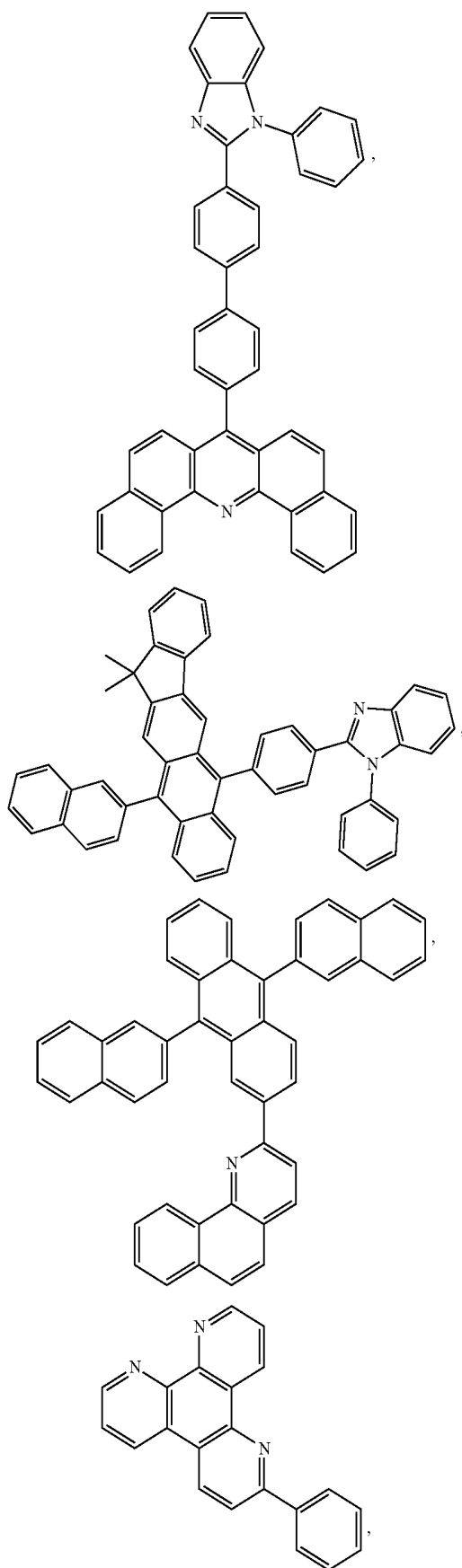
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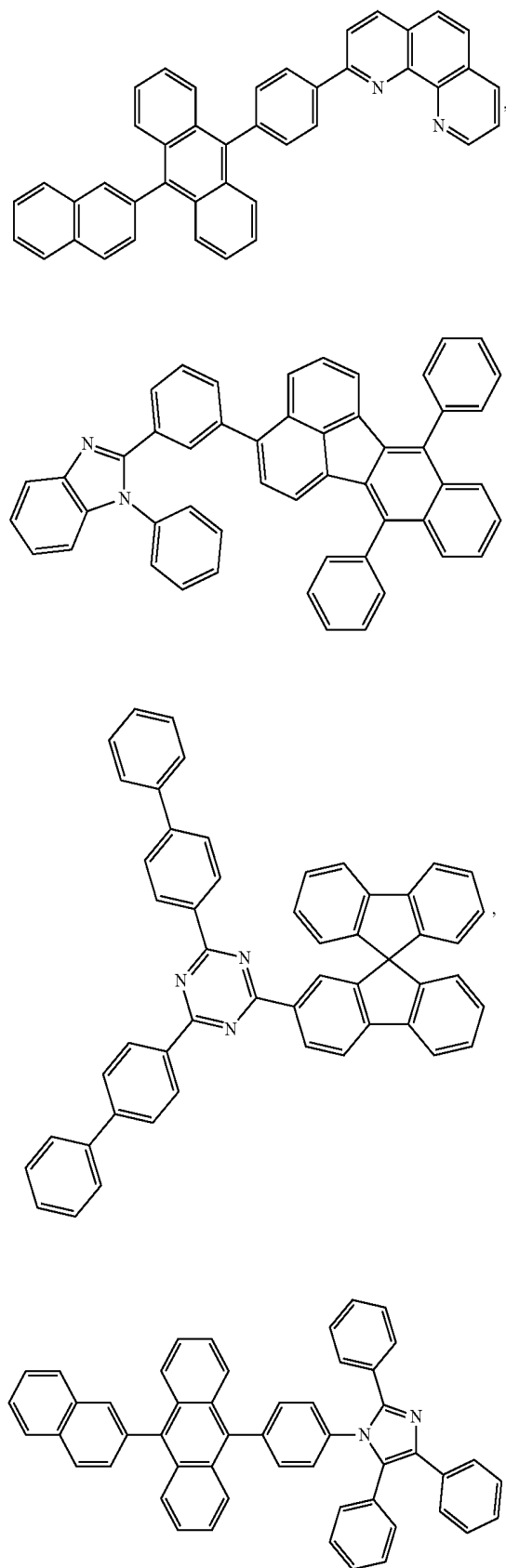
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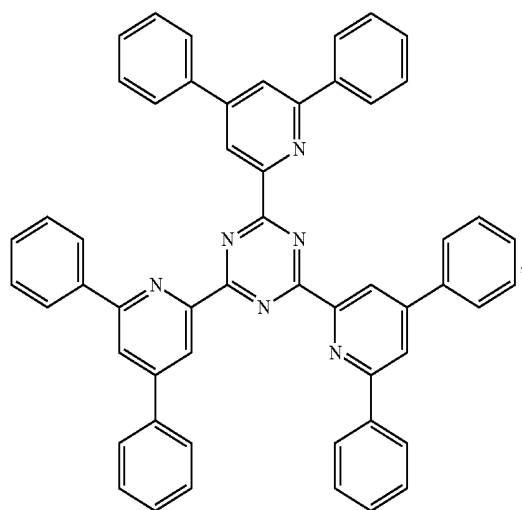
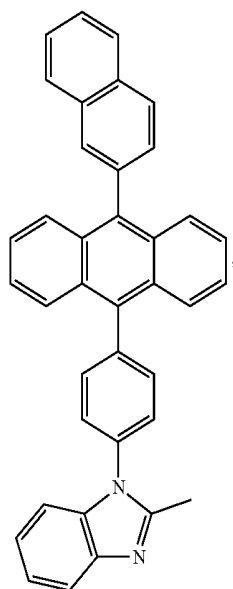
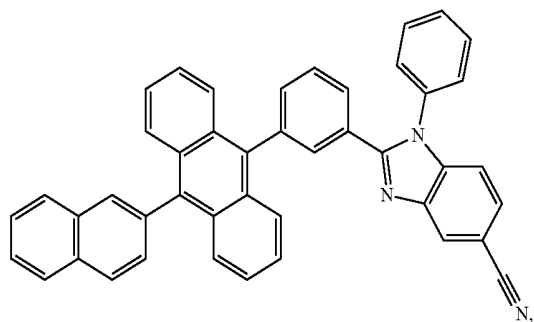
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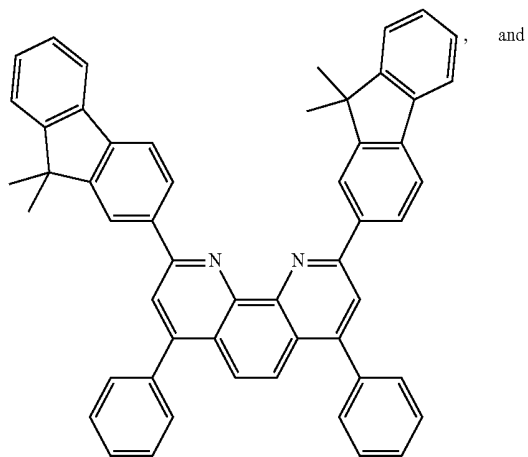
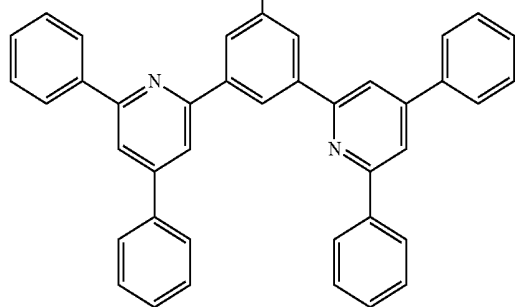
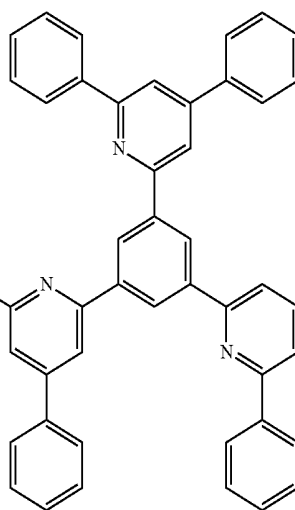
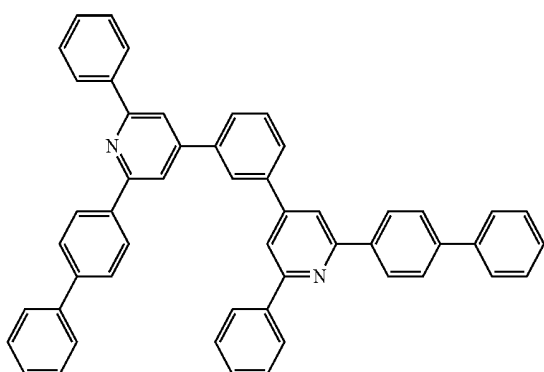
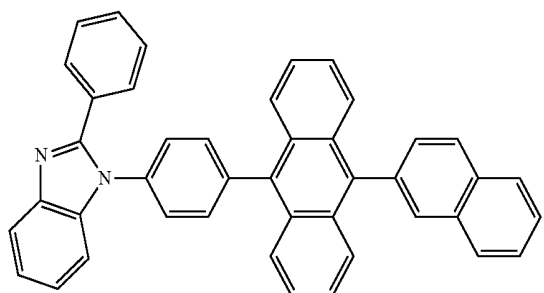
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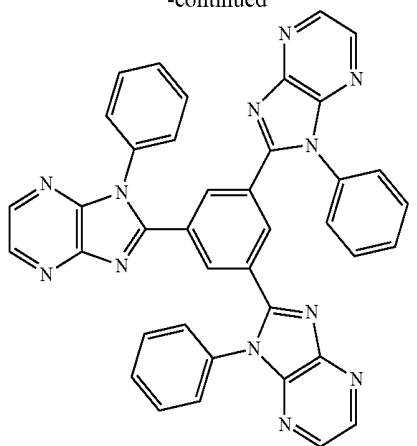


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Charge Generation Layer (CGL)

[0154] In tandem or stacked OLEDs, the CGL plays an essential role in the performance, which is composed of an n-doped layer and a p-doped layer for injection of electrons and holes, respectively. Electrons and holes are supplied from the CGL and electrodes. The consumed electrons and holes in the CGL are refilled by the electrons and holes injected from the cathode and anode, respectively; then, the bipolar currents reach a steady state gradually. Typical CGL materials include n and p conductivity dopants used in the transport layers.

[0155] In any above-mentioned compounds used in each layer of the OLED device, the hydrogen atoms can be partially or fully deuterated. Thus, any specifically listed substituent, such as, without limitation, methyl, phenyl, pyridyl, etc. may be undeuterated, partially deuterated, and fully deuterated versions thereof. Similarly, classes of substituents such as, without limitation, alkyl, aryl, cycloalkyl, heteroaryl, etc. also may be undeuterated, partially deuterated, and fully deuterated versions thereof.

EXPERIMENTAL

Synthesis of Materials

[0156] Chemical abbreviations used throughout this document are as follows:

[0157] $\text{Pd}_2(\text{dba})_3$ is tri(dibenzylideneacetone) dipalladium(0),

[0158] SPhos is dicyclohexyl(2',6'-dimethoxy-[1,1'-biphenyl]-2-yl)phosphine,

[0159] KOAc is potassium acetate,

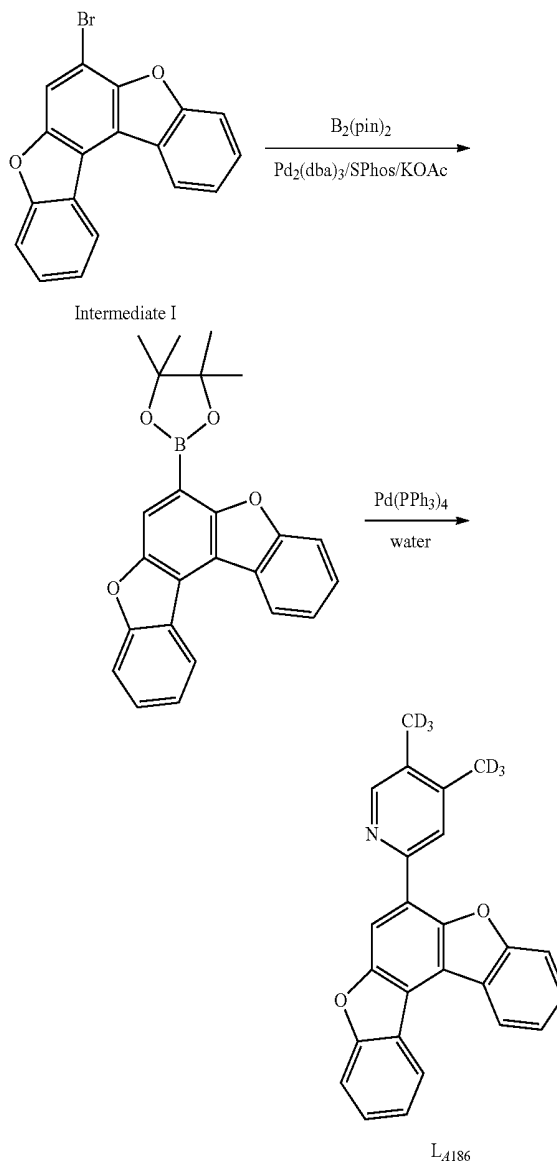
[0160] EtOAc is ethyl acetate,

[0161] THF is tetrahydrofuran,

[0162] DMF is dimethylformamide, and

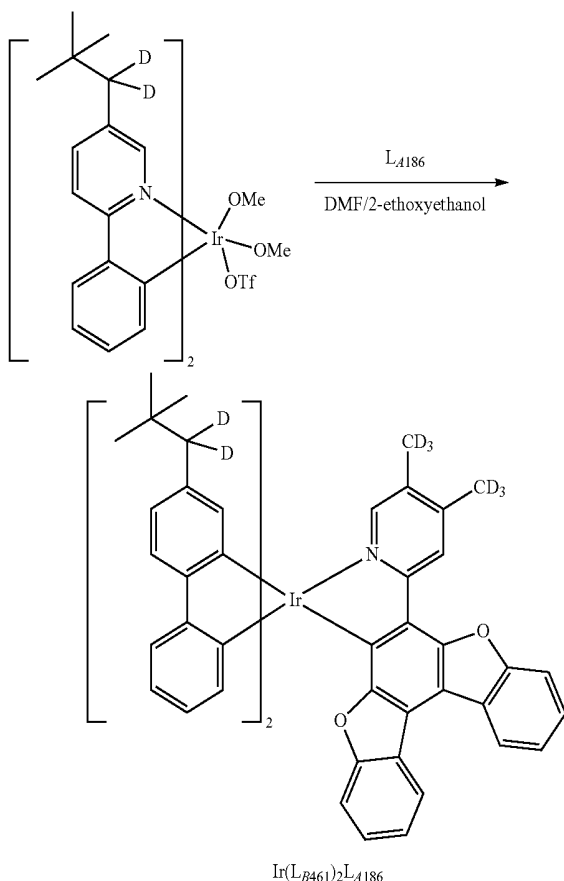
[0163] DCM is dichloromethane.

[0164] Inventive compound $\text{Ir}(\text{L}_{B461})_2\text{L}_{A186}$ can be synthesized by the procedure shown in the following scheme.

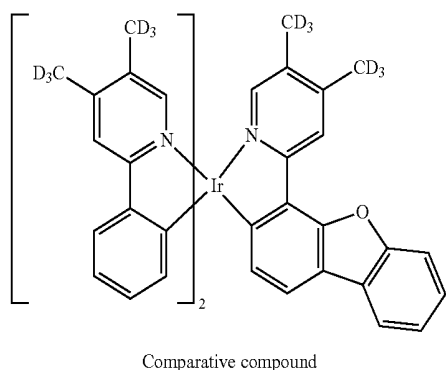


[0165] To a 100 ml round bottom flask was added intermediate I (3.53 g, 10.47 mmol), 4,4',4',5,5',5',5'-octamethyl-2,2'-bi(1,3,2-dioxaborolane) (5.32 g, 20.94 mmol), $\text{Pd}_2(\text{dba})_3$ (0.19 g, 0.21 mmol), SPhos (0.34 g, 0.84 mmol), Potassium acetate (KOAc) (3.1 g, 31.4 mmol), and dioxane (80 ml). The mixture was degassed by bubbling N_2 directly into the mixture for 15 minutes. The mixture was then heated under N_2 at reflux for 16 hours. After the reaction was cooled to room temperature ($\sim 22^\circ \text{C}$), then the crude reaction mixture was used in the next step without purification. 2-bromo-4,5-bis(methyl-d3)pyridine (2.413 g, 12.56 mmol), K_3PO_4 (6.67 g, 31.4 mmol), $\text{Pd}(\text{PPh}_3)_4$ (0.36 g, 0.31 mmol) and water (10 mL) were added to the crude reaction mixture, which was then degassed by bubbling N_2 directly into the mixture for 15 minutes. The mixture was heated under N_2 at reflux for 16 hours. The product was extracted with ethyle acetate (EtOAc). The combined organic phase was washed

with brine. The solvent was removed and the residue was coated on silica gel and purified using a silica gel column eluted with 9/1 heptane/THF to collect the blue emissive spot to give the product 2.2 g (57%).



[0166] Dimer (1.9 g, 2.2 mmol) and $\text{L}_{\text{A}186}$ (1.56, 4.21 mmol) were added to a mixture of DMF (70 ml) and 2-ethoxyethanol (30 ml). The mixture was degassed for 20 mins and then heated to 80° C. under N_2 for 72 h. Excess methanol was added. The solution was filtered through a short plug of silica gel. The solid was dissolved in DCM. The solvent was removed and the residue was coated on silica gel. The product was purified on silica gel column eluted by using 70/30 toluene/heptane. The solvent was removed and the product was recrystallized in toluene/meoH to give the $\text{Ir}(\text{L}_{\text{B}461})_2(\text{L}_{\text{A}186})$.



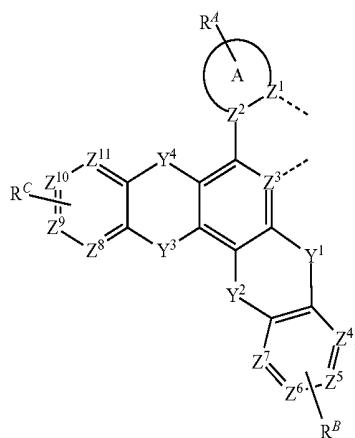
[0167] Compound $\text{Ir}(\text{L}_{\text{B}461})_2(\text{L}_{\text{A}186})$ emits bright green phosphorescence at room temperature with an emission maximum at 540 nm. The photoluminescence (PL) spectra of compound $\text{Ir}(\text{L}_{\text{B}461})_2(\text{L}_{\text{A}186})$ was compared to the comparative compound, and the results are shown in FIG. 3. The PL intensities are normalized to the maximum of the first emission peaks and the emission spectrum of the comparative compound is manually red shifted by 24 nm for better comparison. Both compounds exhibit structural emission profiles. It can be seen that the PL of compound $\text{Ir}(\text{L}_{\text{B}461})_2(\text{L}_{\text{A}186})$ is narrower compared to that of the comparative example. The broad emission spectrum, more specifically the strong contribution from the second emission peak, is a major problem for achieving good color purity. The unique fused polycyclic aromatic rings in compound $\text{Ir}(\text{L}_{\text{B}461})_2(\text{L}_{\text{A}186})$ increases the rigidity of the molecule and effectively suppresses the vibrationally coupled emission peaks. When compound $\text{Ir}(\text{L}_{\text{B}461})_2(\text{L}_{\text{A}186})$ is used as an emitting dopant in an organic electroluminescence device, it would be expected to emit more saturated green light than the comparative example offering improved device performance, such as high electroluminescence efficiency and lower power consumption.

[0168] It is understood that the various embodiments described herein are by way of example only, and are not intended to limit the scope of the invention. For example, many of the materials and structures described herein may be substituted with other materials and structures without deviating from the spirit of the invention. The present invention as claimed may therefore include variations from the particular examples and preferred embodiments described herein, as will be apparent to one of skill in the art. It is understood that various theories as to why the invention works are not intended to be limiting.

We claim:

1. A metal-containing compound comprising a first ligand L_A of Formula I

Formula I



wherein A is a 5- or 6-membered aryl or heteroaryl ring;
wherein R^A , R^B , and R^C each represent mono to a maximum possible number of substitutions, or no substitution;

wherein Z^1 - Z^{11} are each independently selected from the group consisting of C and N;

wherein Y^1 , Y^2 , Y^3 , and Y^4 are each independently selected from the group consisting of a direct bond, BR, NR, PR, O, S, Se, C=O, S=O, SO₂, CRR', SiRR', and GeRR';

wherein at least one of Y^1 and Y^2 is not a direct bond; wherein at least one of Y^3 and Y^4 is not a direct bond; wherein R^A , R^B , R^C , R, and R' are each independently selected from the group consisting of hydrogen, deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof;

wherein any two adjacent substitutions in R^A , R^B and R^C are optionally joined or fused into a ring;

wherein the ligand L_A is coordinated to a metal M;

wherein L_A is optionally linked with other ligands to comprise a tridentate, tetradentate, pentadentate, or hexadentate ligand; and

wherein M is optionally coordinated to other ligands.

2. The compound of claim 1, wherein one of Y^1 and Y^2 is O and the other one of Y^1 and Y^2 is a direct bond, and one of Y^3 and Y^4 is O and the other one of Y^3 and Y^4 is a direct bond, or

wherein one of Y^1 and Y^2 is S and the other one of Y^1 and Y^2 is a direct bond, and one of Y^3 and Y^4 is S and the other one of Y^3 and Y^4 is a direct bond.

3. The compound of claim 1, wherein each of Y^1 , Y^2 , Y^3 , and Y^4 is O or each of Y^1 , Y^2 , Y^3 , and Y^4 is S.

4. The compound of claim 1, wherein Z^1 is N, Z^2 is C, and Z^3 is C.

5. The compound of claim 1, wherein Z^1 is C, Z^2 is N, and Z^3 is C.

6. The compound of claim 1, wherein Z^1 is N, Z^2 is C, and Z^3 is N.

7. The compound of claim 1, wherein each one of Z^4 through Z^{11} is C.

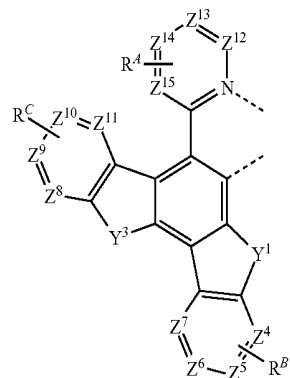
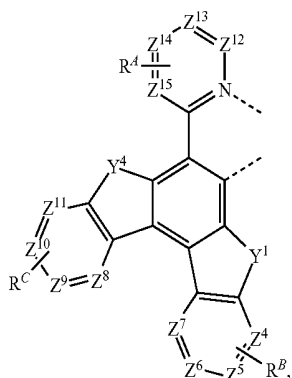
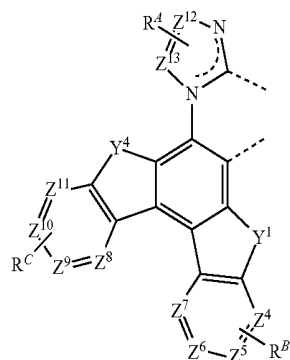
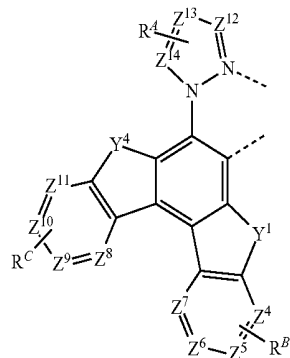
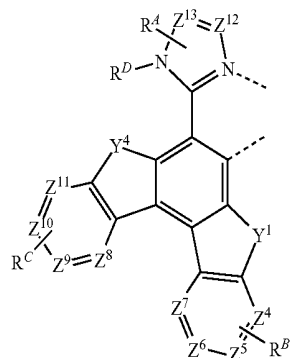
8. The compound of claim 1, wherein at least one of Z^4 through Z^{11} is N.

9. The compound of claim 1, wherein M is selected from the group consisting of Ir, Rh, Re, Ru, Os, Pt, Au, and Cu.

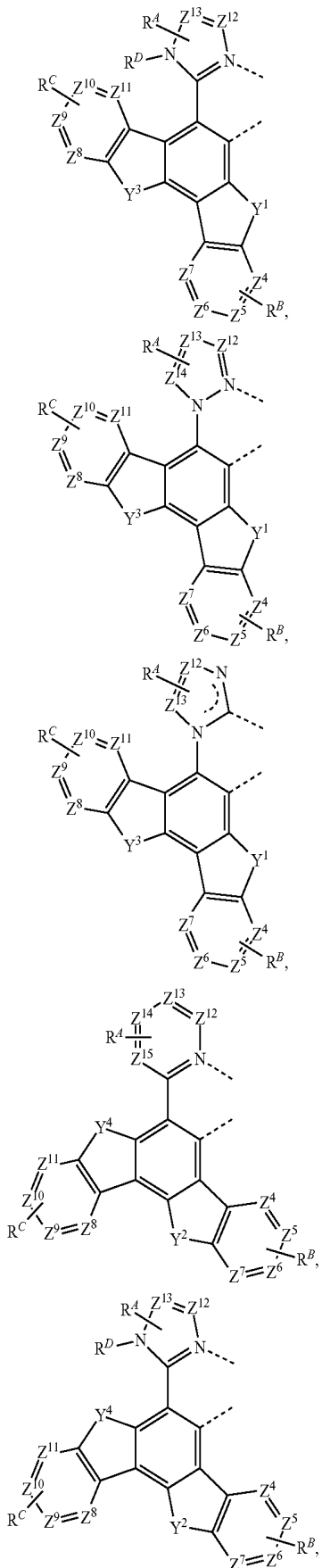
10. The compound of claim 1, wherein ring A is selected from the group consisting of pyridine, pyrimidine, imidazole, pyrazole, and imidazole derived carbene.

11. The compound of claim 1, wherein the first ligand L_A is selected from the group consisting of:

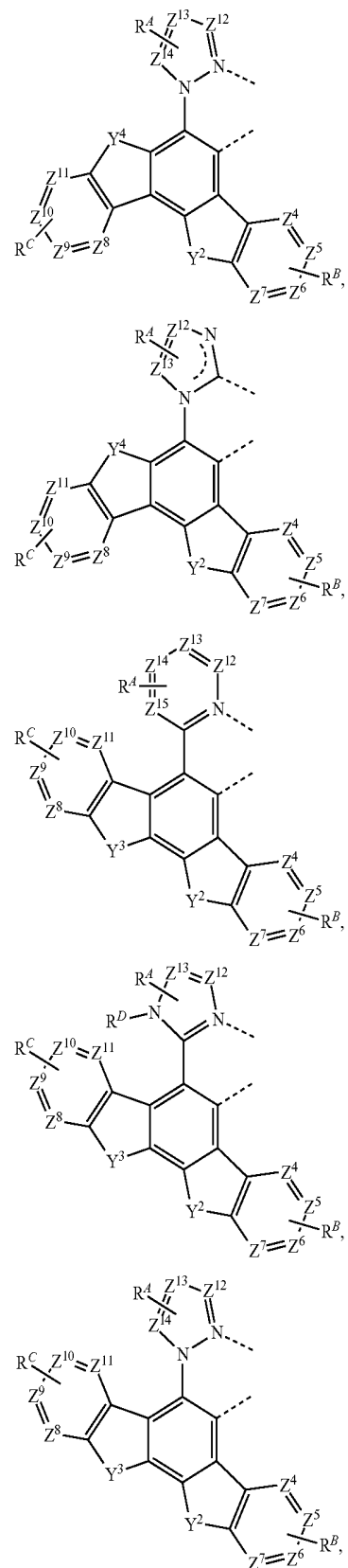
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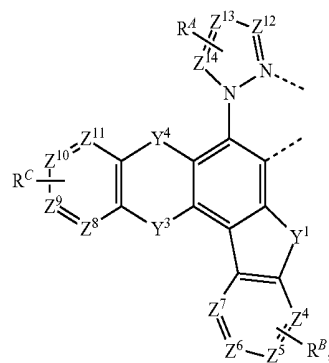
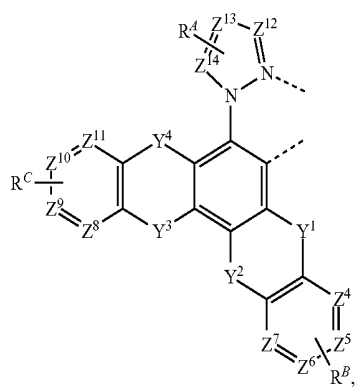
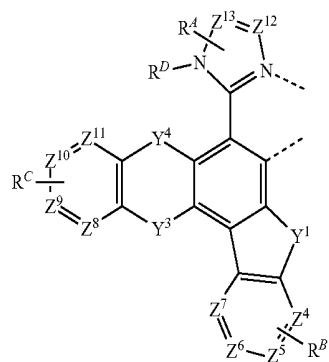
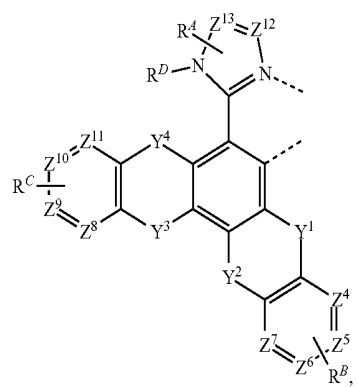
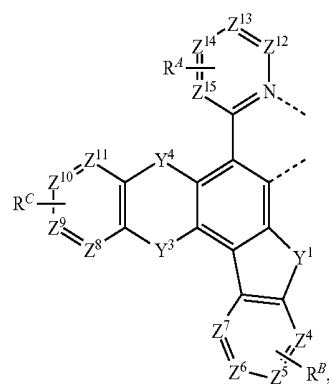
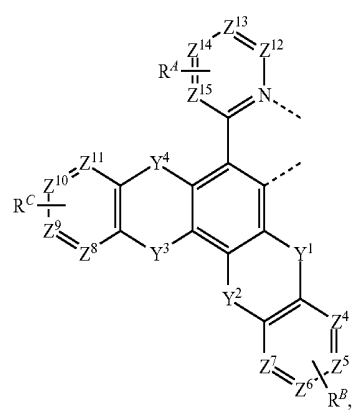
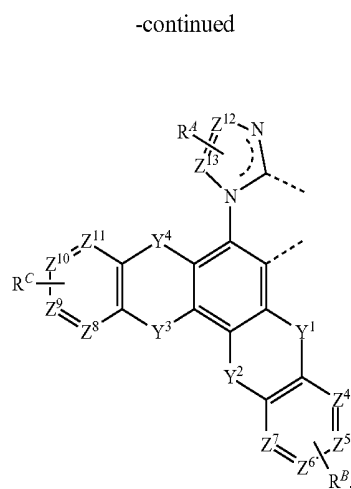
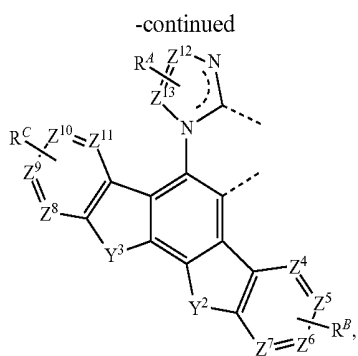


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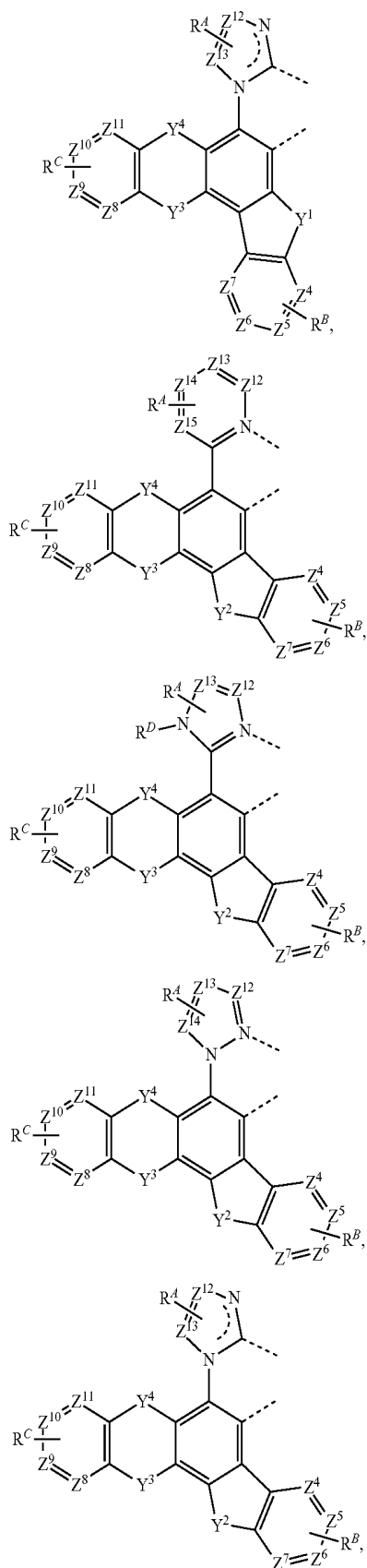


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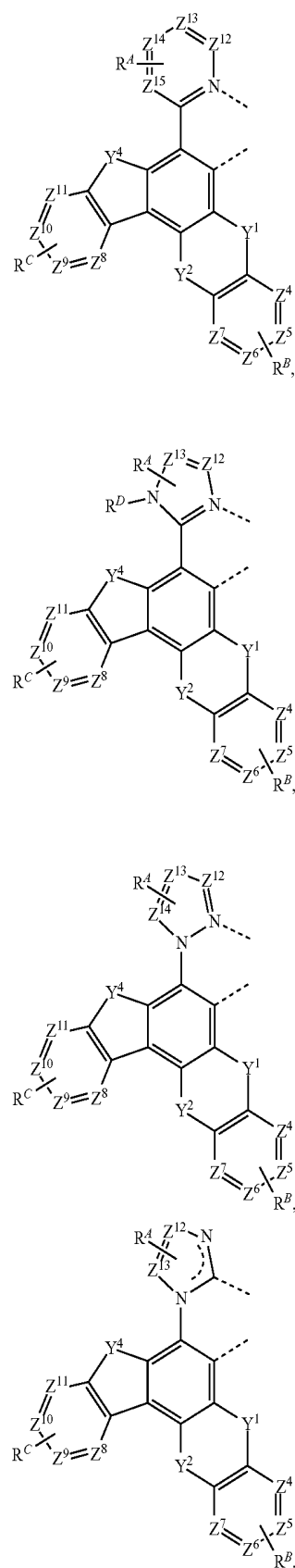




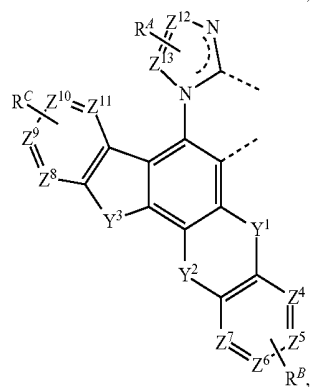
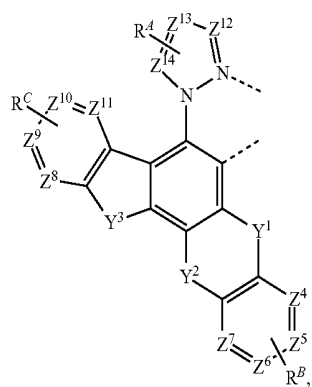
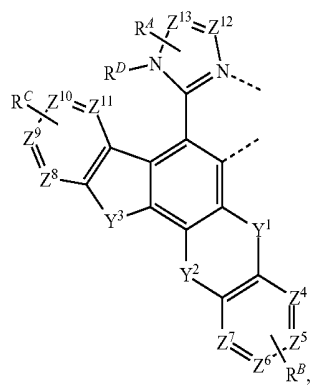
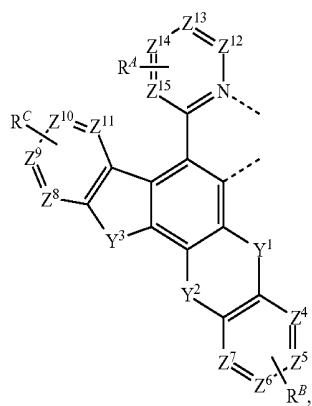
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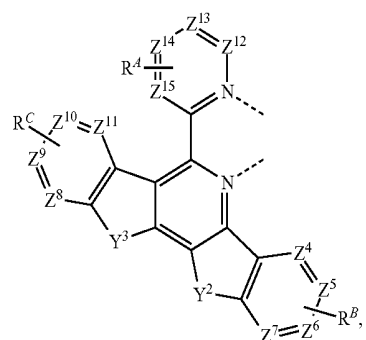
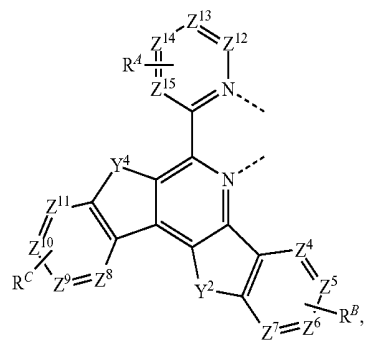
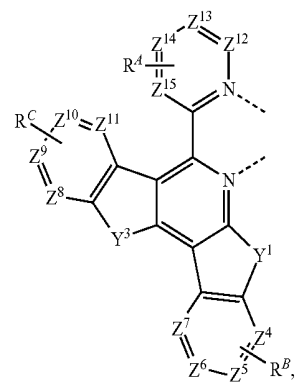
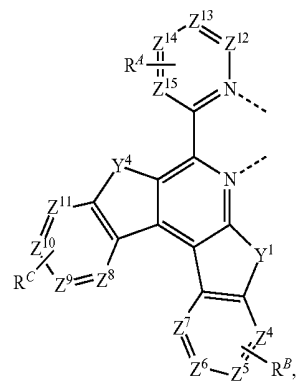
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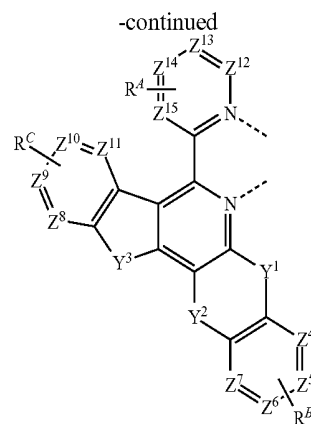
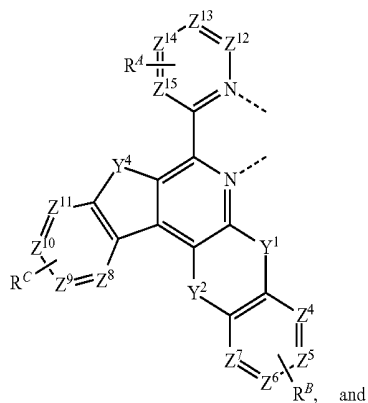
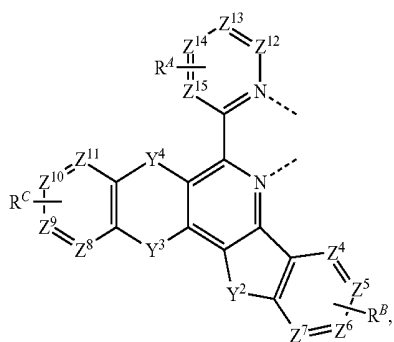
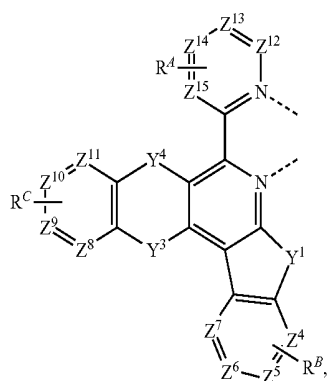
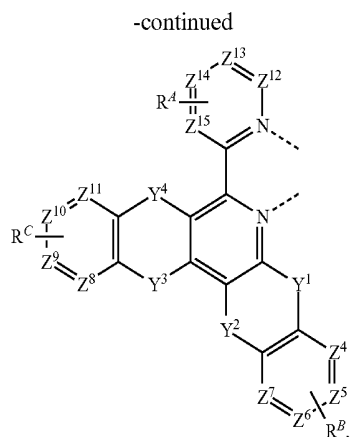


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wherein each of Z^{12} through Z^{14} is independently selected from the group consisting of C and N;

wherein R^D is independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof; and

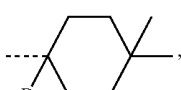
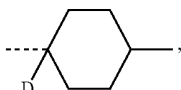
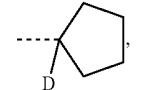
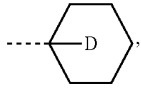
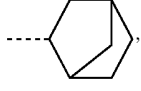
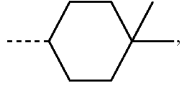
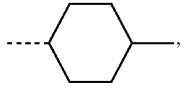
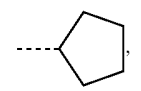
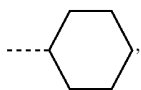
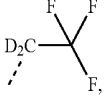
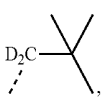
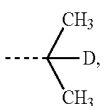
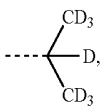
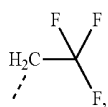
wherein any two adjacent substitutions of R^A , R^B , R^C , and R^D are optionally joined or fused into a ring.

12. The compound of claim 1, wherein ring A is pyridine, Z^1 is nitrogen, and R^A para to Z^1 is not hydrogen or deuterium.

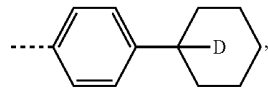
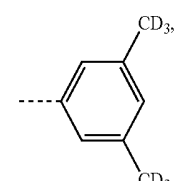
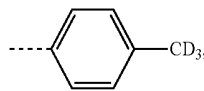
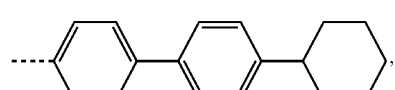
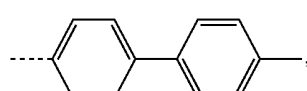
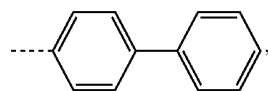
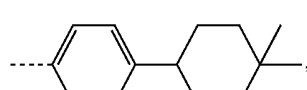
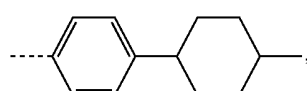
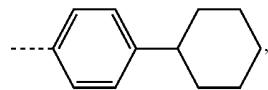
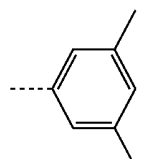
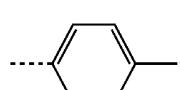
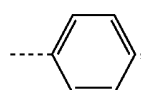
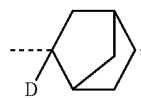
13. The compound of claim 1, wherein R^A is at least a monosubstitution and at least one of R^A substituent is selected from the group consisting of:

- CH₃, Substituent 1
- CD₃, Substituent 2
- CH₂-CH₃, Substituent 3
- CH₂-CD₃, Substituent 4
- CH₂-CH₂-CH₃, Substituent 5
- CH₂-CH₂-CD₃, Substituent 6
- CH(CH₃)₂, Substituent 7
- C(CH₃)₃, Substituent 8

-continued



-continued



Substituent 9

Substituent 10

Substituent 11

Substituent 12

Substituent 13

Substituent 14

Substituent 15

Substituent 16

Substituent 17

Substituent 18

Substituent 19

Substituent 20

Substituent 21

Substituent 22

Substituent 23

Substituent 24

Substituent 25

Substituent 26

Substituent 27

Substituent 28

Substituent 29

Substituent 30

Substituent 31

Substituent 32

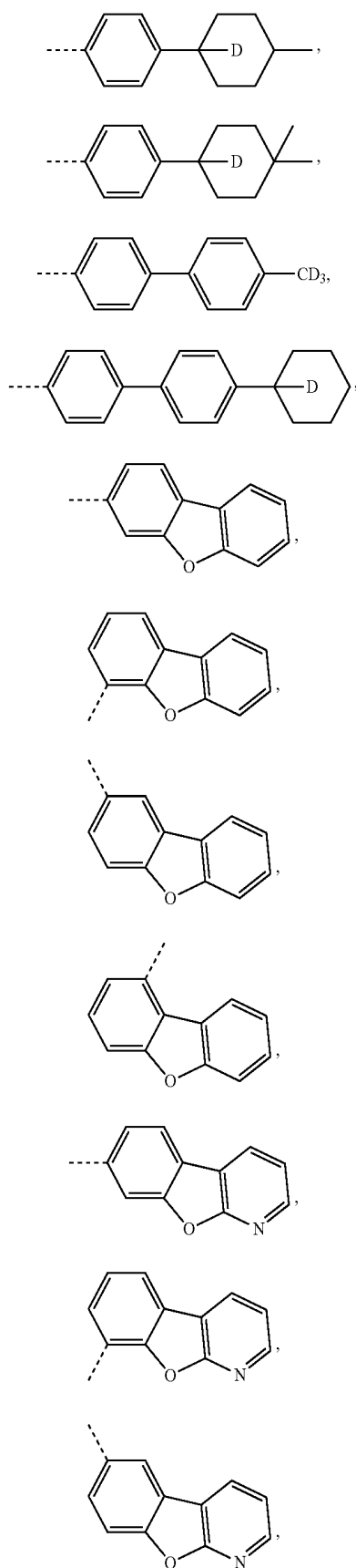
Substituent 33

Substituent 34

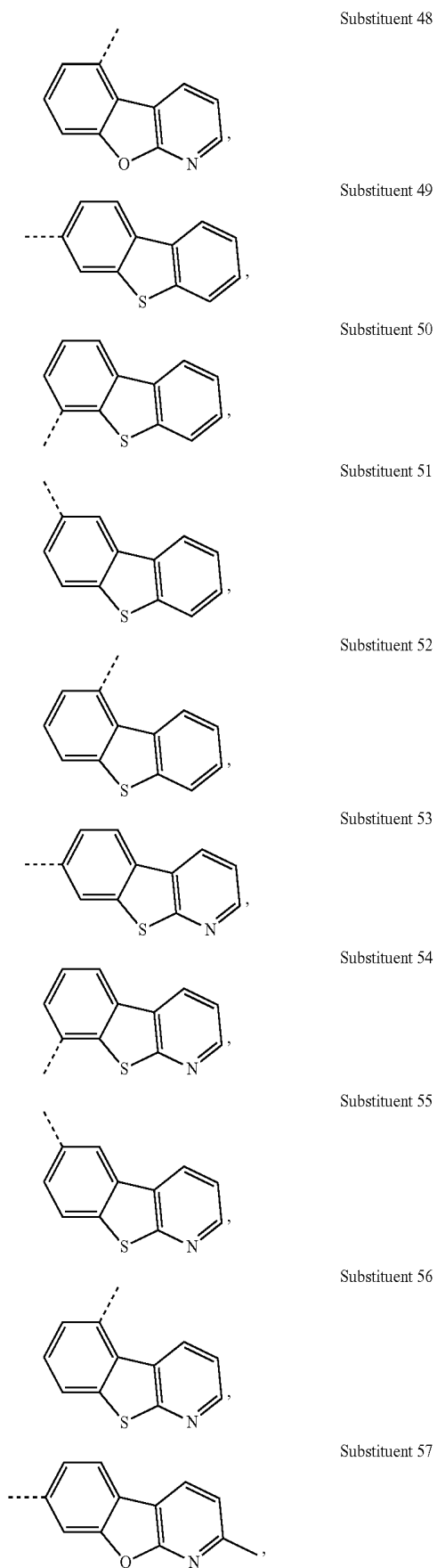
Substituent 35

Substituent 36

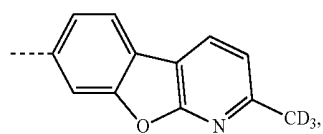
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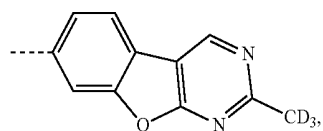
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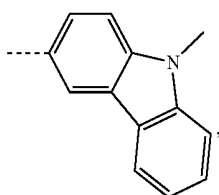
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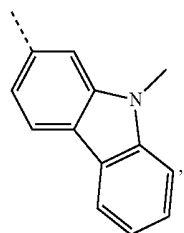
Substituent 58



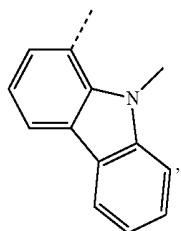
Substituent 59



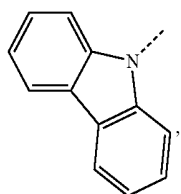
Substituent 60



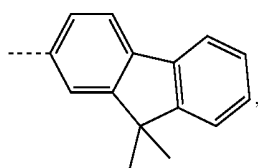
Substituent 61



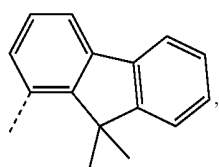
Substituent 62



Substituent 63

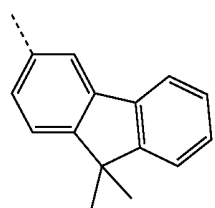


Substituent 64

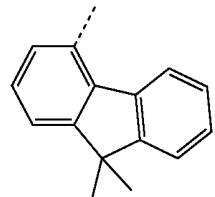


Substituent 65

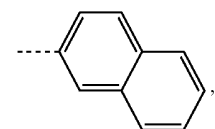
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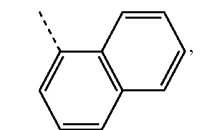
Substituent 66



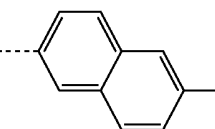
Substituent 67



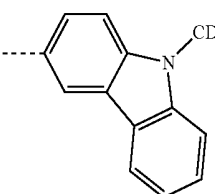
Substituent 68



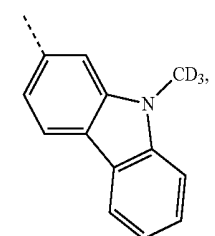
Substituent 69



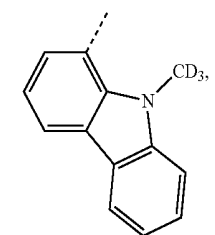
Substituent 70



Substituent 71

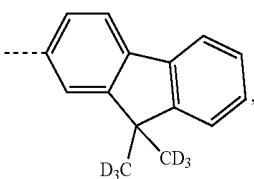


Substituent 72

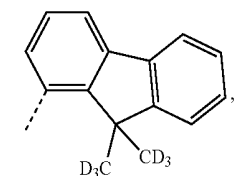


Substituent 73

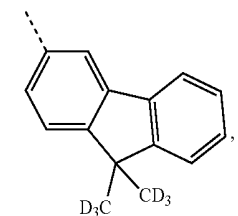
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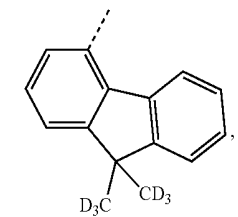
Substituent 74



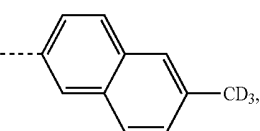
Substituent 75



Substituent 76



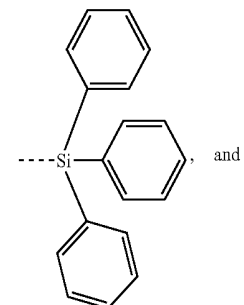
Substituent 77



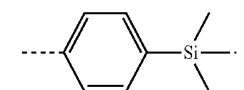
Substituent 78



Substituent 79

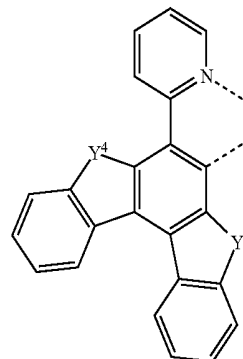


Substituent 80



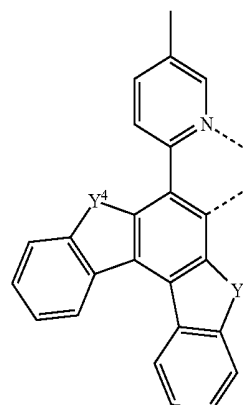
Substituent 81

Ligand L_{A1} through L_{A5}, each represented by the formula



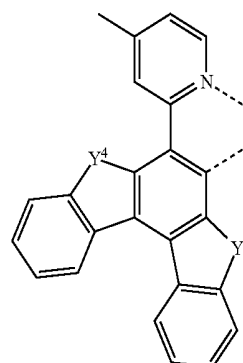
wherein in ligand L_{A1}, Y¹ = O, Y⁴ = O;
 in ligand L_{A2}, Y¹ = S, Y⁴ = S;
 in ligand L_{A3}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A4}, Y¹ = O, Y⁴ = S;
 in ligand L_{A5}, Y¹ = S, Y⁴ = O;

Ligand L_{A6} through L_{A10}, each represented by the formula



wherein in ligand L_{A6}, Y¹ = O, Y⁴ = O;
 in ligand L_{A7}, Y¹ = S, Y⁴ = S;
 in ligand L_{A8}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A9}, Y¹ = O, Y⁴ = S;
 in ligand L_{A10}, Y¹ = S, Y⁴ = O;

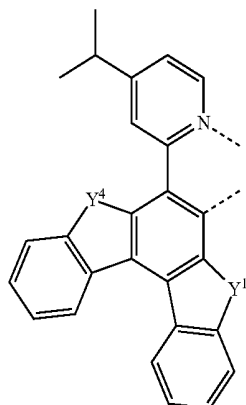
Ligand L_{A11} through L_{A15}, each represented by the formula



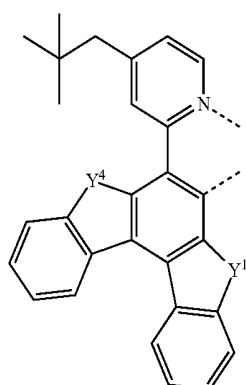
wherein in ligand L_{A11}, Y¹ = O, Y⁴ = O;
 in ligand L_{A12}, Y¹ = S, Y⁴ = S;
 in ligand L_{A13}, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L_{A14}, Y¹ = O, Y⁴ = S;
 in ligand L_{A15}, Y¹ = S, Y⁴ = O;

14. The compound of claim 1, wherein L_A is selected from the group consisting of L_{A1} to L_{A544}, which are defined as follows:

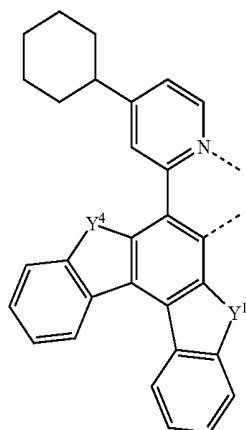
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Ligand L₄₁₆ through L₄₂₀, each represented by the formula

wherein in ligand L₄₁₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₀, Y¹ = S, Y⁴ = O;

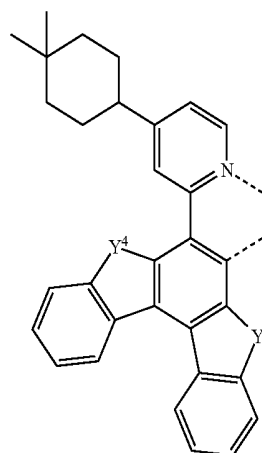
Ligand L₄₂₁ through L₄₂₅, each represented by the formula

wherein in ligand L₄₂₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₅, Y¹ = S, Y⁴ = O;

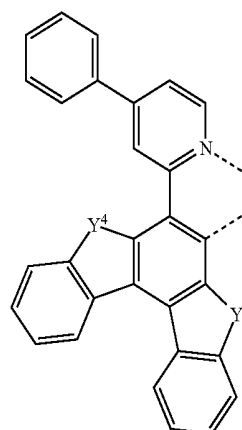
Ligand L₄₂₆ through L₄₃₀, each represented by the formula

wherein in ligand L₄₂₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

-continued

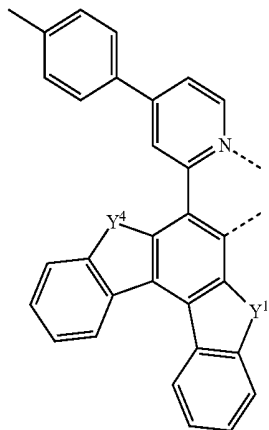
in ligand L₄₂₉, Y¹ = O, Y⁴ = S;in ligand L₄₃₀, Y¹ = S, Y⁴ = O;Ligand L₄₃₁ through L₄₃₅, each represented by the formula

wherein in ligand L₄₃₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₃₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₃₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₃₅, Y¹ = S, Y⁴ = O;

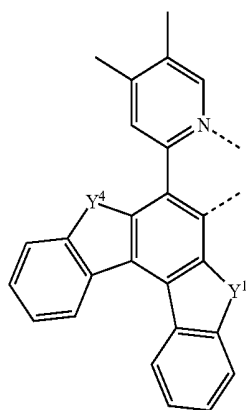
Ligand L₄₃₆ through L₄₄₀, each represented by the formula

wherein in ligand L₄₃₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₃₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₃₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₃₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₄₀, Y¹ = S, Y⁴ = O;

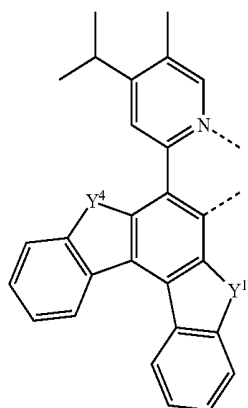
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Ligand L₄₄₁ through L₄₄₅, each represented by the formula

wherein in ligand L₄₄₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₄₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₄₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₄₅, Y¹ = S, Y⁴ = O;

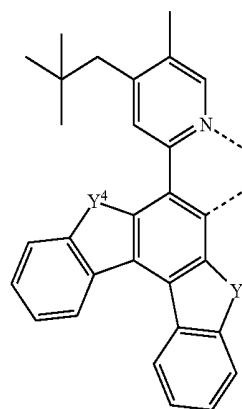
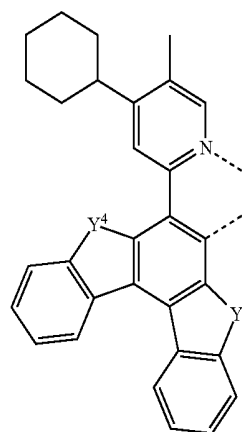
Ligand L₄₄₆ through L₄₅₀, each represented by the formula

wherein in ligand L₄₄₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₄₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₄₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₅₀, Y¹ = S, Y⁴ = O;

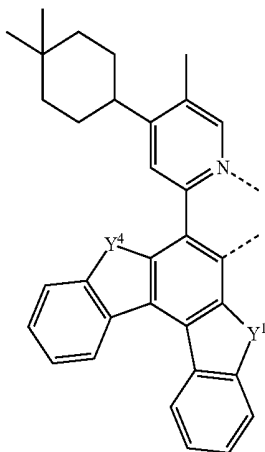
Ligand L₄₅₁ through L₄₅₅, each represented by the formula

wherein in ligand L₄₅₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₅₂, Y¹ = S, Y⁴ = S;

-continued

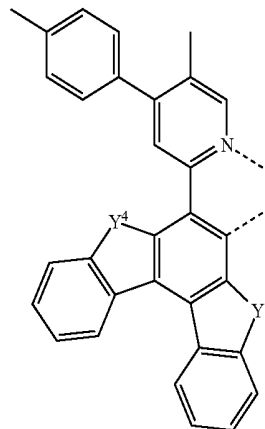
in ligand L₄₅₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₅₄, Y¹ = O, Y⁴ = S;in ligand L₄₅₅, Y¹ = S, Y⁴ = O;Ligand L₄₅₆ through L₄₆₀, each represented by the formulawherein in ligand L₄₅₆, Y¹ = O, Y⁴ = O;in ligand L₄₅₇, Y¹ = S, Y⁴ = S;in ligand L₄₅₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₅₉, Y¹ = O, Y⁴ = S;in ligand L₄₆₀, Y¹ = S, Y⁴ = O;Ligand L₄₆₁ through L₄₆₅, each represented by the formulawherein in ligand L₄₆₁, Y¹ = O, Y⁴ = O;in ligand L₄₆₂, Y¹ = S, Y⁴ = S;in ligand L₄₆₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₆₄, Y¹ = O, Y⁴ = S;in ligand L₄₆₅, Y¹ = S, Y⁴ = O;

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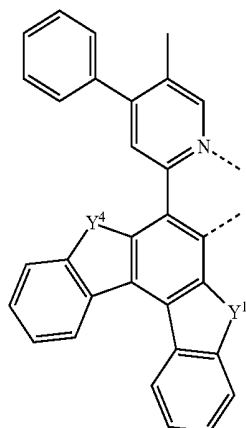
Ligand L₄₆₆ through L₄₇₀, each represented by the formula

wherein in ligand L₄₆₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₆₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₆₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₆₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₇₀, Y¹ = S, Y⁴ = O;

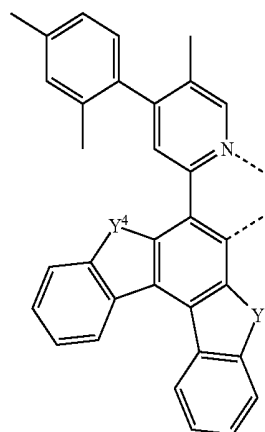
-continued

Ligand L₄₇₆ through L₄₈₀, each represented by the formula

wherein in ligand L₄₇₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₇₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₇₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₇₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₈₀, Y¹ = S, Y⁴ = O;

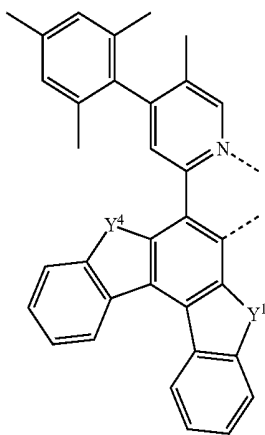
Ligand L₄₇₁ through L₄₇₅, each represented by the formula

wherein in ligand L₄₇₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₇₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₇₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₇₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₇₅, Y¹ = S, Y⁴ = O;

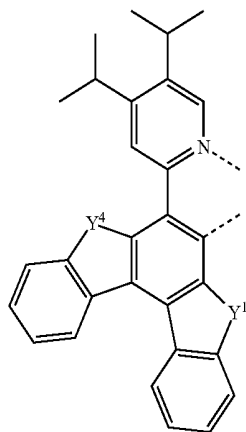
Ligand L₄₈₁ through L₄₈₅, each represented by the formula

wherein in ligand L₄₈₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₈₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₈₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₈₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₈₅, Y¹ = S, Y⁴ = O;

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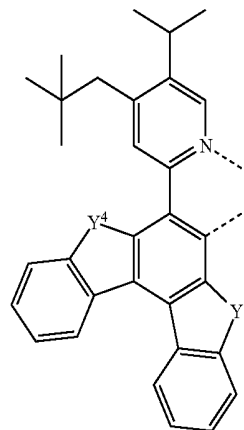
Ligand L_{486} through L_{490} , each represented by the formula

wherein in ligand L_{486} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{487} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{488} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{489} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{490} , $Y^1 = S$, $Y^4 = O$;

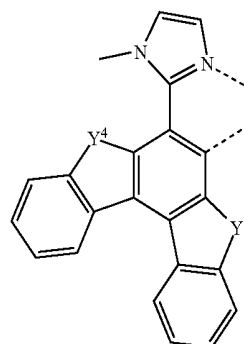
Ligand L_{491} through L_{495} , each represented by the formula

wherein in ligand L_{491} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{492} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{493} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{494} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{495} , $Y^1 = S$, $Y^4 = O$;

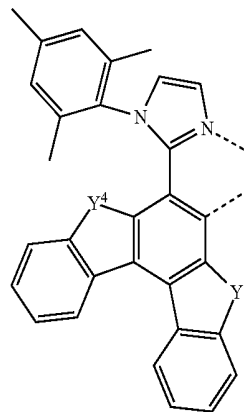
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Ligand L_{496} through L_{4100} , each represented by the formula

wherein in ligand L_{496} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{497} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{498} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{499} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4100} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{4101} through L_{4105} , each represented by the formula

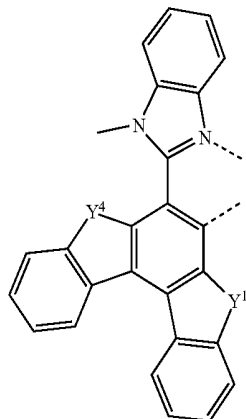


wherein in ligand L_{4101} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4102} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4103} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4104} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4105} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{4106} through L_{4110} , each represented by the formula

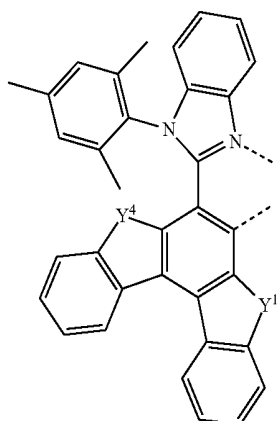


wherein in ligand L_{4106} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4107} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4108} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4109} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4110} , $Y^1 = S$, $Y^4 = O$;

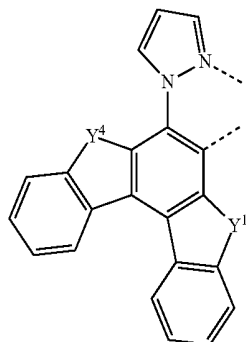
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Ligand L_{A111} through L_{A115} , each represented by the formula

wherein in ligand L_{A111} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A112} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A113} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{A114} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A115} , $Y^1 = S$, $Y^4 = O$;

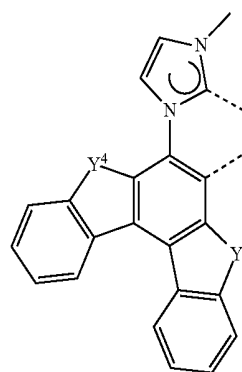
Ligand L_{A116} through L_{A120} , each represented by the formula

wherein in ligand L_{A116} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A117} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A118} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{A119} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A120} , $Y^1 = S$, $Y^4 = O$;

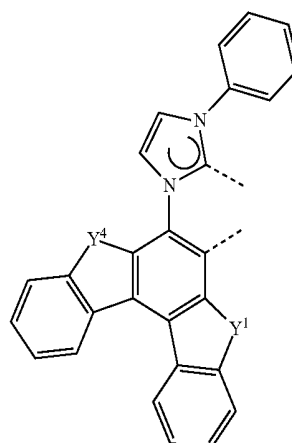
Ligand L_{A121} through L_{A125} , each represented by the formula

wherein in ligand L_{A121} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A122} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A123} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{A124} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A125} , $Y^1 = S$, $Y^4 = O$;

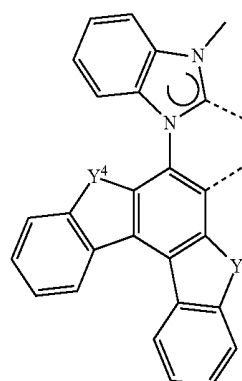
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Ligand L_{A126} through L_{A130} , each represented by the formula

wherein in ligand L_{A126} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A127} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A128} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{A129} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A130} , $Y^1 = S$, $Y^4 = O$;

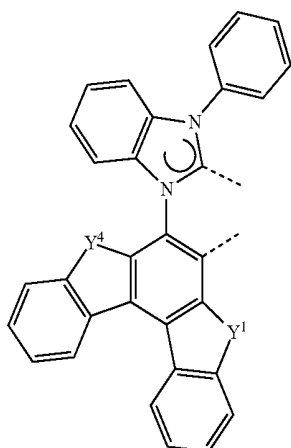
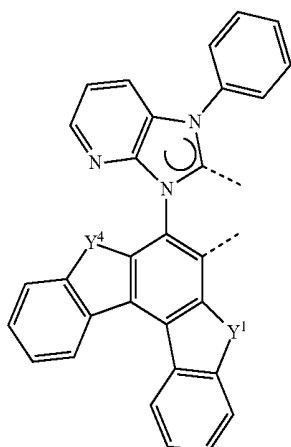
Ligand L_{A131} through L_{A135} , each represented by the formula

wherein in ligand L_{A131} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A132} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A133} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{A134} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A135} , $Y^1 = S$, $Y^4 = O$;

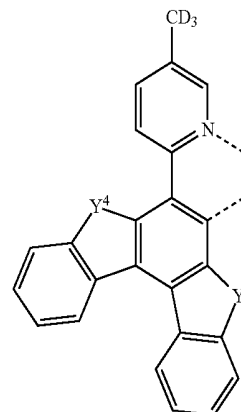
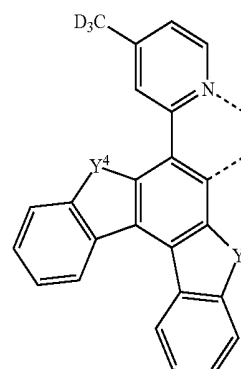
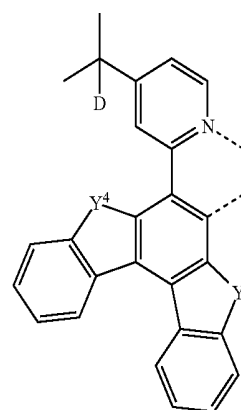
Ligand L_{A136} through L_{A140} , each represented by the formula

wherein in ligand L_{A136} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A137} , $Y^1 = S$, $Y^4 = S$;

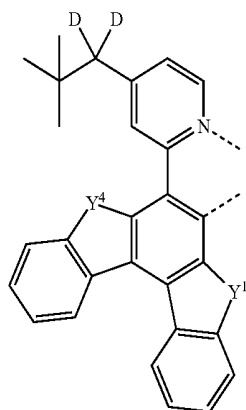
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in ligand L_{A138} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A139} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A140} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A141} through L_{A145} , each represented by the formulawherein in ligand L_{A141} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A142} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A143} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A144} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A145} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A146} through L_{A150} , each represented by the formulawherein in ligand L_{A146} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A147} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A148} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A149} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A150} , $Y^1 = S$, $Y^4 = O$;

-continued

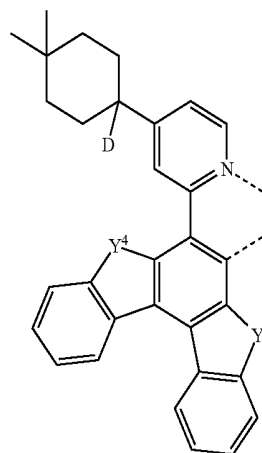
Ligand L_{A151} through L_{A155} , each represented by the formulawherein in ligand L_{A151} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A152} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A153} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A154} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A155} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A156} through L_{A160} , each represented by the formulawherein in ligand L_{A156} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A157} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A158} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A159} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A160} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A161} through L_{A165} , each represented by the formulawherein in ligand L_{A161} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A162} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A163} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A164} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A165} , $Y^1 = S$, $Y^4 = O$;

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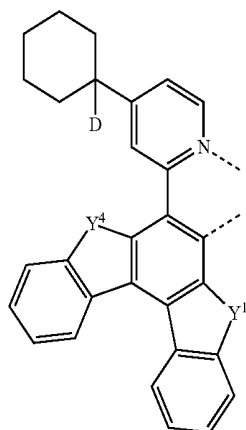
Ligand L₄₁₆₆ through L₄₁₇₀, each represented by the formula

wherein in ligand L₄₁₆₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₆₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₆₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₆₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₇₀, Y¹ = S, Y⁴ = O;

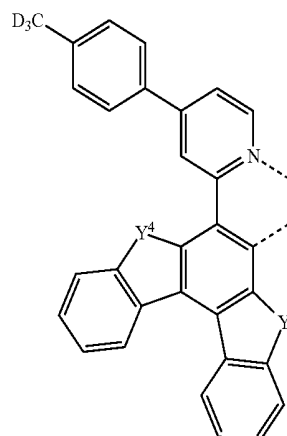
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Ligand L₄₁₇₆ through L₄₁₈₀, each represented by the formula

wherein in ligand L₄₁₇₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₇₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₇₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₇₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₈₀, Y¹ = S, Y⁴ = O;

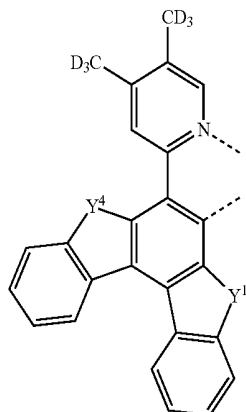
Ligand L₄₁₇₁ through L₄₁₇₅, each represented by the formula

wherein in ligand L₄₁₇₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₇₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₇₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₇₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₇₅, Y¹ = S, Y⁴ = O;

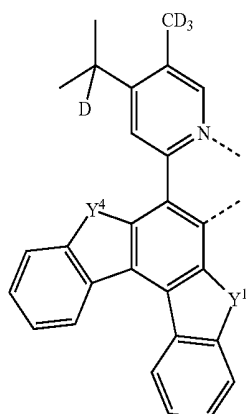
Ligand L₄₁₈₁ through L₄₁₈₅, each represented by the formula

wherein in ligand L₄₁₈₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₈₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₈₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₈₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₈₅, Y¹ = S, Y⁴ = O;

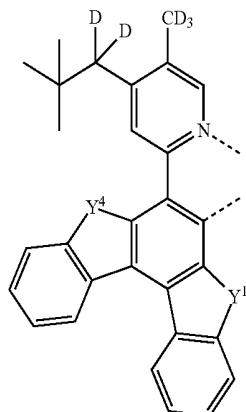
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Ligand L₄₁₈₆ through L₄₁₉₀, each represented by the formula

wherein in ligand L₄₁₈₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₈₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₈₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₈₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₉₀, Y¹ = S, Y⁴ = O;

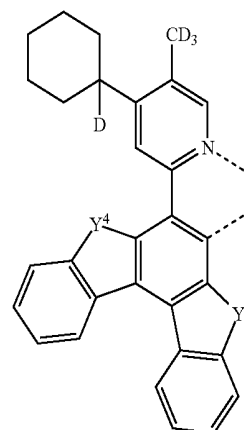
Ligand L₄₁₉₁ through L₄₁₉₅, each represented by the formula

wherein in ligand L₄₁₉₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₉₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₁₉₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₁₉₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₁₉₅, Y¹ = S, Y⁴ = O;

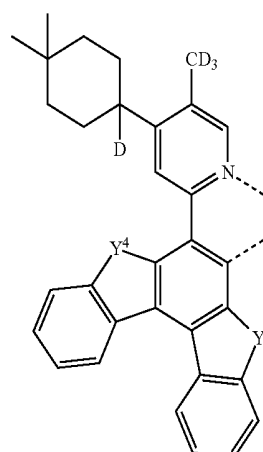
Ligand L₄₁₉₆ through L₄₂₀₀, each represented by the formula

wherein in ligand L₄₁₉₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₁₉₇, Y¹ = S, Y⁴ = S;

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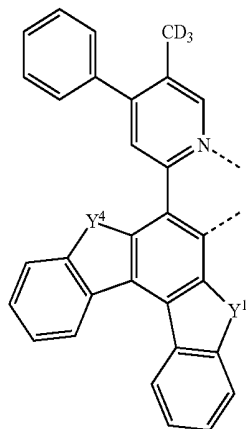
in ligand L₄₁₉₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;in ligand L₄₁₉₉, Y¹ = O, Y⁴ = S;in ligand L₄₂₀₀, Y¹ = S, Y⁴ = O;Ligand L₄₂₀₁ through L₄₂₀₅, each represented by the formula

wherein in ligand L₄₂₀₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₀₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₀₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₀₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₀₅, Y¹ = S, Y⁴ = O;

Ligand L₄₂₆₁ through L₄₂₁₀, each represented by the formula

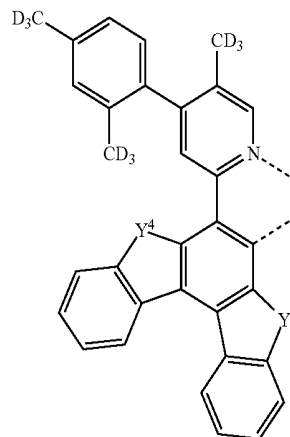
wherein in ligand L₄₂₀₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₀₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₀₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₀₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₁₀, Y¹ = S, Y⁴ = O;

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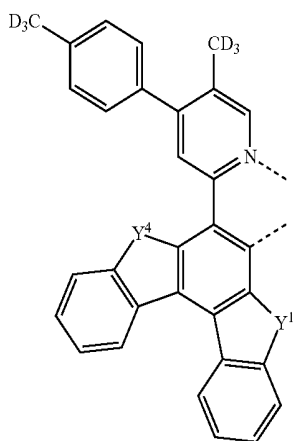
Ligand L₄₂₁₁ through L₄₂₁₅, each represented by the formula

wherein in ligand L₄₂₁₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₁₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₁₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₁₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₁₅, Y¹ = S, Y⁴ = O;

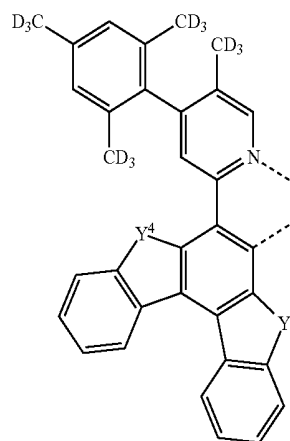
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Ligand L₄₂₂₁ through L₄₂₂₅, each represented by the formula

wherein in ligand L₄₂₂₁, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₂₂, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₂₃, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₂₄, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₂₅, Y¹ = S, Y⁴ = O;

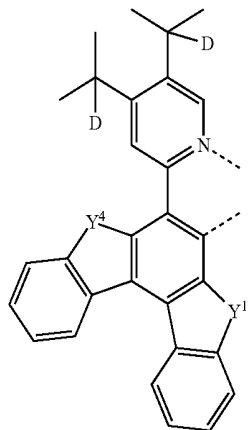
Ligand L₄₂₁₆ through L₄₂₂₀, each represented by the formula

wherein in ligand L₄₂₁₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₁₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₁₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₁₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₂₀, Y¹ = S, Y⁴ = O;

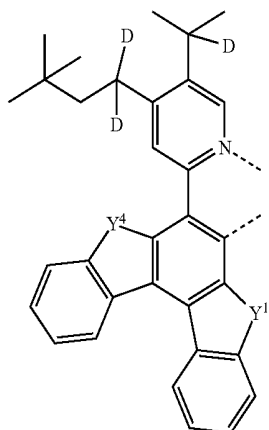
Ligand L₄₂₂₆ through L₄₂₃₀, each represented by the formula

wherein in ligand L₄₂₂₆, Y¹ = O, Y⁴ = O;
 in ligand L₄₂₂₇, Y¹ = S, Y⁴ = S;
 in ligand L₄₂₂₈, Y¹ = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₂₂₉, Y¹ = O, Y⁴ = S;
 in ligand L₄₂₃₀, Y¹ = S, Y⁴ = O;

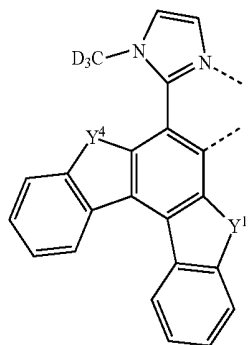
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Ligand L_{A231} through L_{A235} , each represented by the formula

wherein in ligand L_{A231} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A232} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A233} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{A234} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A235} , $Y^1 = S$, $Y^4 = O$;

Ligand L_{A236} through L_{A240} , each represented by the formula

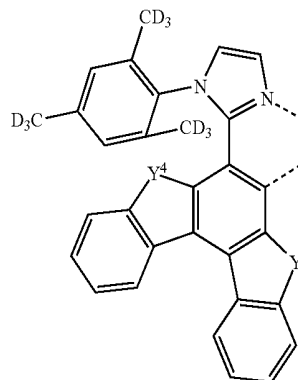
wherein in ligand L_{A236} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A237} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A238} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{A239} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A240} , $Y^1 = S$, $Y^4 = O$;

Ligand L_{A241} through L_{A245} , each represented by the formula

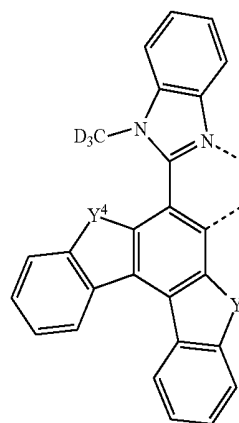
wherein in ligand L_{A241} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A242} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A243} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

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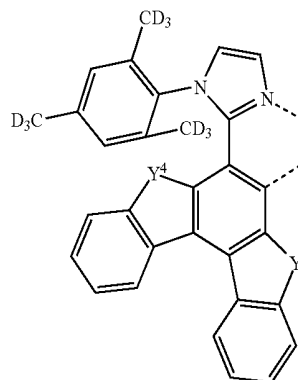
in ligand L_{A244} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A245} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{A246} through L_{A250} , each represented by the formula



wherein in ligand L_{A246} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A247} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A248} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{A249} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A250} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{A251} through L_{A255} , each represented by the formula



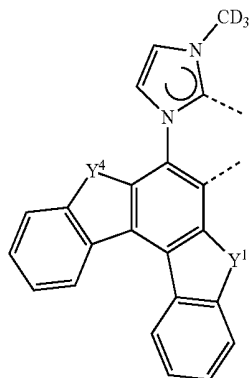
wherein in ligand L_{A251} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A252} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A253} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{A254} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{A255} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{A256} through L_{A260} , each represented by the formula



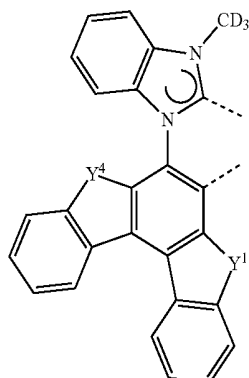
wherein in ligand L_{A256} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{A257} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{A258} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

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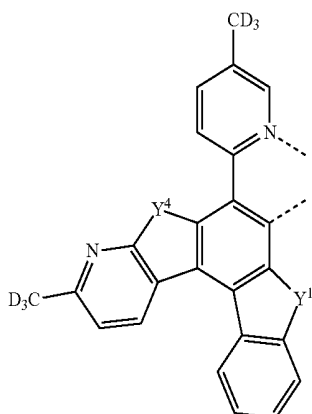
in ligand L_{4259} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4260} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{4261} through L_{4265} , each represented by the formula



wherein in ligand L_{4261} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4262} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4263} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4264} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4265} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{4266} through L_{4270} , each represented by the formula



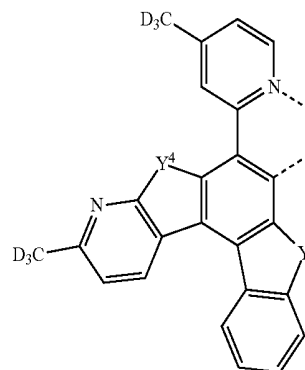
wherein in ligand L_{4266} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4267} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4268} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4269} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4270} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{4271} through L_{4275} , each represented by the formula



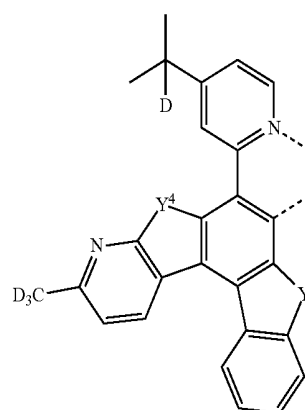
wherein in ligand L_{4271} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4272} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4273} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

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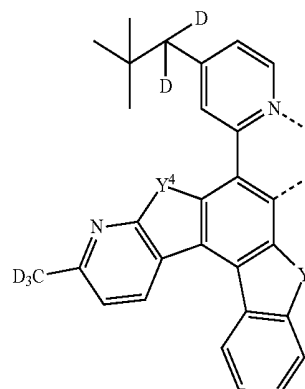
in ligand L_{4274} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4275} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{4276} through L_{4280} , each represented by the formula



wherein in ligand L_{4276} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4277} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4278} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4279} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4280} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{4281} through L_{4285} , each represented by the formula

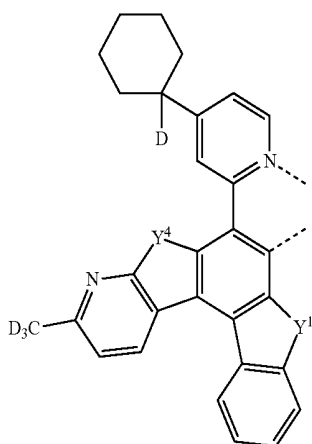
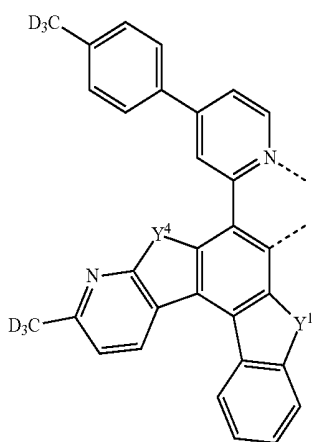


wherein in ligand L_{4281} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4282} , $Y^1 = S$, $Y^4 = S$;
 in ligand L_{4283} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4284} , $Y^1 = O$, $Y^4 = S$;
 in ligand L_{4285} , $Y^1 = S$, $Y^4 = O$;
 Ligand L_{4286} through L_{4290} , each represented by the formula

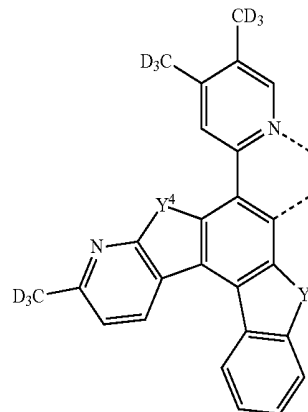
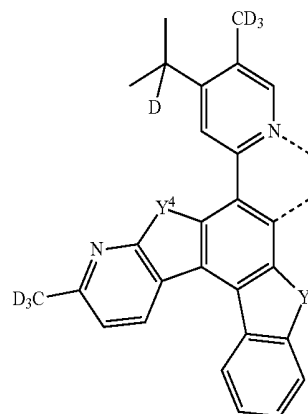
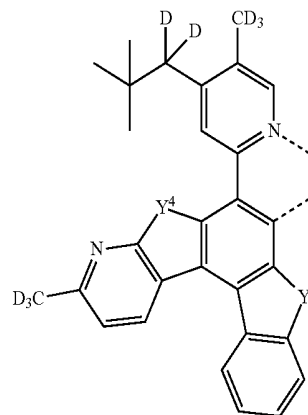


wherein in ligand L_{4286} , $Y^1 = O$, $Y^4 = O$;
 in ligand L_{4287} , $Y^1 = S$, $Y^4 = S$;

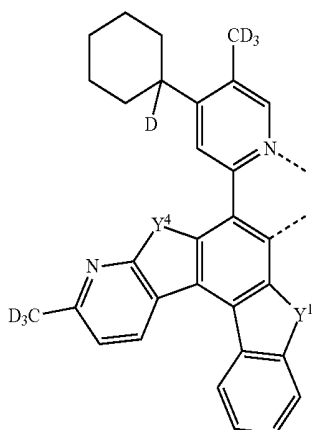
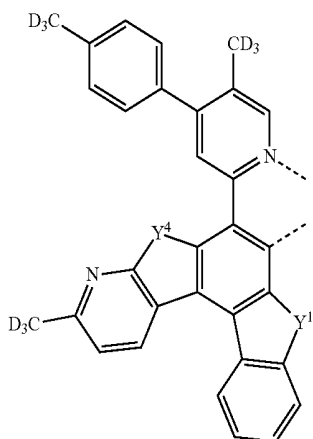
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in ligand L_{4288} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{4289} , $Y^1 = O$, $Y^4 = S$;in ligand L_{4290} , $Y^1 = S$, $Y^4 = O$;Ligand L_{4291} through L_{4295} , each represented by the formulawherein in ligand L_{4291} , $Y^1 = O$, $Y^4 = O$;in ligand L_{4292} , $Y^1 = S$, $Y^4 = S$;in ligand L_{4293} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{4294} , $Y^1 = O$, $Y^4 = S$;in ligand L_{4295} , $Y^1 = S$, $Y^4 = O$;Ligand L_{4296} through L_{4300} , each represented by the formulawherein in ligand L_{4296} , $Y^1 = O$, $Y^4 = O$;in ligand L_{4297} , $Y^1 = S$, $Y^4 = S$;in ligand L_{4298} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{4299} , $Y^1 = O$, $Y^4 = S$;in ligand L_{4300} , $Y^1 = S$, $Y^4 = O$;

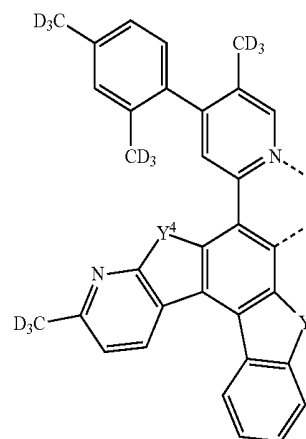
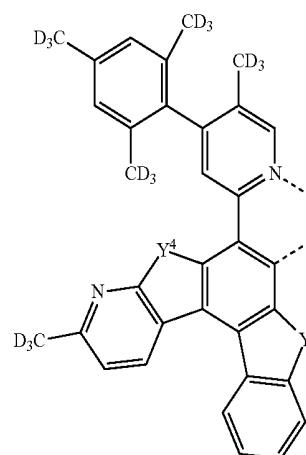
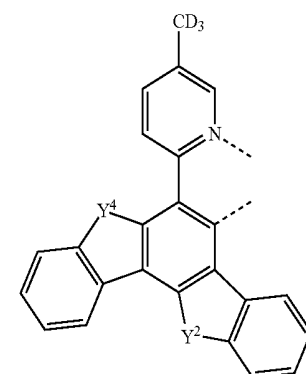
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Ligand L_{4301} through L_{4305} , each represented by the formulawherein in ligand L_{4301} , $Y^1 = O$, $Y^4 = O$;in ligand L_{4302} , $Y^1 = S$, $Y^4 = S$;in ligand L_{4303} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{4304} , $Y^1 = O$, $Y^4 = S$;in ligand L_{4305} , $Y^1 = S$, $Y^4 = O$;Ligand L_{4306} through L_{4310} , each represented by the formulawherein in ligand L_{4306} , $Y^1 = O$, $Y^4 = O$;in ligand L_{4307} , $Y^1 = S$, $Y^4 = S$;in ligand L_{4308} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{4309} , $Y^1 = O$, $Y^4 = S$;in ligand L_{4310} , $Y^1 = S$, $Y^4 = O$;Ligand L_{4311} through L_{4315} , each represented by the formulawherein in ligand L_{4311} , $Y^1 = O$, $Y^4 = O$;in ligand L_{4312} , $Y^1 = S$, $Y^4 = S$;in ligand L_{4313} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

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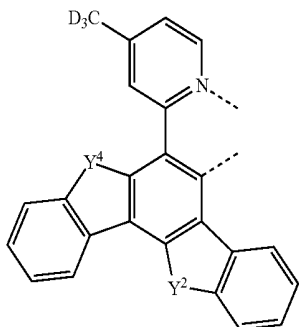
in ligand L_{A314} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A315} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A316} through L_{A320} , each represented by the formulawherein in ligand L_{A316} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A317} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A318} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A319} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A320} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A321} through L_{A325} , each represented by the formulawherein in ligand L_{A321} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A322} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A323} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A324} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A325} , $Y^1 = S$, $Y^4 = O$;

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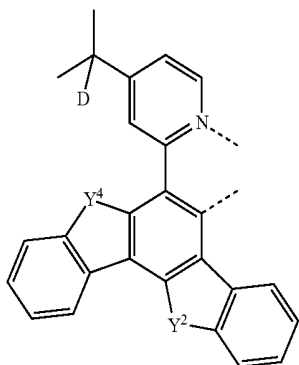
Ligand L_{A326} through L_{A330} , each represented by the formulawherein in ligand L_{A326} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A327} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A328} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A329} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A330} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A331} through L_{A335} , each represented by the formulawherein in ligand L_{A331} , $Y^1 = O$, $Y^4 = O$;in ligand L_{A332} , $Y^1 = S$, $Y^4 = S$;in ligand L_{A333} , $Y^1 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;in ligand L_{A334} , $Y^1 = O$, $Y^4 = S$;in ligand L_{A335} , $Y^1 = S$, $Y^4 = O$;Ligand L_{A336} through L_{A340} , each represented by the formulawherein in ligand L_{A336} , $Y^2 = O$, $Y^4 = O$;in ligand L_{A337} , $Y^2 = S$, $Y^4 = S$;

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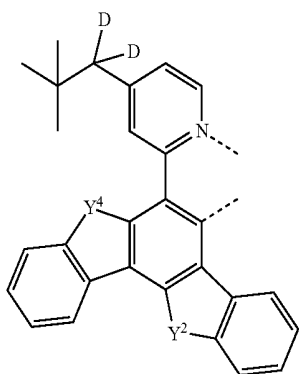
in ligand L_{4338} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4339} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4340} , $Y^2 = S$, $Y^4 = O$;
 Ligand L_{4341} through L_{4345} , each represented by the formula



wherein in ligand L_{4341} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4342} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4343} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4344} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4345} , $Y^2 = S$, $Y^4 = O$;
 Ligand L_{4346} through L_{4350} , each represented by the formula



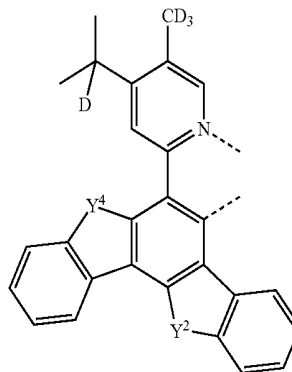
wherein in ligand L_{4346} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4347} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4348} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4349} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4350} , $Y^2 = S$, $Y^4 = O$;
 Ligand L_{4351} through L_{4355} , each represented by the formula



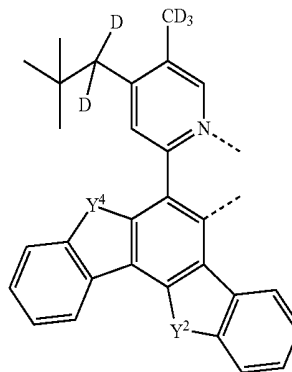
wherein in ligand L_{4351} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4352} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4353} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4354} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4355} , $Y^2 = S$, $Y^4 = O$;

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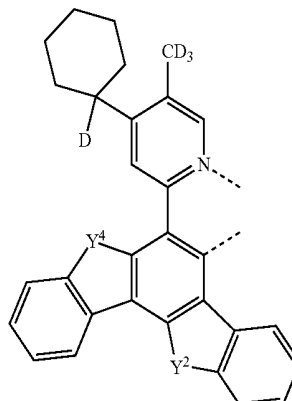
Ligand L_{4356} through L_{4360} , each represented by the formula



wherein in ligand L_{4356} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4357} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4358} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4359} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4360} , $Y^2 = S$, $Y^4 = O$;
 Ligand L_{4361} through L_{4365} , each represented by the formula

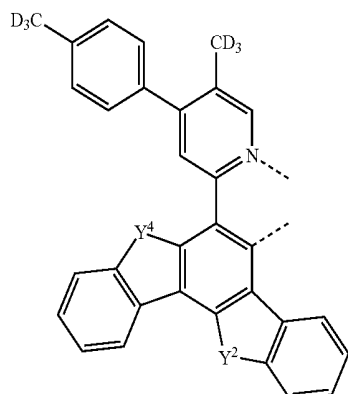


wherein in ligand L_{4361} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4362} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4363} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4364} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4365} , $Y^2 = S$, $Y^4 = O$;
 Ligand L_{4366} through L_{4370} , each represented by the formula

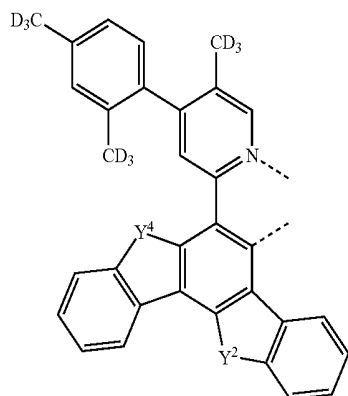


wherein in ligand L_{4366} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4367} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4368} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4369} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4370} , $Y^2 = S$, $Y^4 = O$;

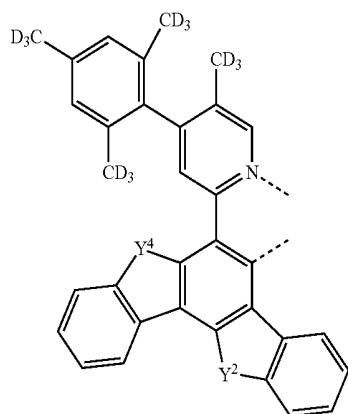
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Ligand L_{4371} through L_{4375} , each represented by the formula

wherein in ligand L_{4371} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4372} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4373} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4374} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4375} , $Y^2 = S$, $Y^4 = O$;

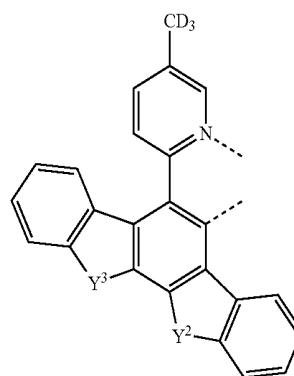
Ligand L_{4376} through L_{4380} , each represented by the formula

wherein in ligand L_{4376} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4377} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4378} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4379} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4380} , $Y^2 = S$, $Y^4 = O$;

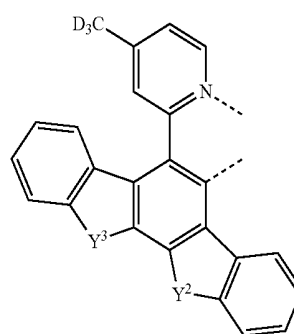
Ligand L_{4381} through L_{4385} , each represented by the formula

wherein in ligand L_{4381} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4382} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4383} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4384} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4385} , $Y^2 = S$, $Y^4 = O$;

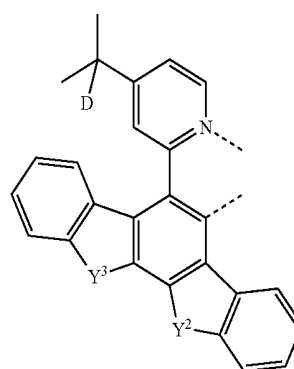
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Ligand L_{4386} through L_{4390} , each represented by the formula

wherein in ligand L_{4386} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4387} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4388} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4389} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4390} , $Y^2 = S$, $Y^4 = O$;

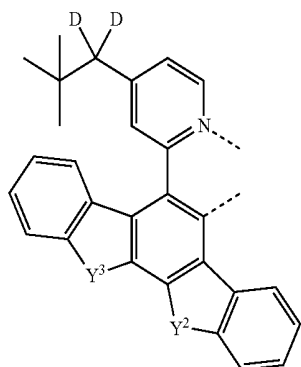
Ligand L_{4391} through L_{4395} , each represented by the formula

wherein in ligand L_{4391} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4392} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4393} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4394} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4395} , $Y^2 = S$, $Y^4 = O$;

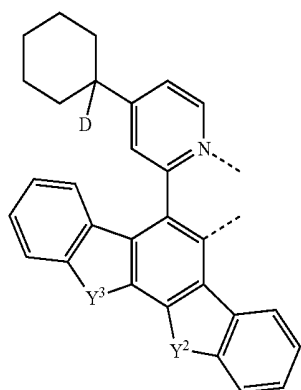
Ligand L_{4396} through L_{4400} , each represented by the formula

wherein in ligand L_{4396} , $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4397} , $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4398} , $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 in ligand L_{4399} , $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4400} , $Y^2 = S$, $Y^4 = O$;

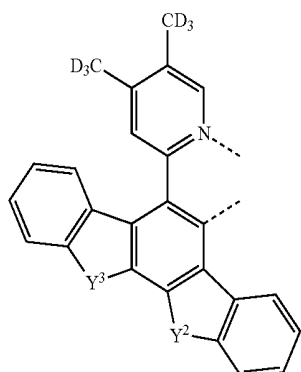
-continued

Ligand L₄₄₀₁ through L₄₄₀₅, each represented by the formula

wherein in ligand L₄₄₀₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₀₂, Y² = S, Y⁴ = S;
 in ligand L₄₄₀₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₀₄, Y² = O, Y⁴ = S;
 in ligand L₄₄₀₅, Y² = S, Y⁴ = O;

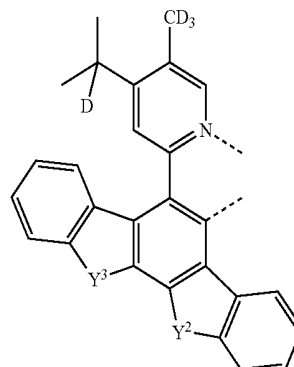
Ligand L₄₄₀₆ through L₄₄₁₀, each represented by the formula

wherein in ligand L₄₄₀₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₀₇, Y² = S, Y⁴ = S;
 in ligand L₄₄₀₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₀₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₁₀, Y² = S, Y⁴ = O;

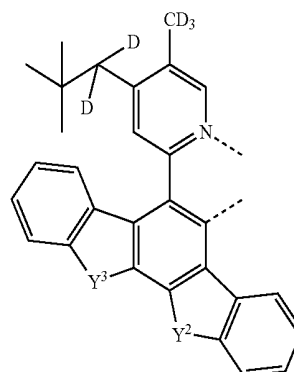
Ligand L₄₄₁₁ through L₄₄₁₅, each represented by the formula

wherein in ligand L₄₄₁₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₁₂, Y² = S, Y⁴ = S;
 in ligand L₄₄₁₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₁₄, Y² = O, Y⁴ = S;
 in ligand L₄₄₁₅, Y² = S, Y⁴ = O;

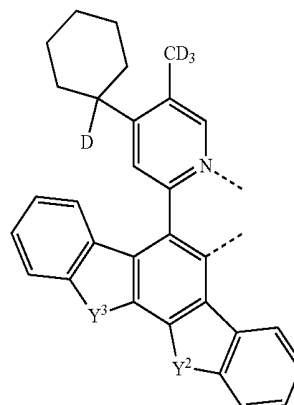
-continued

Ligand L₄₄₁₆ through L₄₄₂₀, each represented by the formula

wherein in ligand L₄₄₁₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₁₇, Y² = S, Y⁴ = S;
 in ligand L₄₄₁₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₁₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₂₀, Y² = S, Y⁴ = O;

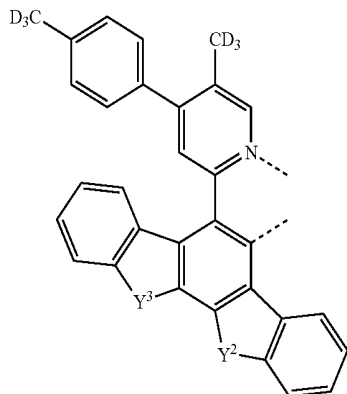
Ligand L₄₄₁₆ through L₄₄₂₀, each represented by the formula

wherein in ligand L₄₄₁₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₁₇, Y² = S, Y⁴ = S;
 in ligand L₄₄₁₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₁₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₂₀, Y² = S, Y⁴ = O;

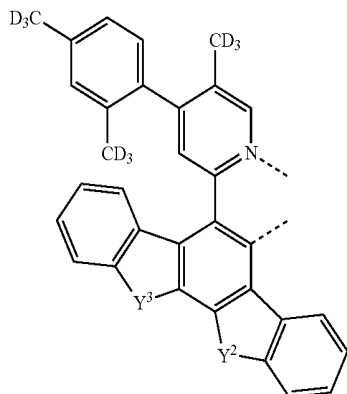
Ligand L₄₄₂₁ through L₄₄₂₅, each represented by the formula

wherein in ligand L₄₄₂₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₂₂, Y² = S, Y⁴ = S;
 in ligand L₄₄₂₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₂₄, Y² = O, Y⁴ = S;
 in ligand L₄₄₂₅, Y² = S, Y⁴ = O;

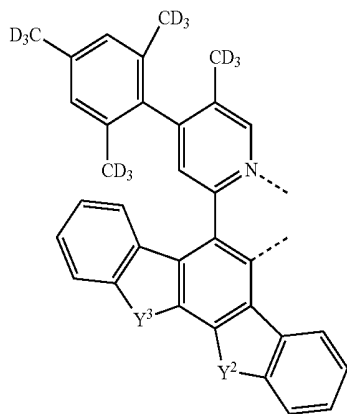
-continued

Ligand L₄₄₂₆ through L₄₄₃₀, each represented by the formula

wherein in ligand L₄₄₂₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₂₇, Y² = S, Y⁴ = S;
 in ligand L₄₄₂₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₂₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₃₀, Y² = S, Y⁴ = O;

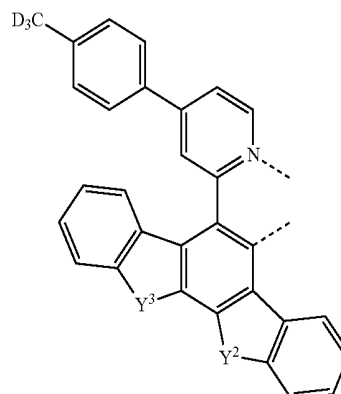
Ligand L₄₄₃₁ through L₄₄₃₅, each represented by the formula

wherein in ligand L₄₄₃₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₃₂, Y² = S, Y⁴ = S;
 in ligand L₄₄₃₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₃₄, Y² = O, Y⁴ = S;
 in ligand L₄₄₃₅, Y² = S, Y⁴ = O;

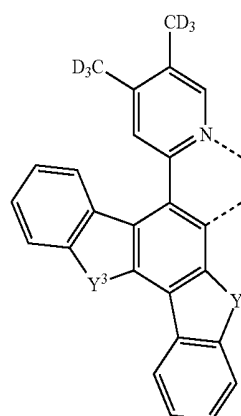
Ligand L₄₄₃₆ through L₄₄₄₀, each represented by the formula

wherein in ligand L₄₄₃₆, Y² = O, Y⁴ = O;
 in ligand L₄₄₃₇, Y² = S, Y⁴ = S;
 in ligand L₄₄₃₈, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₃₉, Y² = O, Y⁴ = S;
 in ligand L₄₄₄₀, Y² = S, Y⁴ = O;

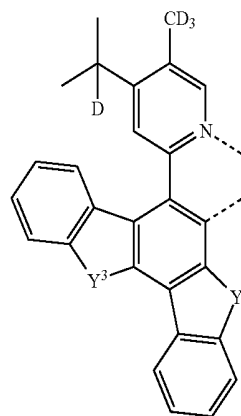
-continued

Ligand L₄₄₄₁ through L₄₄₄₅, each represented by the formula

wherein in ligand L₄₄₄₁, Y² = O, Y⁴ = O;
 in ligand L₄₄₄₂, Y² = S, Y⁴ = S;
 in ligand L₄₄₄₃, Y² = C(CH₃)₂, Y⁴ = C(CH₃)₂;
 in ligand L₄₄₄₄, Y² = O, Y⁴ = S;
 in ligand L₄₄₄₅, Y² = S, Y⁴ = O;

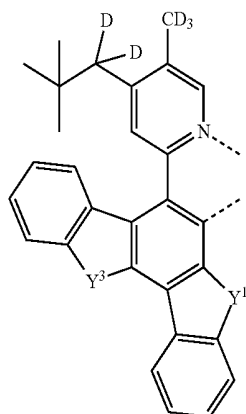
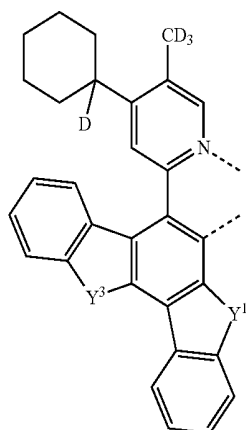
Ligand L₄₄₄₆ through L₄₄₅₀, each represented by the formula

wherein in ligand L₄₄₄₆, Y¹ = O, Y³ = O;
 in ligand L₄₄₄₇, Y¹ = S, Y³ = S;
 in ligand L₄₄₄₈, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;
 in ligand L₄₄₄₉, Y¹ = O, Y³ = S;
 in ligand L₄₄₅₀, Y¹ = S, Y³ = O;

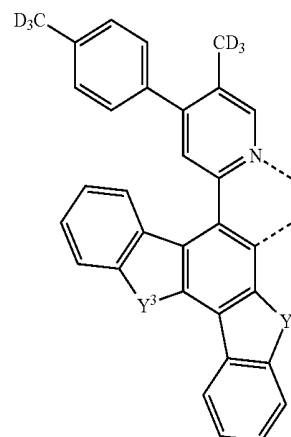
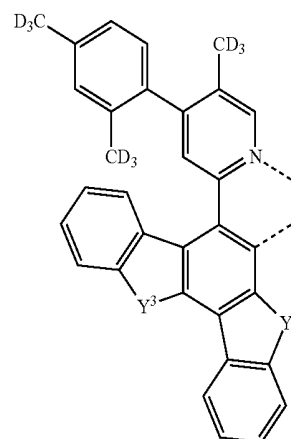
Ligand L₄₄₅₁ through L₄₄₅₅, each represented by the formula

wherein in ligand L₄₄₅₁, Y¹ = O, Y³ = O;
 in ligand L₄₄₅₂, Y¹ = S, Y³ = S;
 in ligand L₄₄₅₃, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;

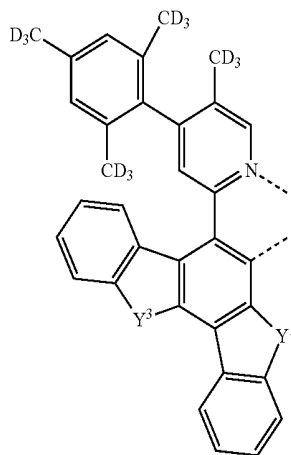
-continued

in ligand L_{4454} , $Y^1 = O$, $Y^3 = S$;in ligand L_{4455} , $Y^1 = S$, $Y^3 = O$;Ligand L_{4456} through L_{4460} , each represented by the formulawherein in ligand L_{4456} , $Y^1 = O$, $Y^3 = O$;in ligand L_{4457} , $Y^1 = S$, $Y^3 = S$;in ligand L_{4458} , $Y^1 = C(CH_3)_2$, $Y^3 = C(CH_3)_2$;in ligand L_{4459} , $Y^1 = O$, $Y^3 = S$;in ligand L_{4460} , $Y^1 = S$, $Y^3 = O$;Ligand L_{4461} through L_{4465} , each represented by the formulawherein in ligand L_{4461} , $Y^1 = O$, $Y^3 = O$;in ligand L_{4462} , $Y^1 = S$, $Y^3 = S$;in ligand L_{4463} , $Y^1 = C(CH_3)_2$, $Y^3 = C(CH_3)_2$;in ligand L_{4464} , $Y^1 = O$, $Y^3 = S$;in ligand L_{4465} , $Y^1 = S$, $Y^3 = O$;

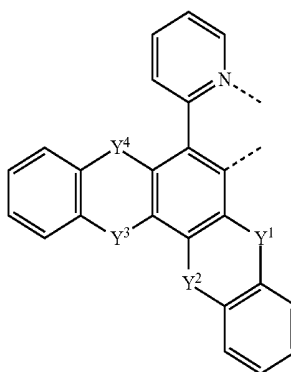
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Ligand L_{4466} through L_{4470} , each represented by the formulawherein in ligand L_{4466} , $Y^1 = O$, $Y^3 = O$;in ligand L_{4467} , $Y^1 = S$, $Y^3 = S$;in ligand L_{4468} , $Y^1 = C(CH_3)_2$, $Y^3 = C(CH_3)_2$;in ligand L_{4469} , $Y^1 = O$, $Y^3 = S$;in ligand L_{4470} , $Y^1 = S$, $Y^3 = O$;Ligand L_{4471} through L_{4475} , each represented by the formulawherein in ligand L_{4471} , $Y^1 = O$, $Y^3 = O$;in ligand L_{4472} , $Y^1 = S$, $Y^3 = S$;in ligand L_{4473} , $Y^1 = C(CH_3)_2$, $Y^3 = C(CH_3)_2$;in ligand L_{4474} , $Y^1 = O$, $Y^3 = S$;in ligand L_{4475} , $Y^1 = S$, $Y^3 = O$;

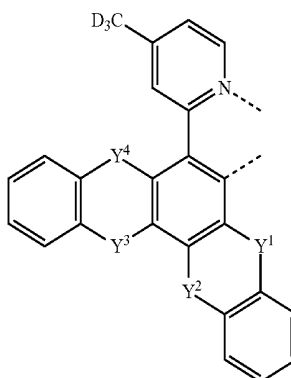
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Ligand L₄₄₇₆ through L₄₄₈₀, each represented by the formula

wherein in ligand L₄₄₇₆, Y¹ = O, Y³ = O;
 in ligand L₄₄₇₇, Y¹ = S, Y³ = S;
 in ligand L₄₄₇₈, Y¹ = C(CH₃)₂, Y³ = C(CH₃)₂;
 in ligand L₄₄₇₉, Y¹ = O, Y³ = S;
 in ligand L₄₄₈₀, Y¹ = S, Y³ = O;

Ligand L₄₄₈₁ through L₄₄₈₅, each represented by the formula

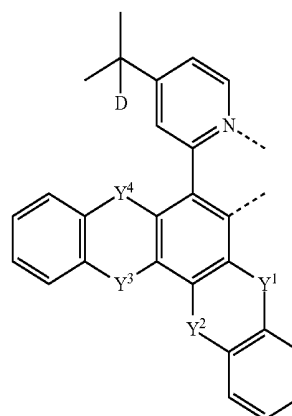
wherein in ligand L₄₄₈₁, Y¹ = O, Y² = O, Y³ = O, Y⁴ = O;
 in ligand L₄₄₈₂, Y¹ = S, Y² = S, Y³ = S, Y⁴ = S;
 in ligand L₄₄₈₃, Y¹ = O, Y² = O, Y³ = S, Y⁴ = S;
 in ligand L₄₄₈₄, Y¹ = O, Y² = S, Y³ = S, Y⁴ = O;
 in ligand L₄₄₈₅, Y¹ = C(CH₃)₂, Y² = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

Ligand L₄₄₈₆ through L₄₄₉₀, each represented by the formula

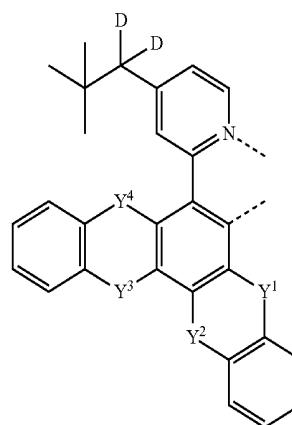
wherein in ligand L₄₄₈₆, Y¹ = O, Y² = O, Y³ = O, Y⁴ = O;
 in ligand L₄₄₈₇, Y¹ = S, Y² = S, Y³ = S, Y⁴ = S;

-continued

in ligand L₄₄₈₈, Y¹ = O, Y² = O, Y³ = S, Y⁴ = S;
 in ligand L₄₄₈₉, Y¹ = O, Y² = S, Y³ = S, Y⁴ = O;
 in ligand L₄₄₉₀, Y¹ = C(CH₃)₂, Y² = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

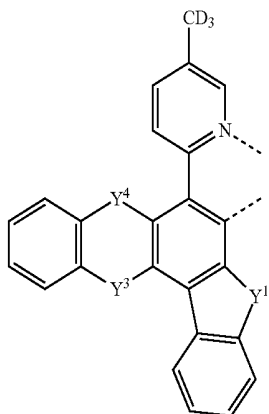
Ligand L₄₄₉₁ through L₄₄₉₅, each represented by the formula

wherein in ligand L₄₄₉₁, Y¹ = O, Y² = O, Y³ = O, Y⁴ = O;
 in ligand L₄₄₉₂, Y¹ = S, Y² = S, Y³ = S, Y⁴ = S;
 in ligand L₄₄₉₃, Y¹ = O, Y² = O, Y³ = S, Y⁴ = S;
 in ligand L₄₄₉₄, Y¹ = O, Y² = S, Y³ = S, Y⁴ = O;
 in ligand L₄₄₉₅, Y¹ = C(CH₃)₂, Y² = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

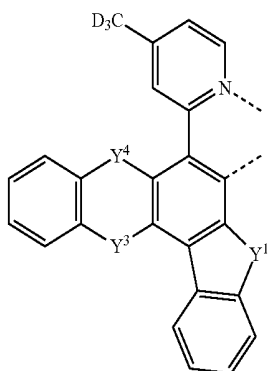
Ligand L₄₄₉₆ through L₄₅₀₀, each represented by the formula

wherein in ligand L₄₄₉₆, Y¹ = O, Y² = O, Y³ = O, Y⁴ = O;
 in ligand L₄₄₉₇, Y¹ = S, Y² = S, Y³ = S, Y⁴ = S;
 in ligand L₄₄₉₈, Y¹ = O, Y² = O, Y³ = S, Y⁴ = S;
 in ligand L₄₄₉₉, Y¹ = O, Y² = S, Y³ = S, Y⁴ = O;
 in ligand L₄₅₀₀, Y¹ = C(CH₃)₂, Y² = C(CH₃)₂, Y³ = C(CH₃)₂, Y⁴ = C(CH₃)₂;

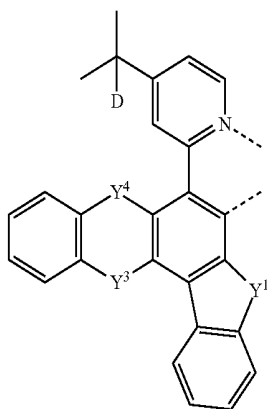
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Ligand L_{4501} through L_{4505} , each represented by the formula

wherein in ligand L_{4501} , $Y^1 = O$, $Y^3 = O$, $Y^4 = O$;
 in ligand L_{4502} , $Y^1 = S$, $Y^3 = S$, $Y^4 = S$;
 in ligand L_{4503} , $Y^1 = O$, $Y^3 = S$, $Y^4 = S$;
 in ligand L_{4504} , $Y^1 = S$, $Y^3 = O$, $Y^4 = O$;
 in ligand L_{4505} , $Y^1 = C(CH_3)_2$, $Y^3 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 Ligand L_{4505} through L_{4510} , each represented by the formula

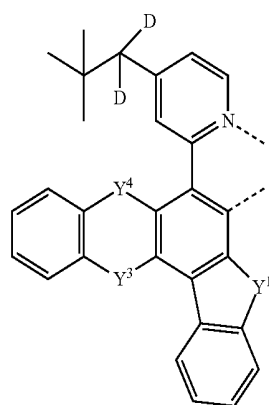


wherein in ligand L_{4505} , $Y^1 = O$, $Y^3 = O$, $Y^4 = O$;
 in ligand L_{4506} , $Y^1 = S$, $Y^3 = S$, $Y^4 = S$;
 in ligand L_{4507} , $Y^1 = O$, $Y^3 = S$, $Y^4 = S$;
 in ligand L_{4508} , $Y^1 = S$, $Y^3 = O$, $Y^4 = O$;
 in ligand L_{4509} , $Y^1 = C(CH_3)_2$, $Y^3 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 Ligand L_{4511} through L_{4515} , each represented by the formula

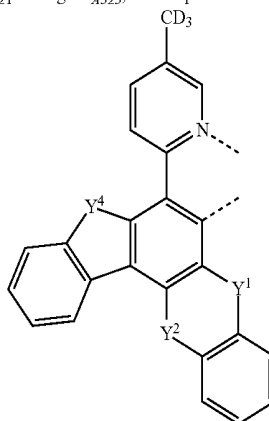


wherein in ligand L_{4511} , $Y^1 = O$, $Y^3 = O$, $Y^4 = O$;
 in ligand L_{4512} , $Y^1 = S$, $Y^3 = S$, $Y^4 = S$;
 in ligand L_{4513} , $Y^1 = O$, $Y^3 = S$, $Y^4 = S$;
 in ligand L_{4514} , $Y^1 = S$, $Y^3 = O$, $Y^4 = O$;
 in ligand L_{4515} , $Y^1 = C(CH_3)_2$, $Y^3 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

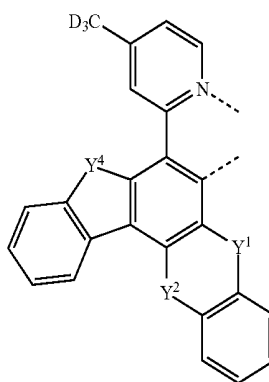
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Ligand L_{4516} through L_{4520} , each represented by the formula

wherein in ligand L_{4516} , $Y^1 = O$, $Y^3 = O$, $Y^4 = O$;
 in ligand L_{4517} , $Y^1 = S$, $Y^3 = S$, $Y^4 = S$;
 in ligand L_{4518} , $Y^1 = O$, $Y^3 = S$, $Y^4 = S$;
 in ligand L_{4519} , $Y^1 = S$, $Y^3 = O$, $Y^4 = O$;
 in ligand L_{4520} , $Y^1 = C(CH_3)_2$, $Y^3 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 Ligand L_{4521} through L_{4525} , each represented by the formula

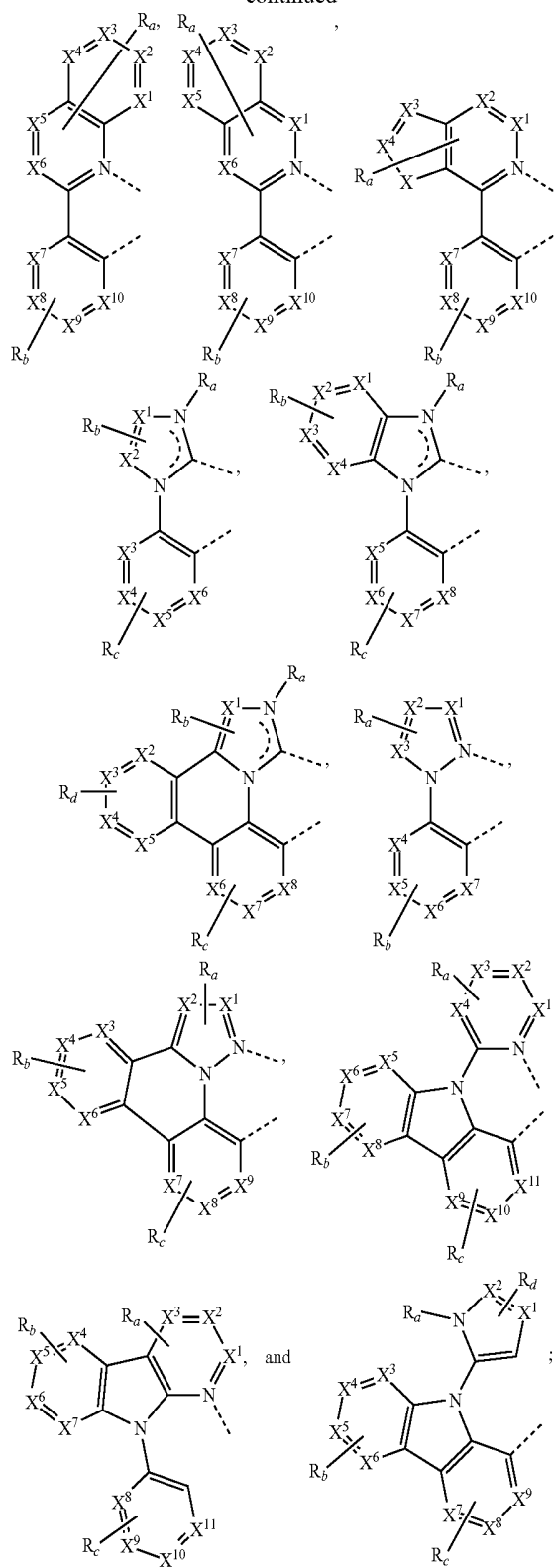


wherein in ligand L_{4521} , $Y^1 = O$, $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4522} , $Y^1 = S$, $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4523} , $Y^1 = O$, $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4524} , $Y^1 = S$, $Y^2 = S$, $Y^4 = O$;
 in ligand L_{4525} , $Y^1 = C(CH_3)_2$, $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;
 Ligand L_{4526} through L_{4530} , each represented by the formula



wherein in ligand L_{4526} , $Y^1 = O$, $Y^2 = O$, $Y^4 = O$;
 in ligand L_{4527} , $Y^1 = S$, $Y^2 = S$, $Y^4 = S$;
 in ligand L_{4528} , $Y^1 = O$, $Y^2 = O$, $Y^4 = S$;
 in ligand L_{4529} , $Y^1 = S$, $Y^2 = S$, $Y^4 = O$;
 in ligand L_{4530} , $Y^1 = C(CH_3)_2$, $Y^2 = C(CH_3)_2$, $Y^4 = C(CH_3)_2$;

-continued



wherein each X^1 to X^{13} are independently selected from the group consisting of carbon and nitrogen;

wherein X is selected from the group consisting of $BR', NR', PR', O, S, Se, C=O, S=O, SO_2, CR'R'', SiR'R''$, and $GeR'R''$;

wherein R' and R'' are optionally fused or joined to form a ring;

wherein each R_a, R_b, R_c , and R_d may represent from mono substitution to the possible maximum number of substitution, or no substitution;

wherein R', R'', R_a, R_b, R_c , and R_d are each independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof; and

wherein any two adjacent substituents of R_a, R_b, R_c , and R_d are optionally fused or joined to form a ring or form a multidentate ligand.

17. The compound of claim 14, wherein:

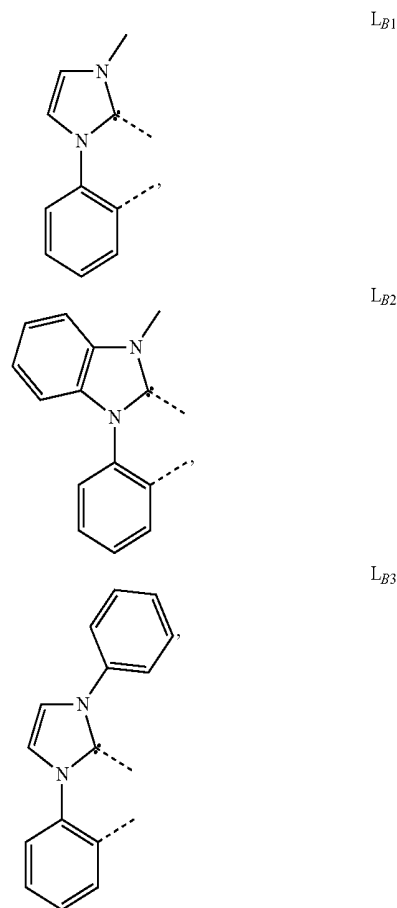
(i) the compound is selected from Compound A1 through Compound A544, wherein Compound Ax has the formula $Ir(L_{Ai})_3$;

wherein $x=i$; and i is an integer from 1 to 544, or

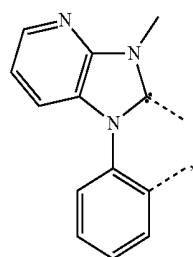
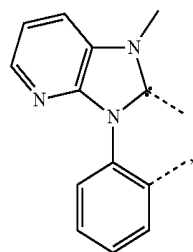
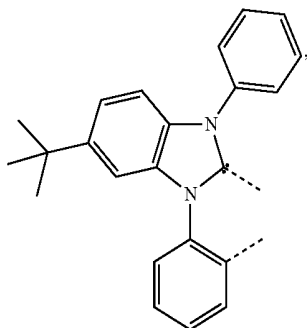
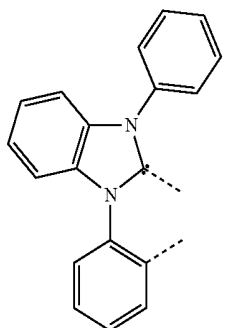
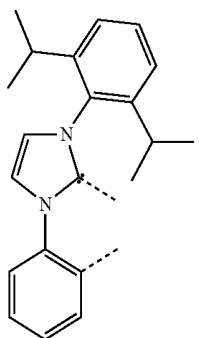
(ii) the compound is selected from Compound B1 through Compound B254592, wherein Compound By has the formula $Ir(L_{Aj})(L_{Bk})_2$;

wherein $y=468j+k-468$; j is an integer from 1 to 544, and k is an integer from 1 to 468; and

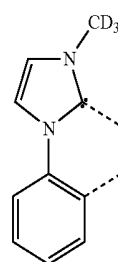
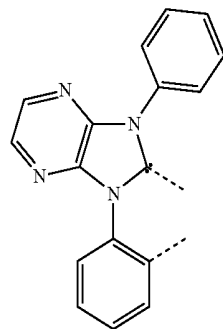
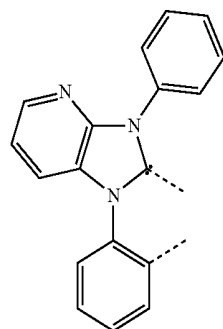
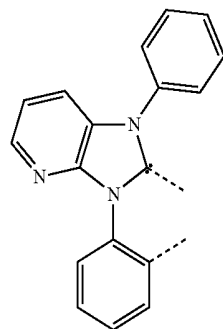
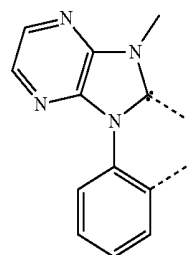
wherein L_{B1} to L_{B468} have the following structures:



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L_{B4}

L_{B9}

L_{B5}

L_{B10}

L_{B6}

L_{B11}

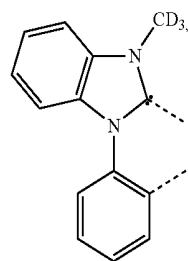
L_{B7}

L_{B12}

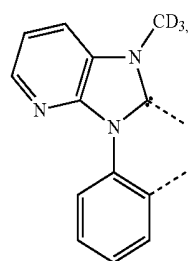
L_{B8}

L_{B13}

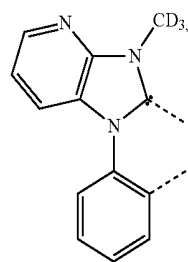
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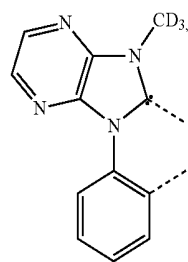
L_{B14}



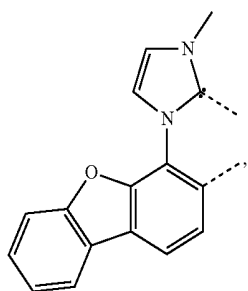
L_{B15}



L_{B16}

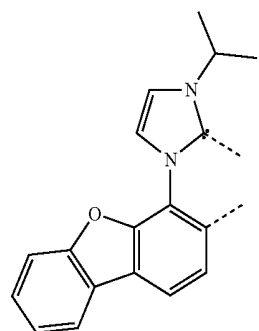


L_{B17}

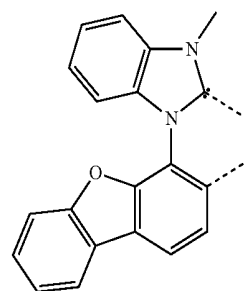


L_{B18}

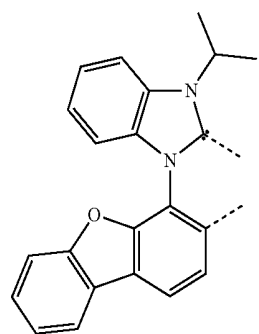
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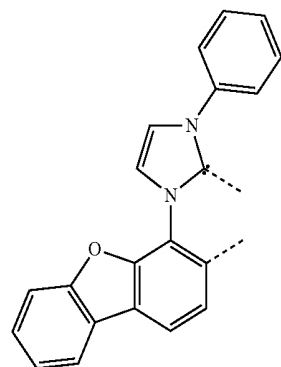
L_{B19}



L_{B20}

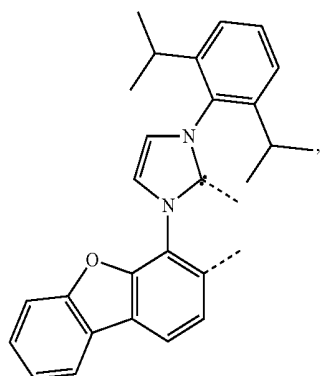


L_{B21}

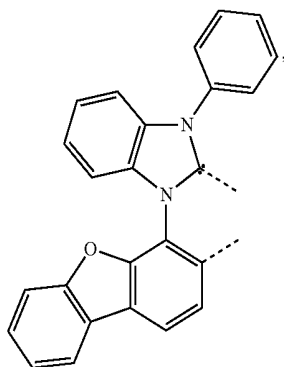


L_{B22}

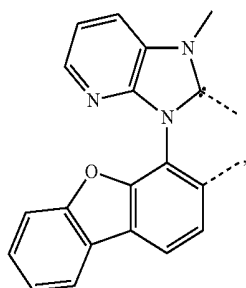
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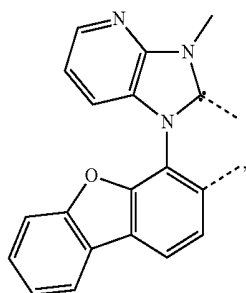
L_{B23}



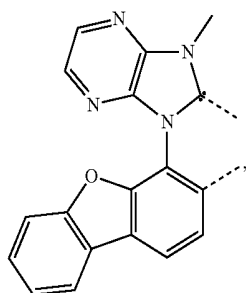
L_{B24}



L_{B25}

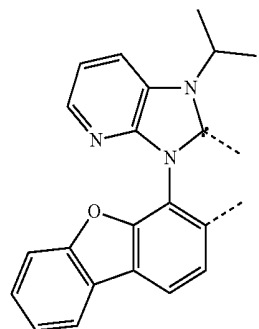


L_{B26}

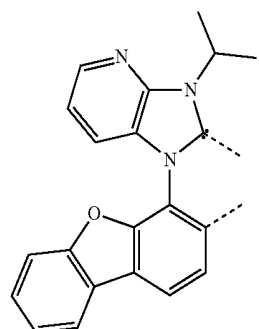


L_{B27}

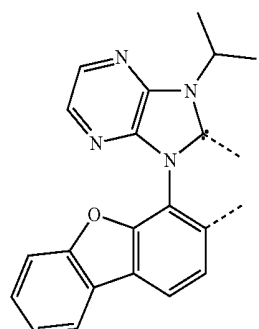
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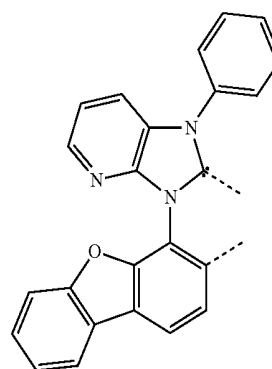
L_{B28}



L_{B29}

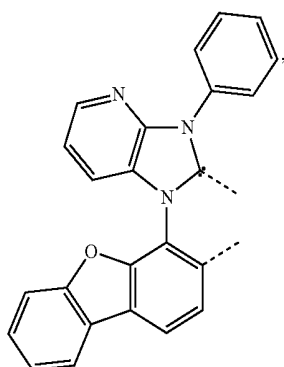


L_{B30}

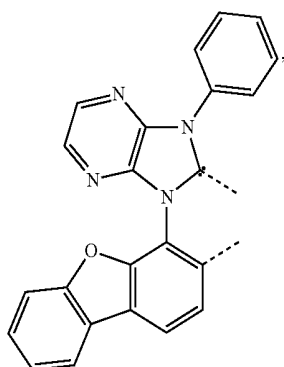


L_{B31}

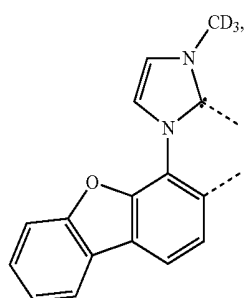
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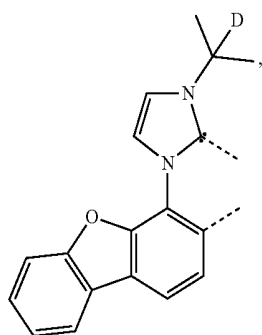
L_{B32}



L_{B33}

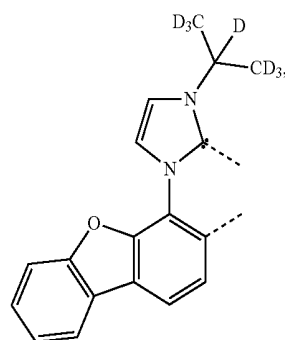


L_{B34}

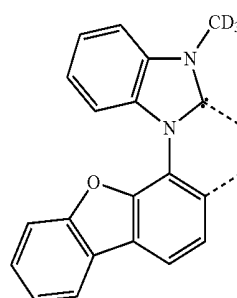


L_{B35}

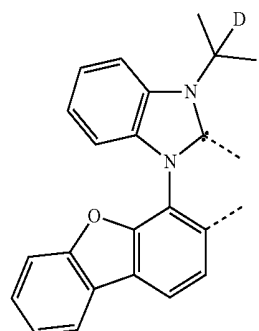
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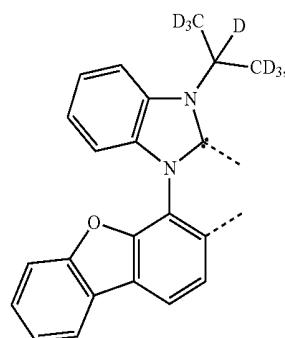
L_{B36}



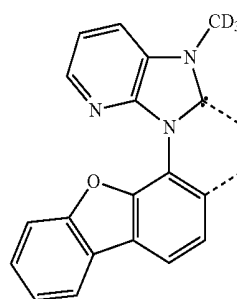
L_{B37}



L_{B38}

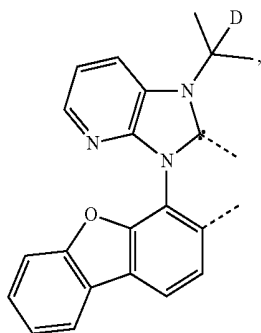


L_{B39}

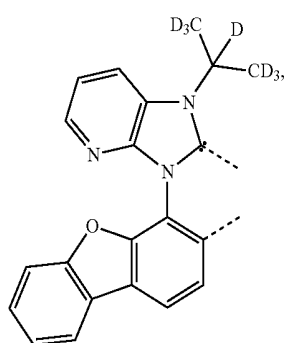


L_{B40}

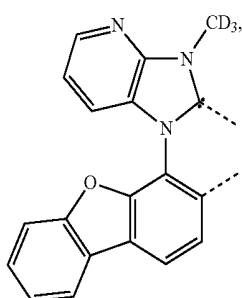
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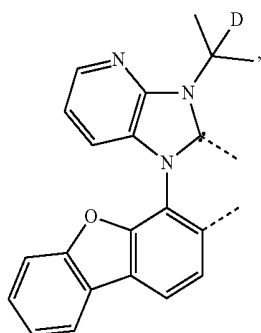
L_{B41}



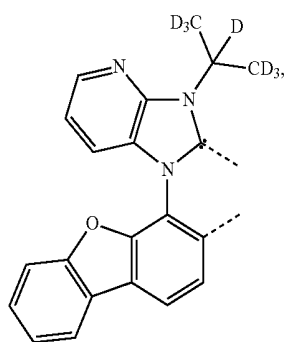
L_{B42}



L_{B43}

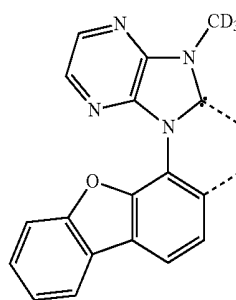


L_{B44}

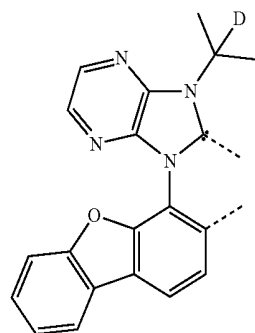


L_{B45}

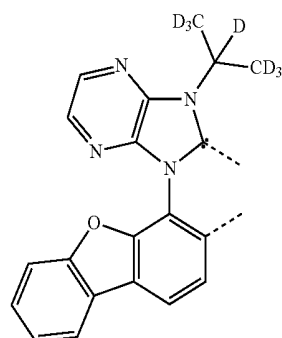
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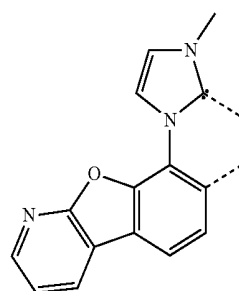
L_{B46}



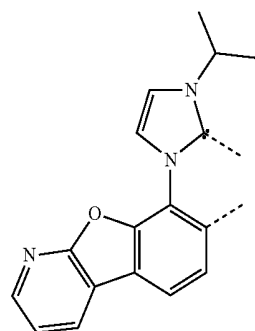
L_{B47}



L_{B48}

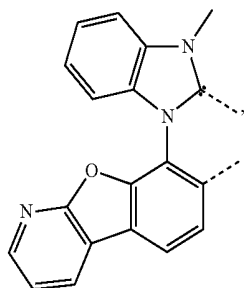


L_{B49}

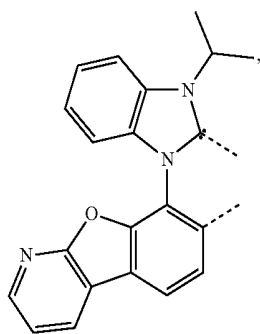


L_{B50}

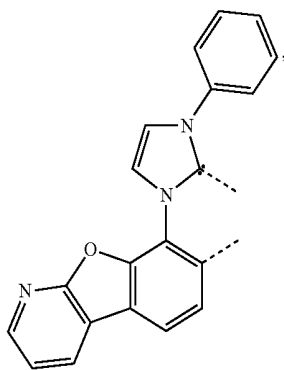
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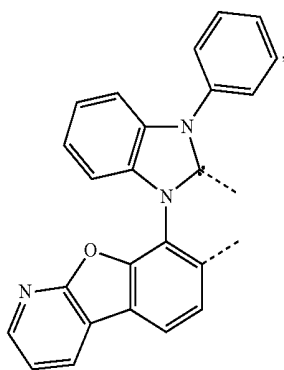
L_{B51}



L_{B52}

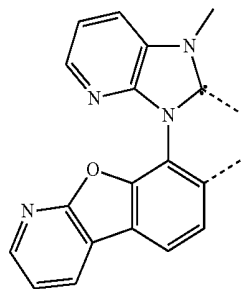


L_{B53}

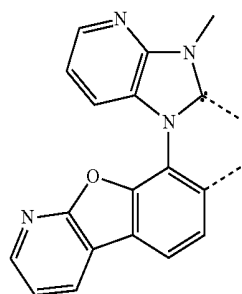


L_{B54}

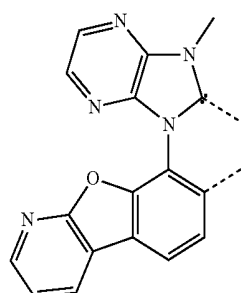
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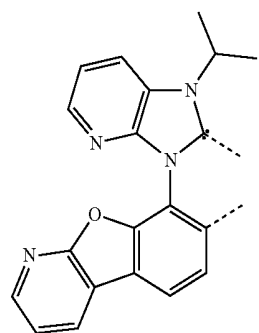
L_{B55}



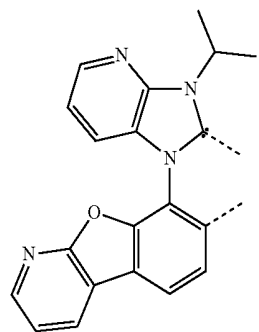
L_{B56}



L_{B57}

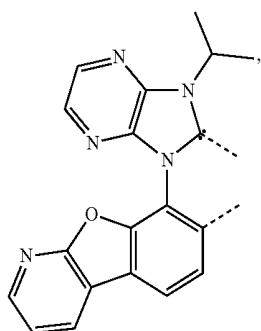


L_{B58}

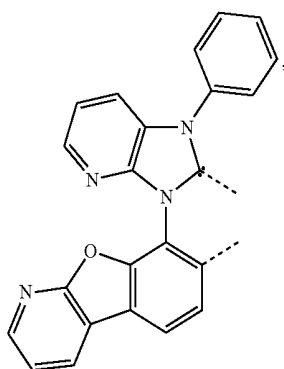


L_{B59}

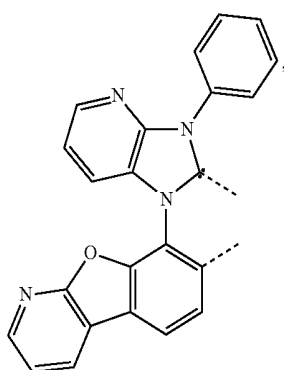
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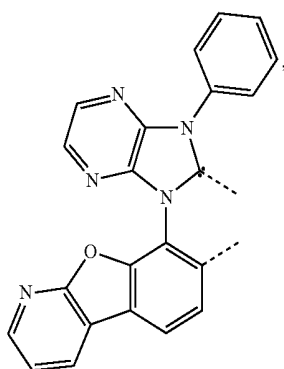
L_{B60}



L_{B61}

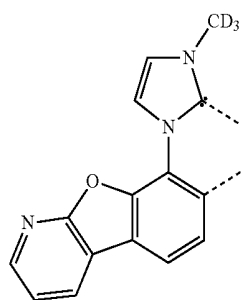


L_{B62}

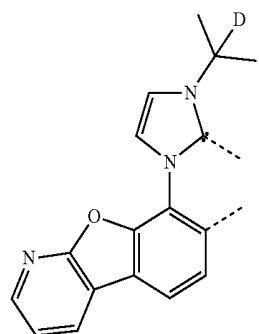


L_{B63}

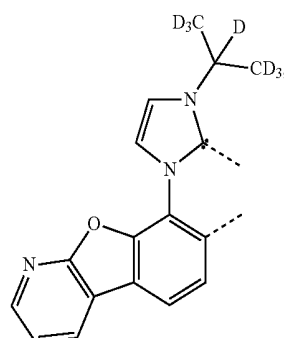
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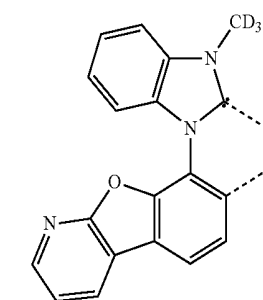
L_{B64}



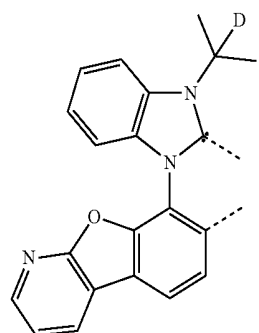
L_{B65}



L_{B66}

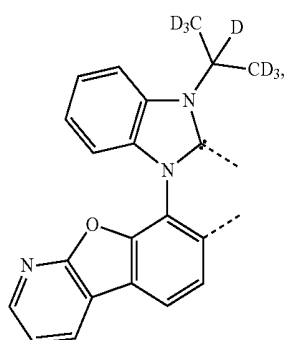
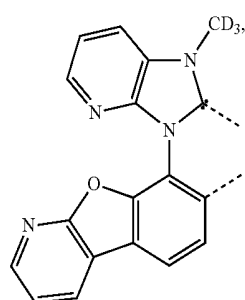
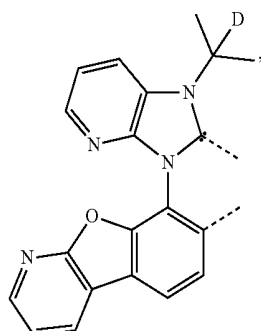
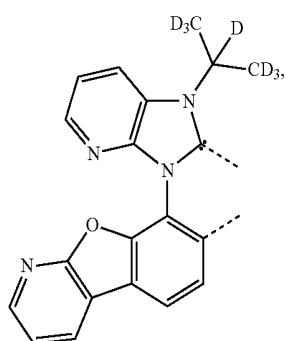
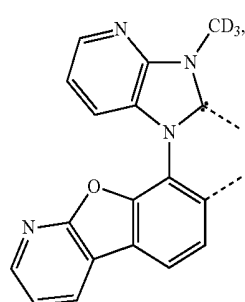


L_{B67}

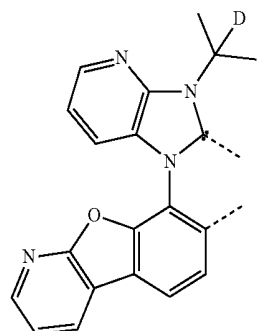
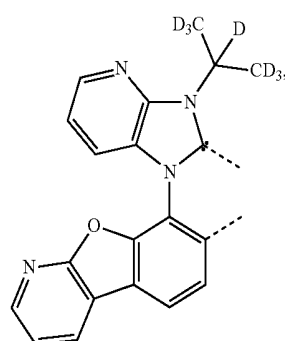
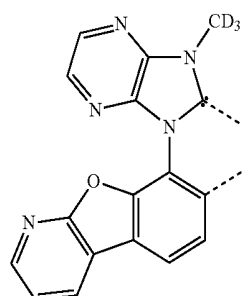
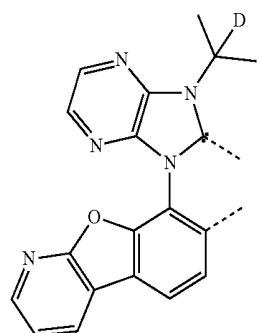
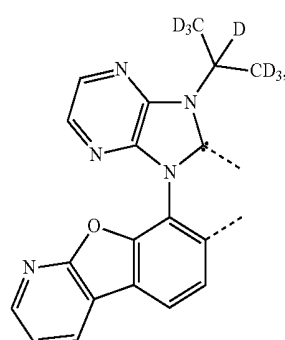


L_{B68}

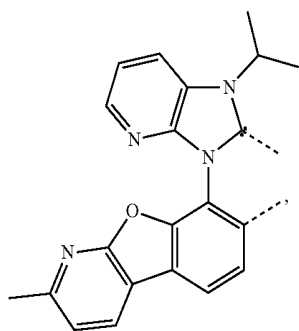
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L_{B69}L_{B70}L_{B71}L_{B72}L_{B73}

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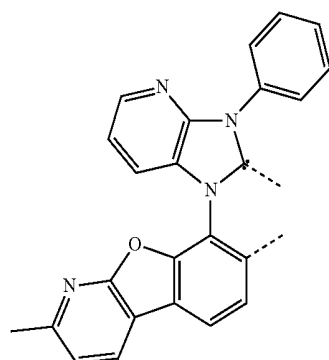
L_{B74}L_{B75}L_{B76}L_{B77}L_{B78}

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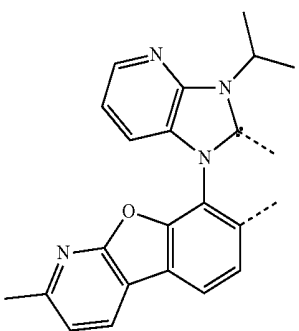


L_{B89}

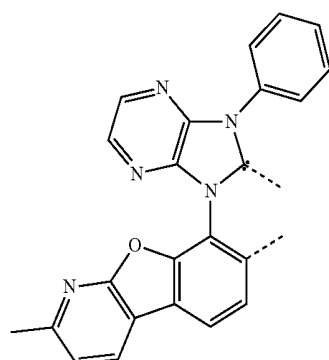
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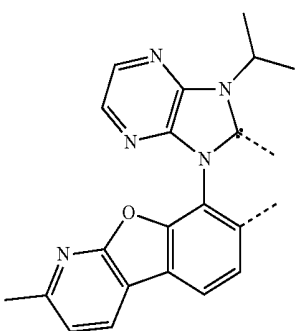
L_{B93}



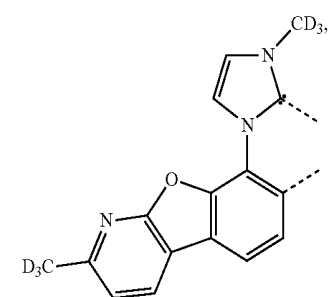
L_{B90}



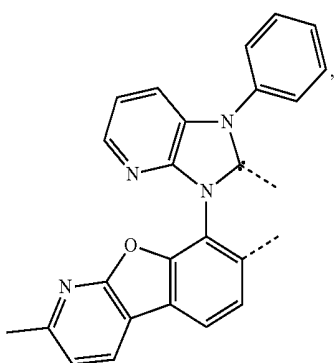
L_{B94}



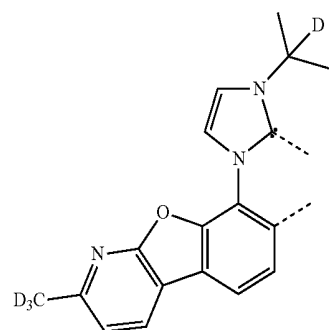
L_{B91}



L_{B95}

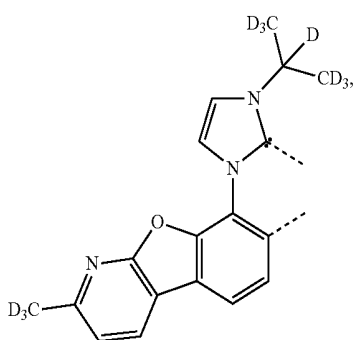


L_{B92}



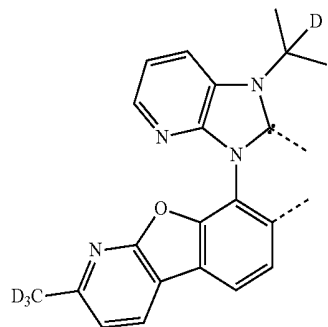
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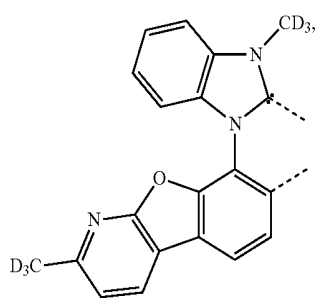


L_{B97}

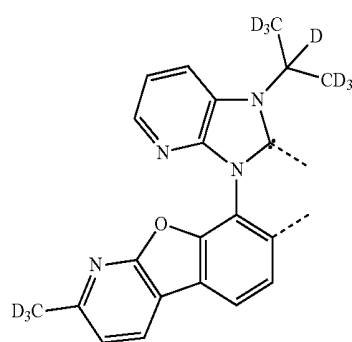
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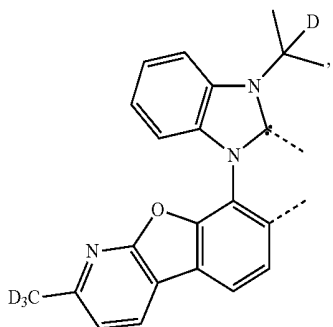
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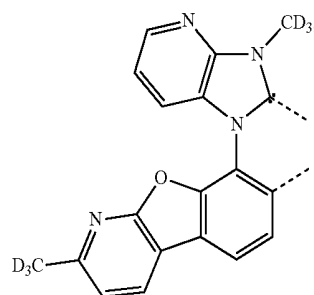
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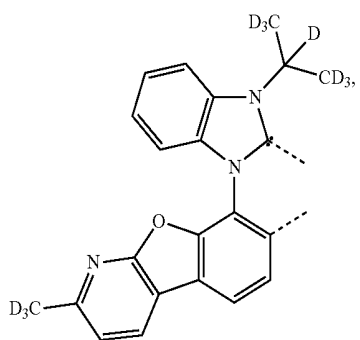
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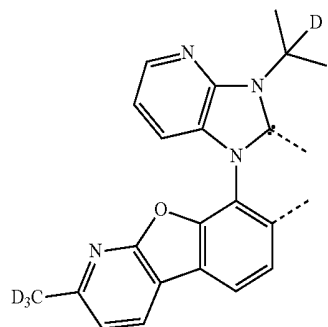
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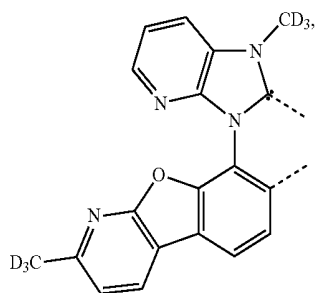
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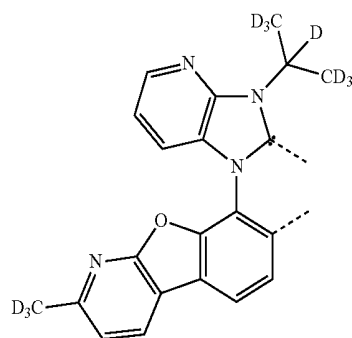
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L_{B105}

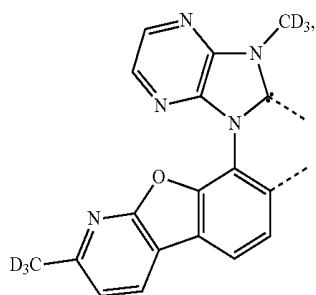


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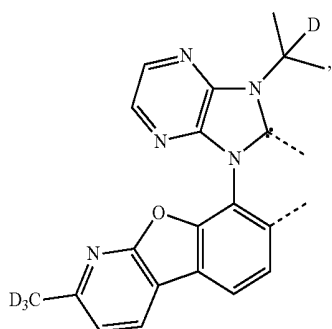


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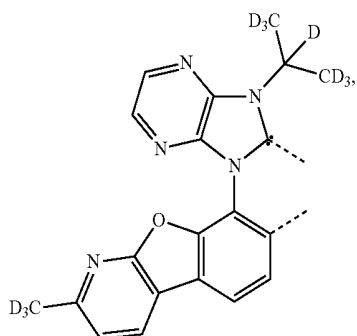
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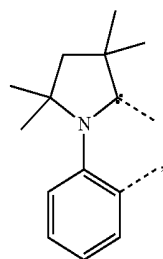
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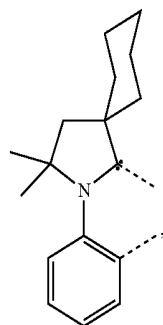
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LB109

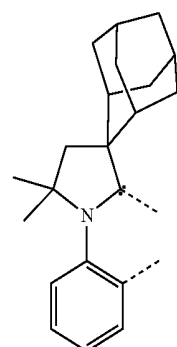


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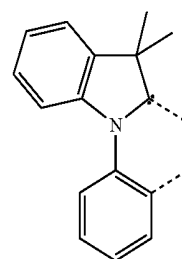


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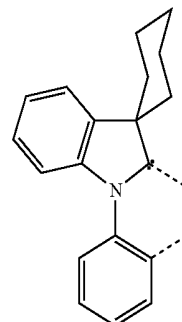
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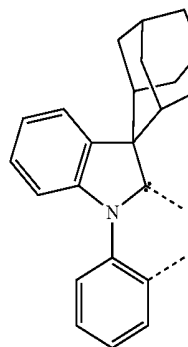
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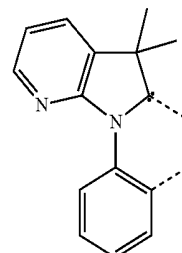
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LB114

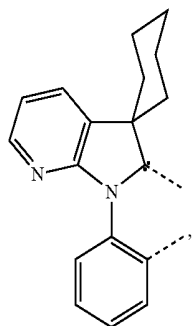


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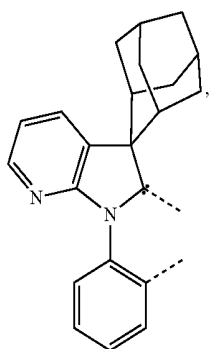


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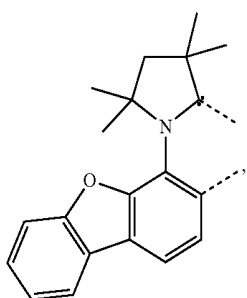
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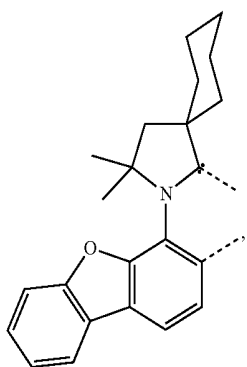
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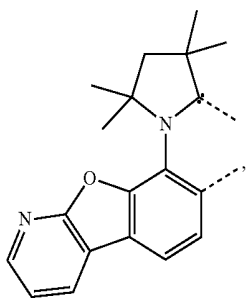
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LB119

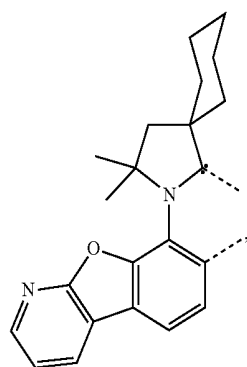


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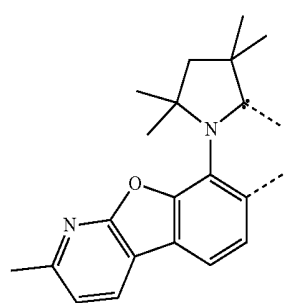


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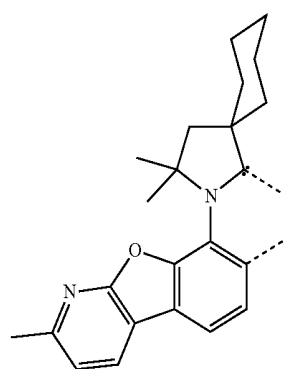
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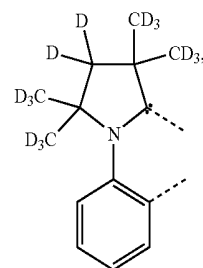
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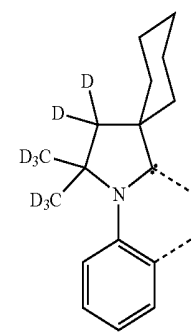
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LB124

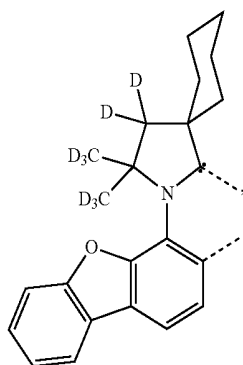
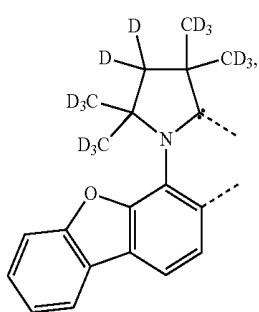
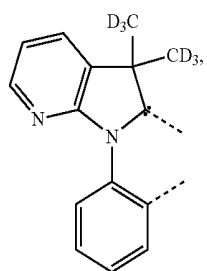
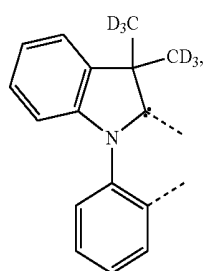
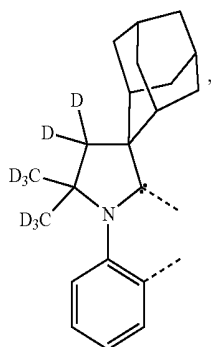


LB125



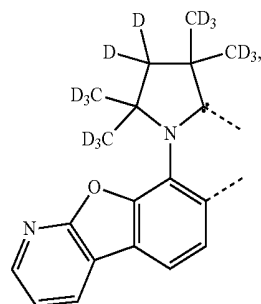
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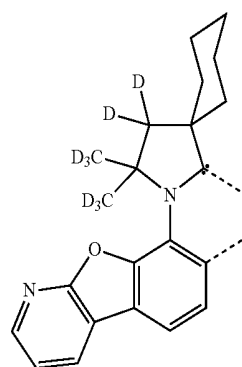
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L_{B127}



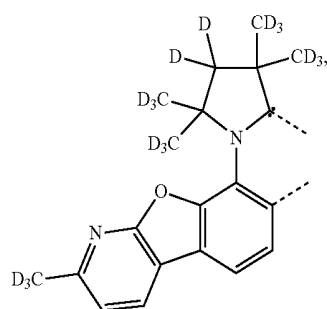
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L_{B128}



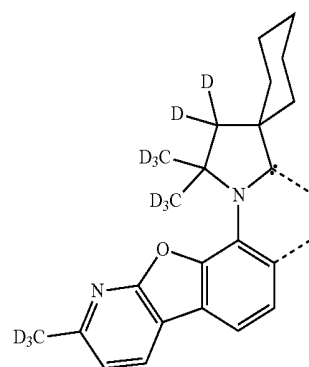
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L_{B129}



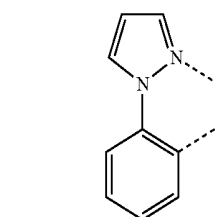
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L_{B130}



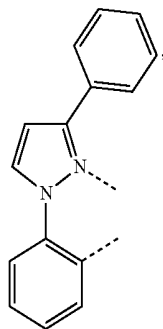
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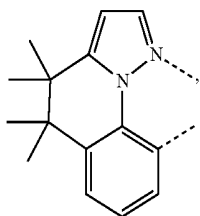


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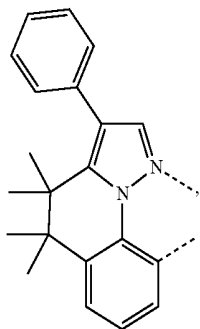
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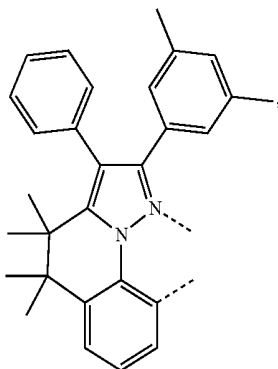
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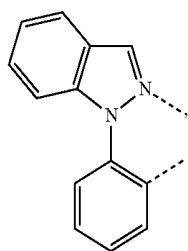
LB138



LB139

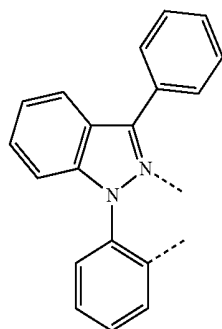


LB140

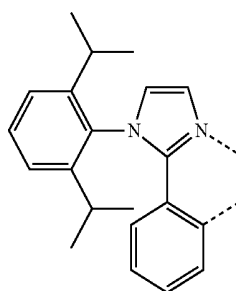


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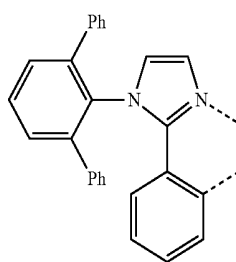
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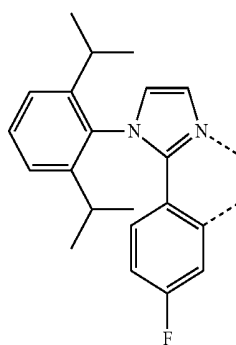
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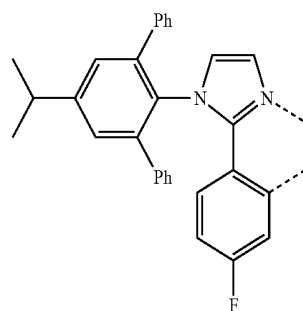
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LB144

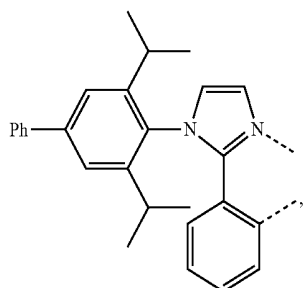


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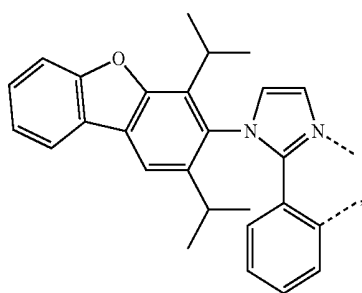


LB146

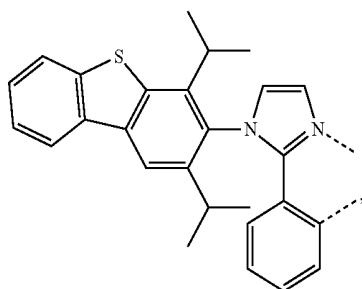
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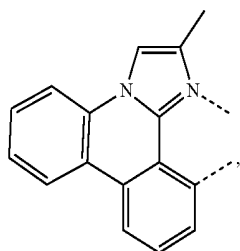
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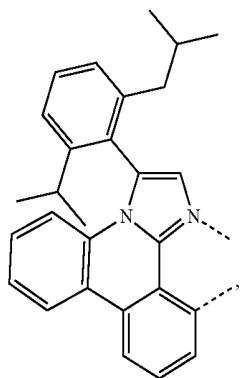
LB148



LB149

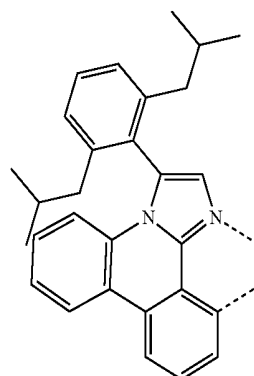


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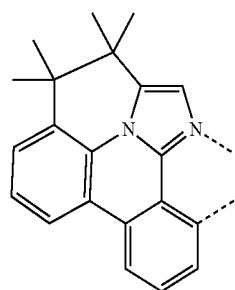


LB151

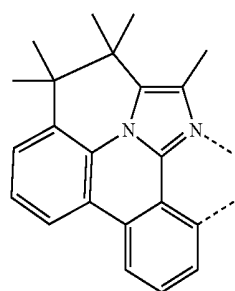
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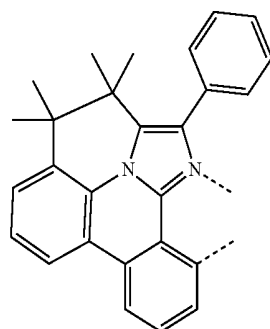
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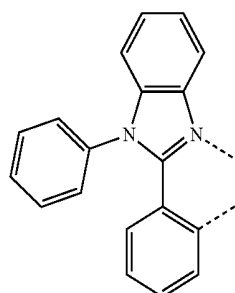
LB153



LB154

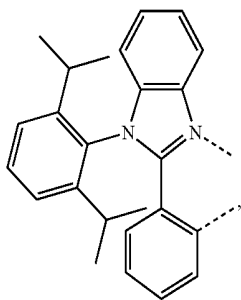


LB155

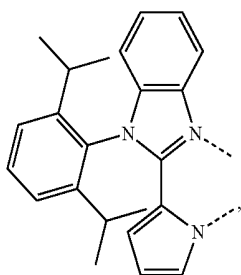


LB156

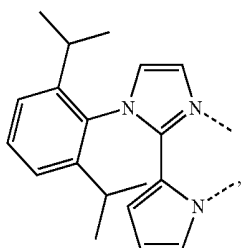
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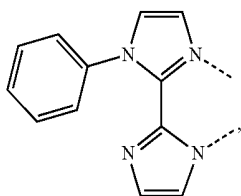
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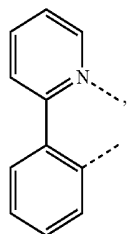
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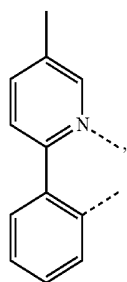
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L_{B160}

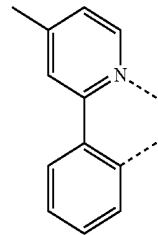


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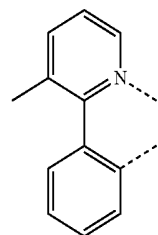


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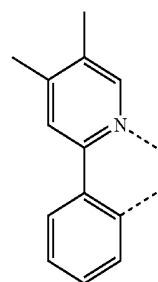
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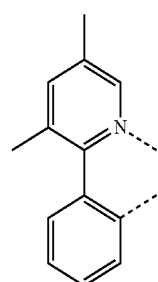
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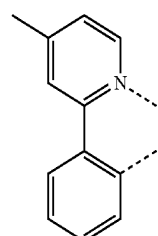
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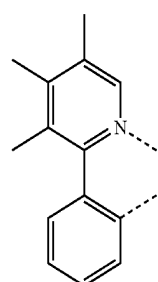
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L_{B166}

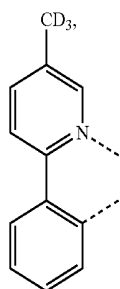
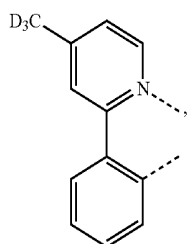
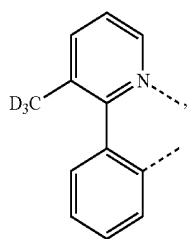
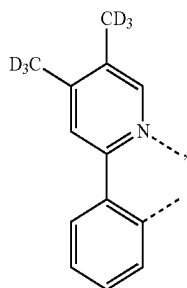
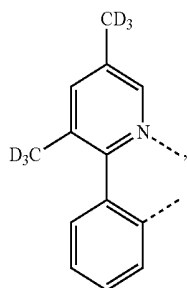
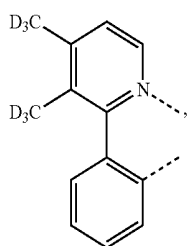


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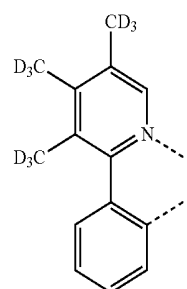
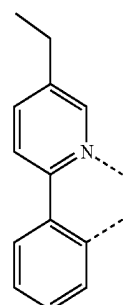
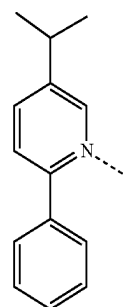
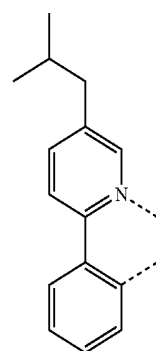
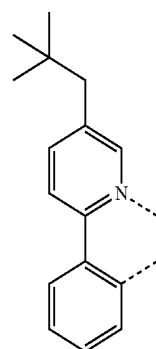


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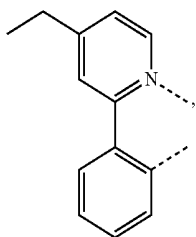
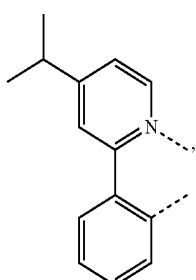
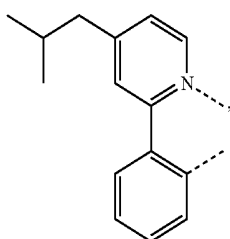
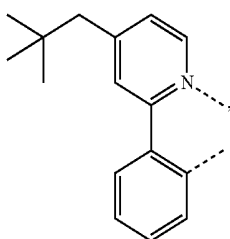
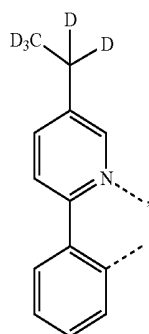
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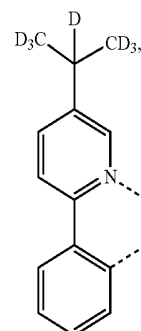
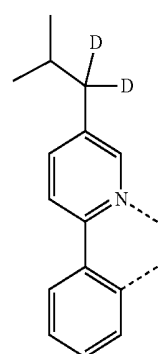
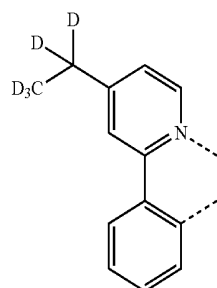
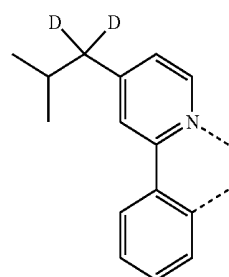
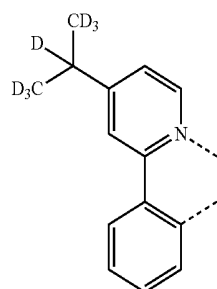
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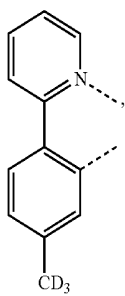
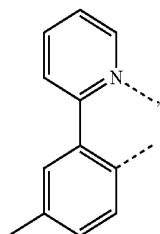
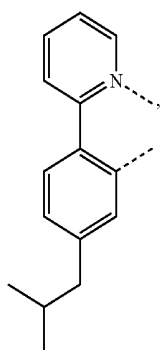
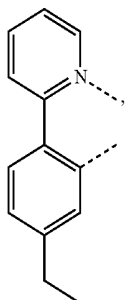
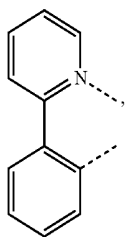
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L_{B190}

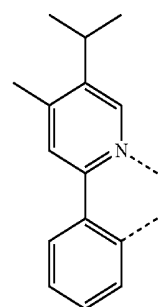
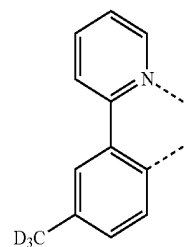
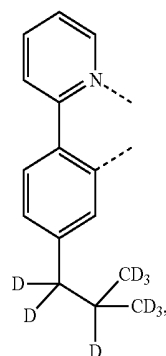
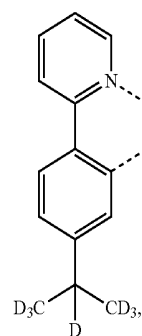
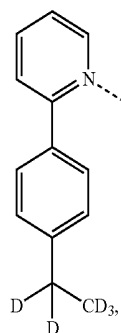
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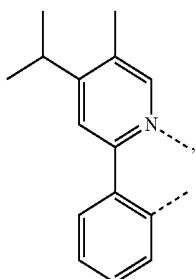
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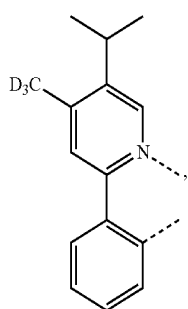
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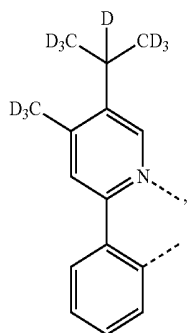
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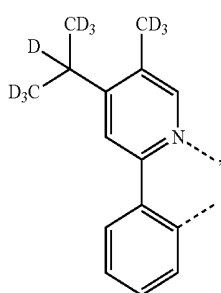
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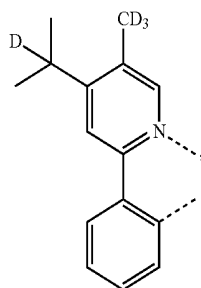
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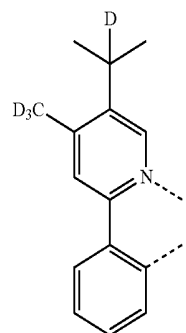


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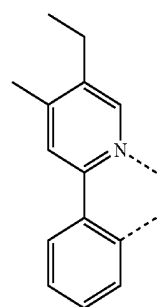


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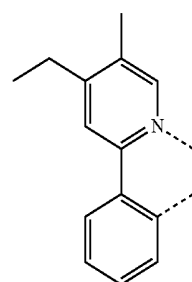
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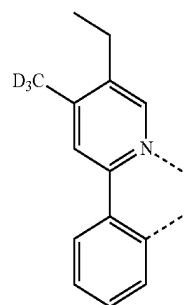
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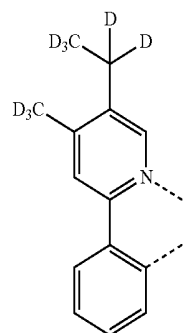
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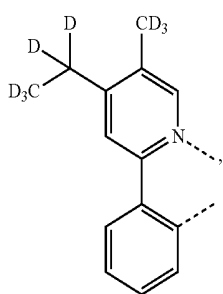


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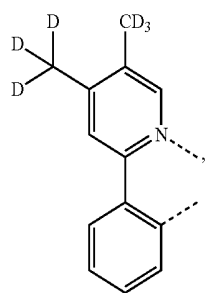


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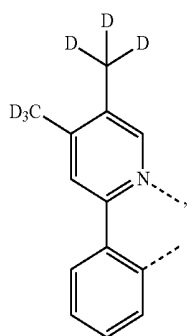
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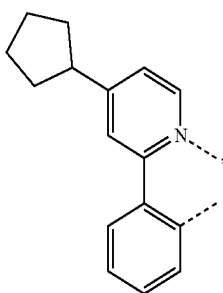
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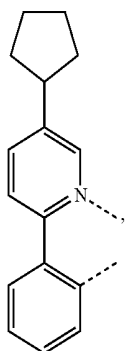
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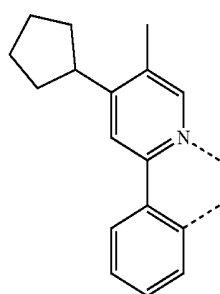


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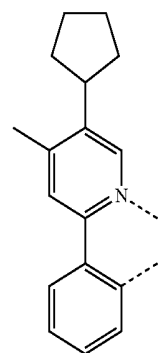


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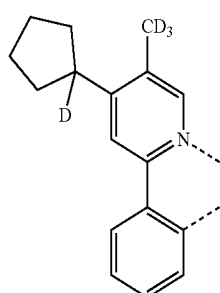
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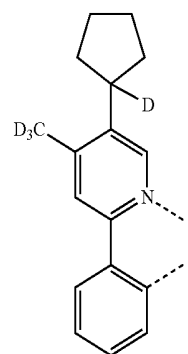
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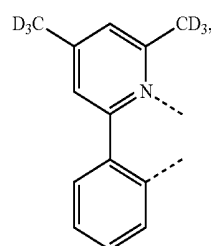
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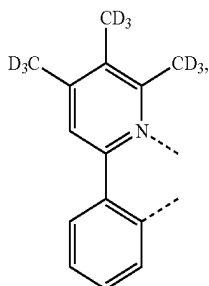


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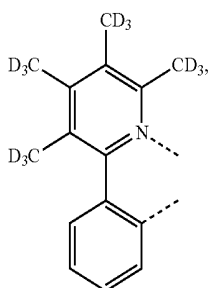


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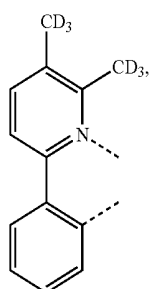
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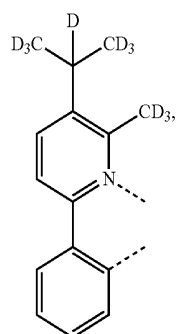
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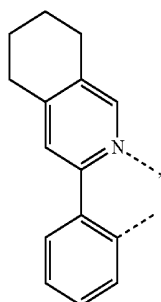
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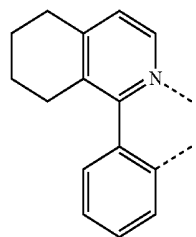


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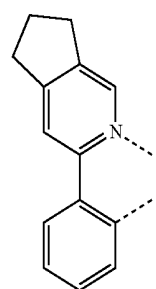


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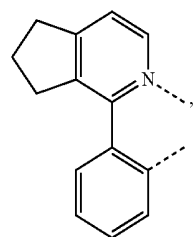
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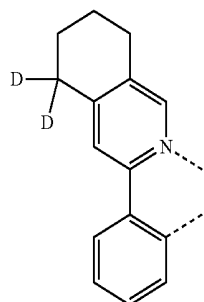
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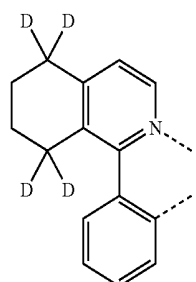
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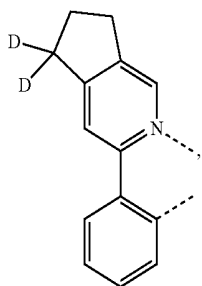


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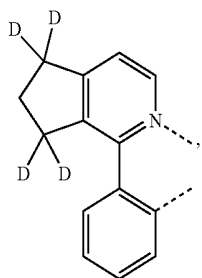


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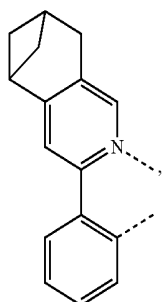
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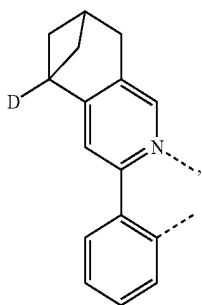
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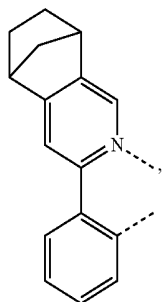
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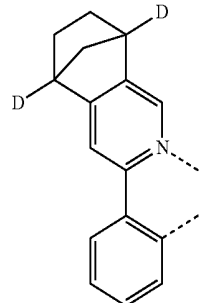


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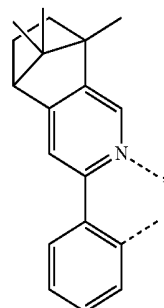


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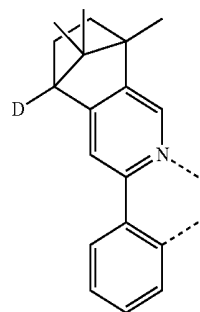
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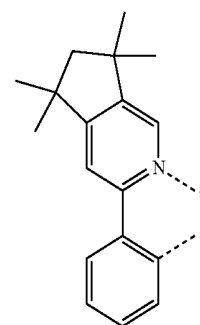
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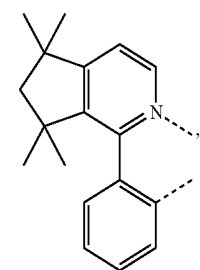
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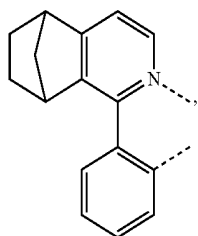


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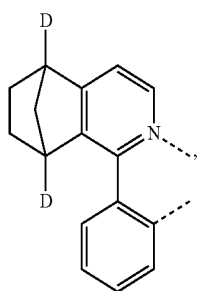


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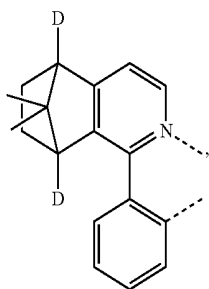
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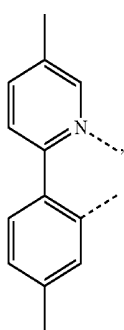
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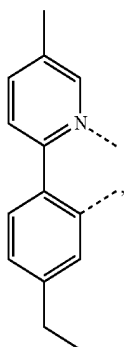
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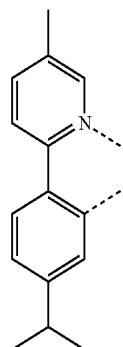


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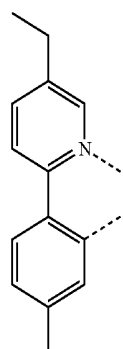


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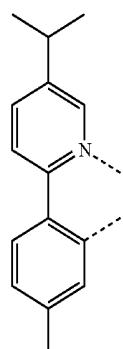
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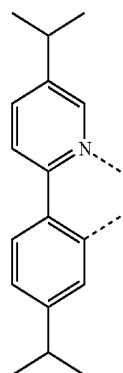
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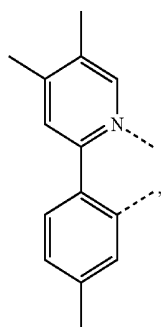


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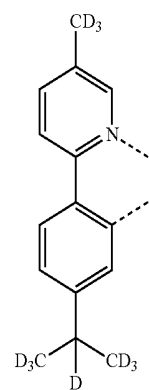
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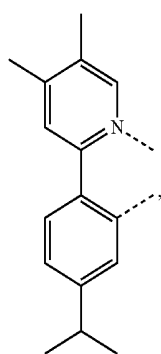


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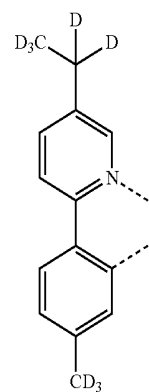
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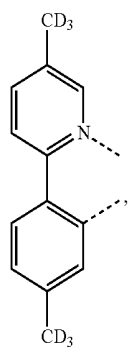
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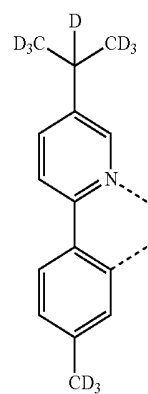
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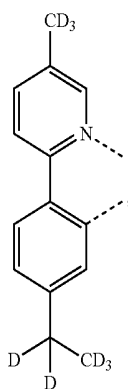
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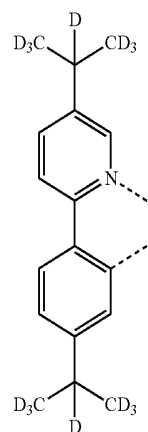
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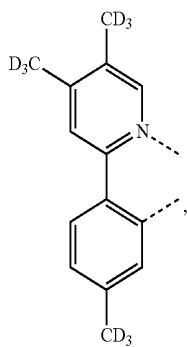


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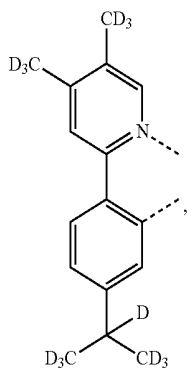


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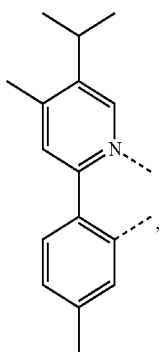
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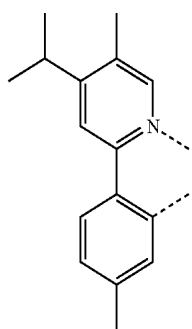
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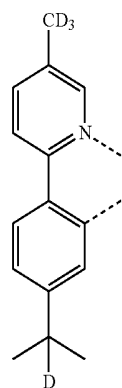


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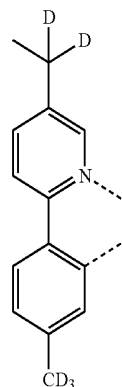


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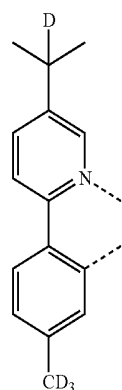
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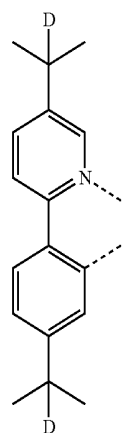
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L_{B262}

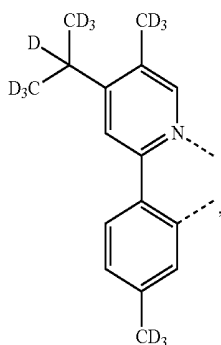


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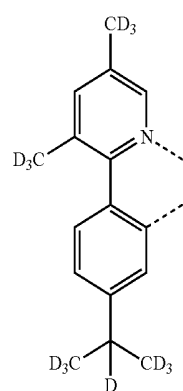
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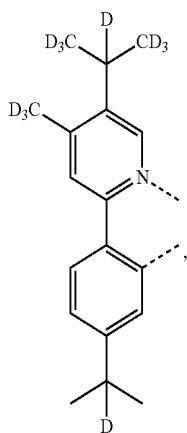


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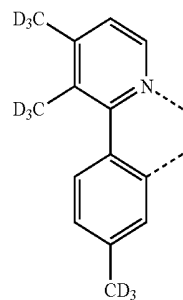
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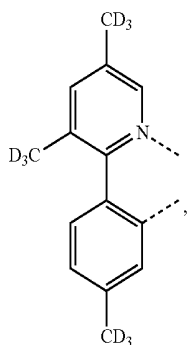
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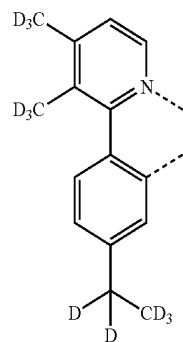
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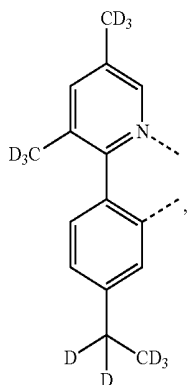
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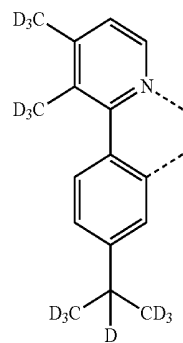
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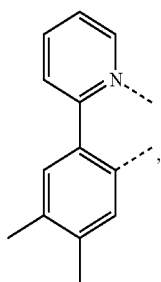
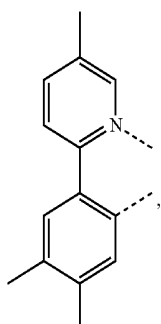
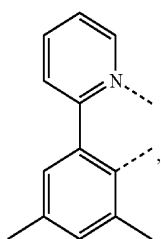
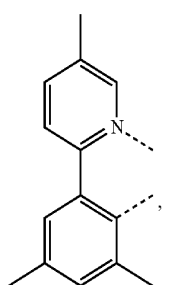
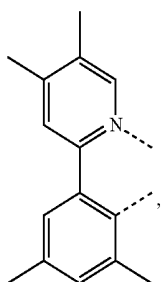


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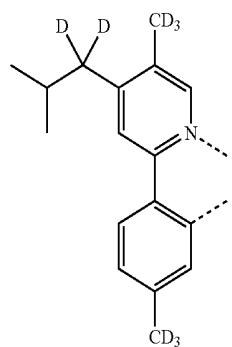
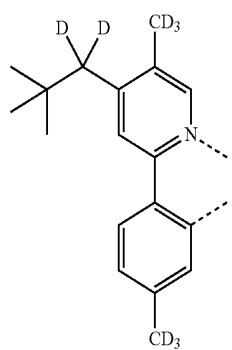
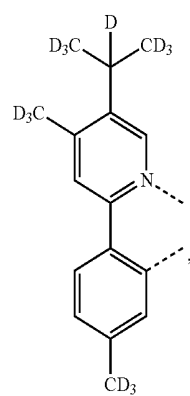
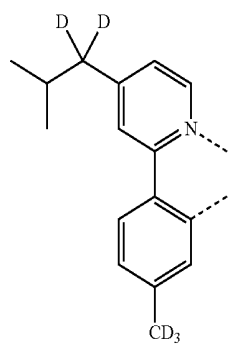


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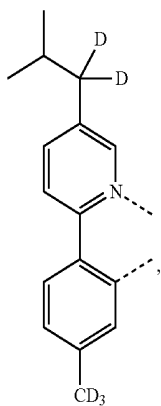
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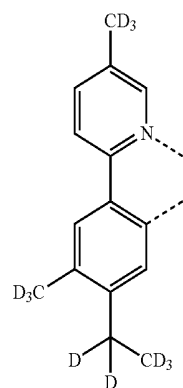
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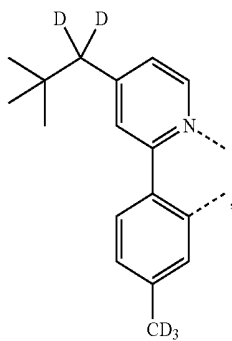


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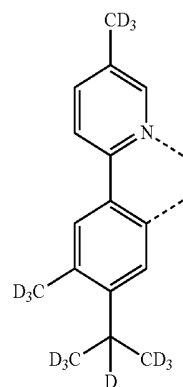
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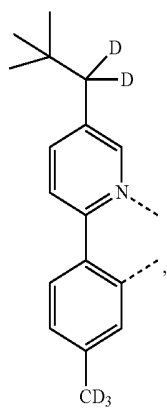
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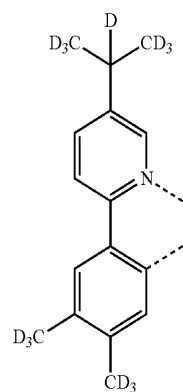
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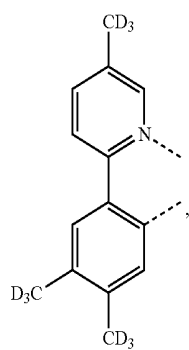
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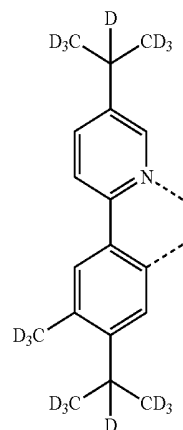
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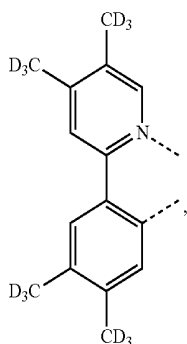


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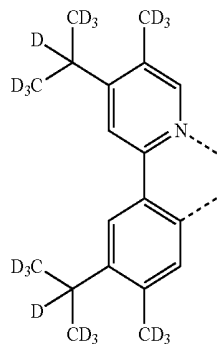
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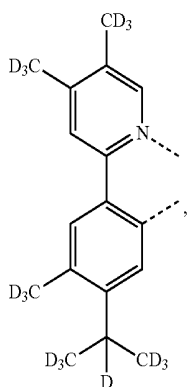


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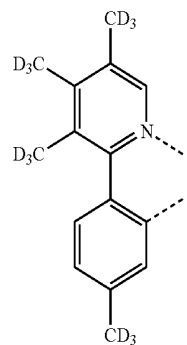
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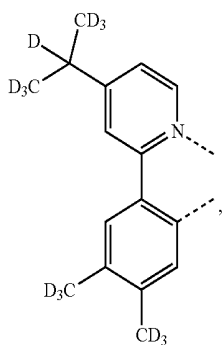
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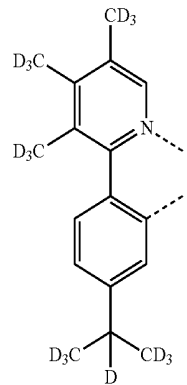
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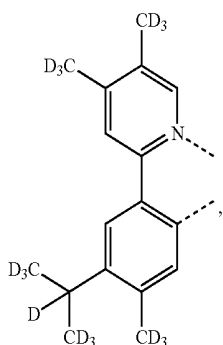
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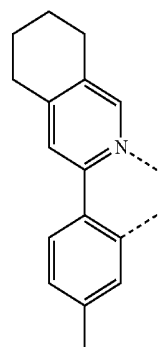
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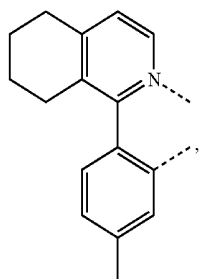


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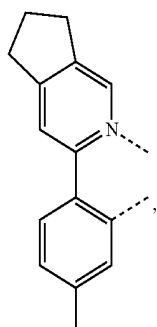


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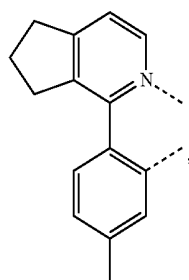
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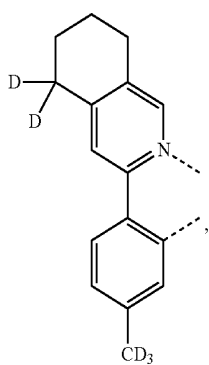
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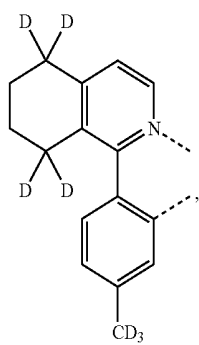
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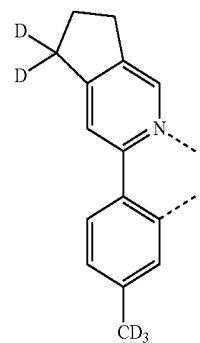


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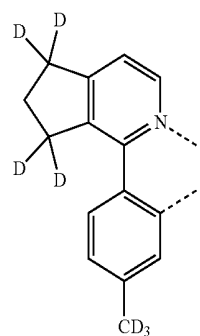


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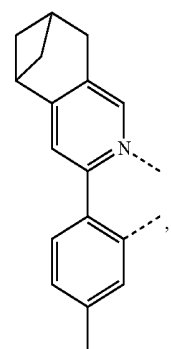
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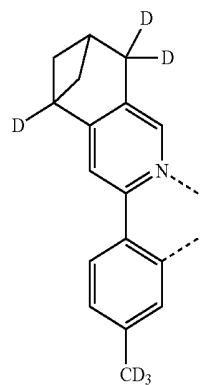
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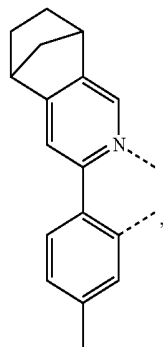


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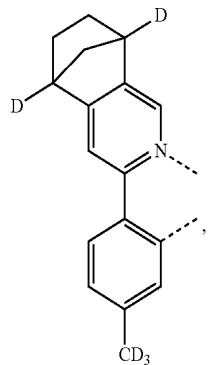


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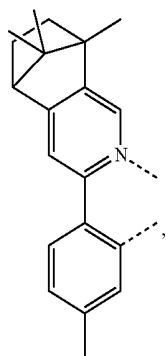
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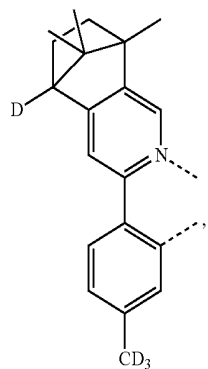
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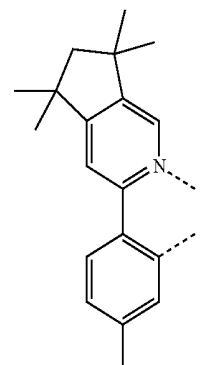


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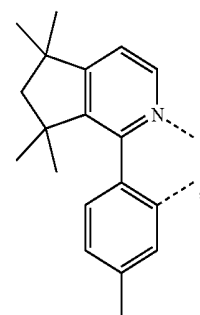


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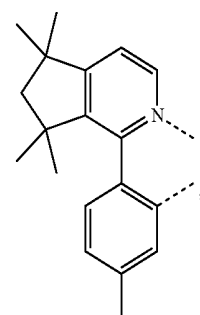
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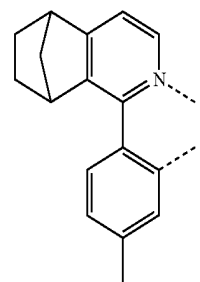
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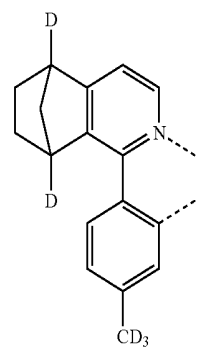
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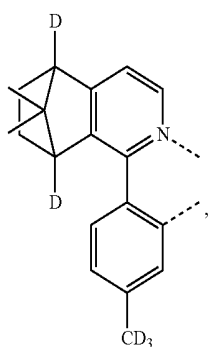


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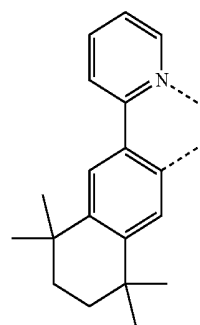
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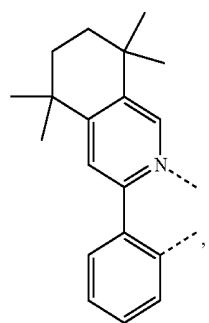


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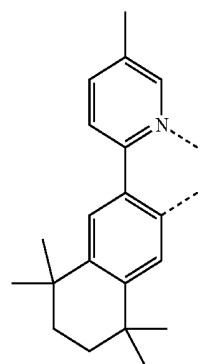
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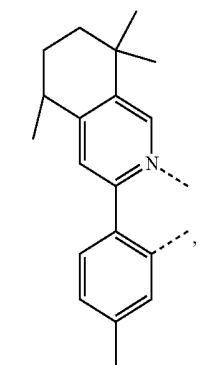
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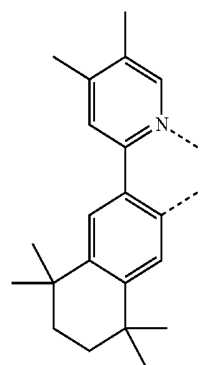
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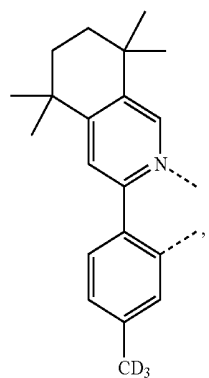
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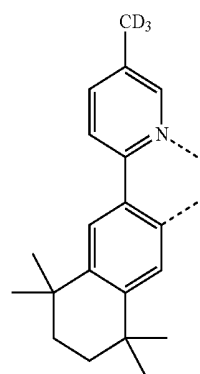
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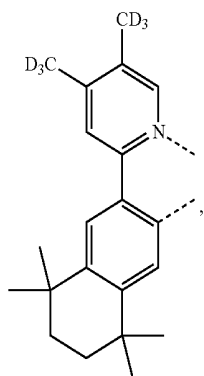


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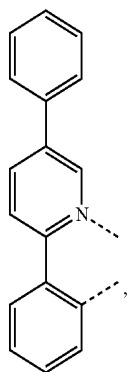


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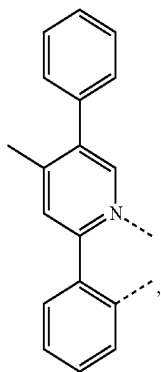
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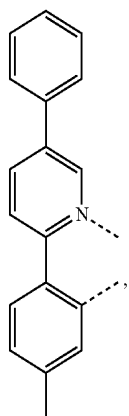
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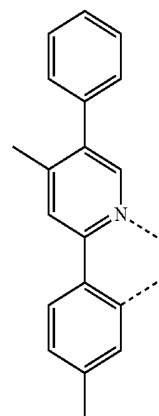


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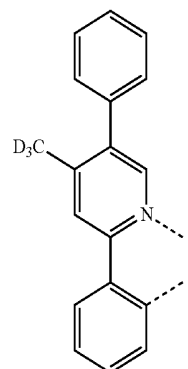


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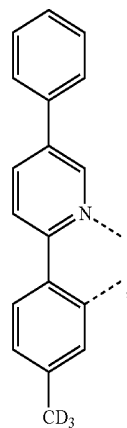
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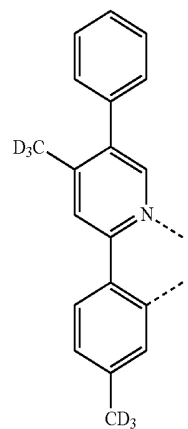
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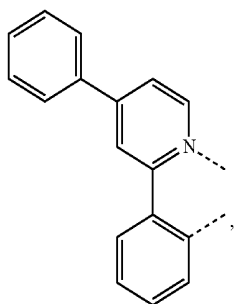


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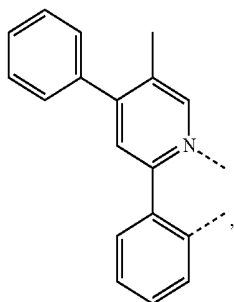


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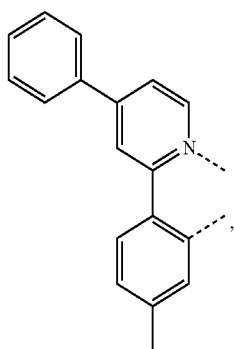
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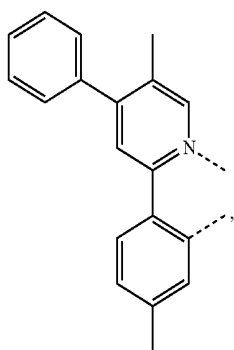
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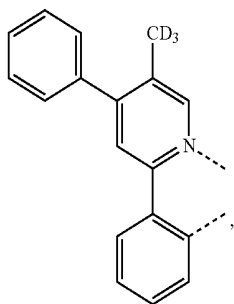
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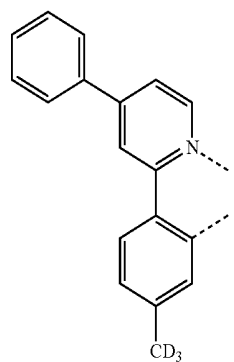


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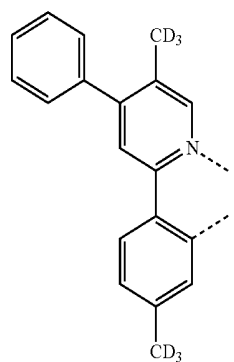


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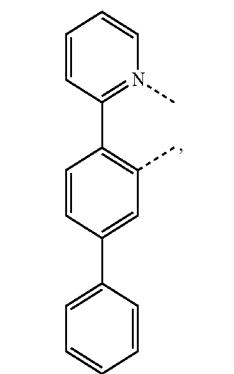
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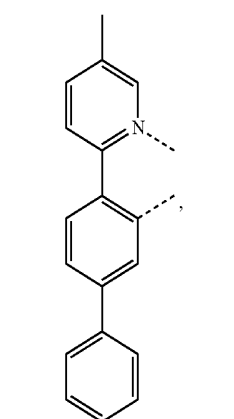
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LB337

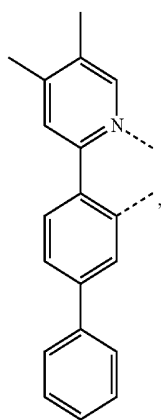


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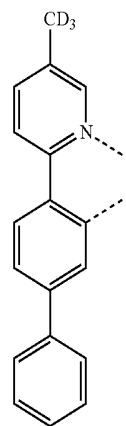
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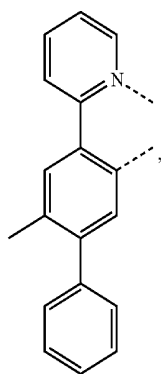


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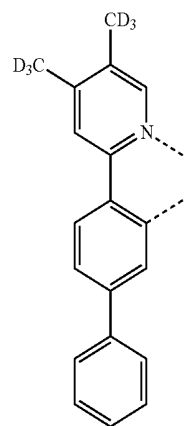
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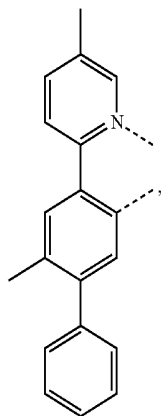
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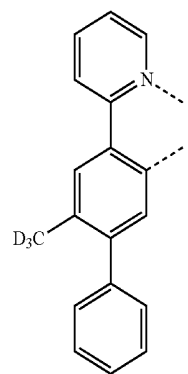
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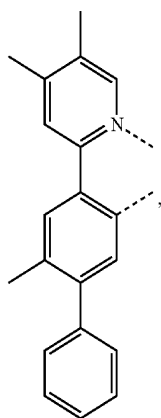
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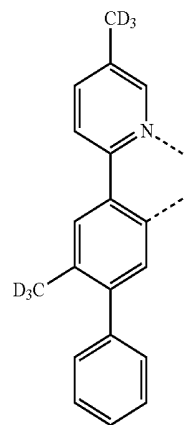
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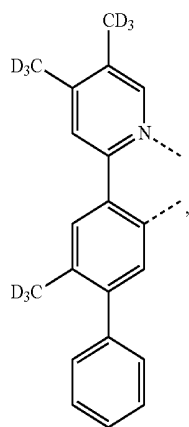


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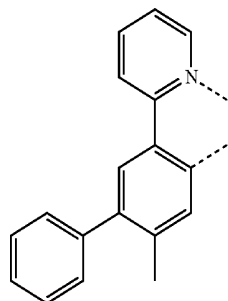
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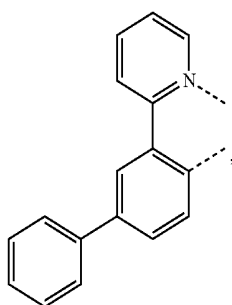


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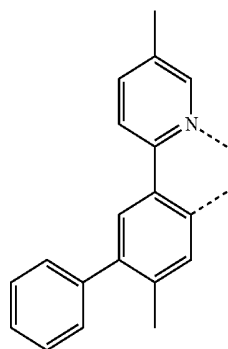
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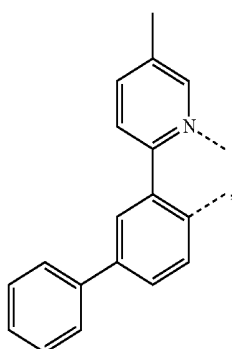
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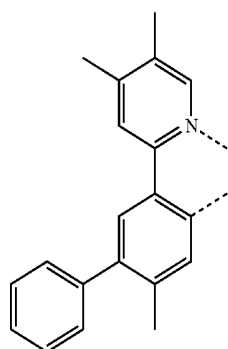
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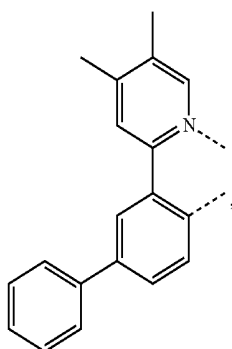
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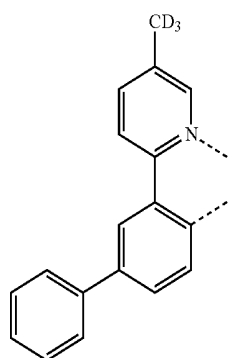
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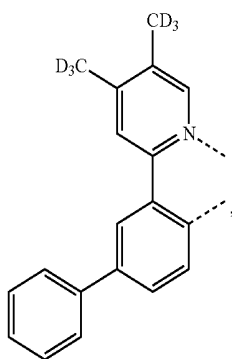


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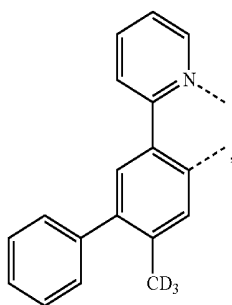


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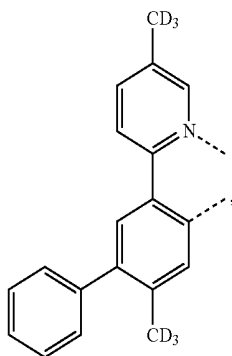
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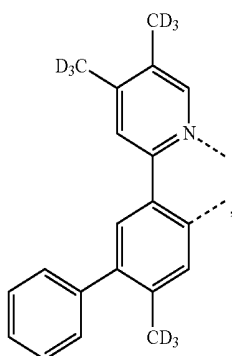
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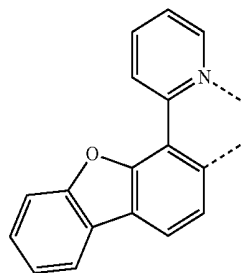


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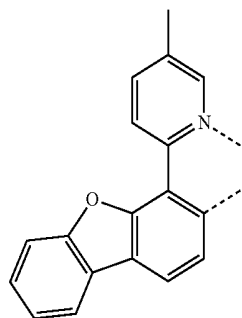


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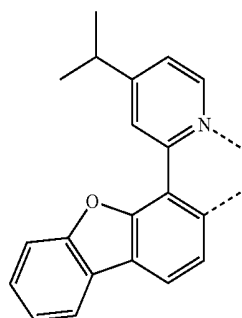
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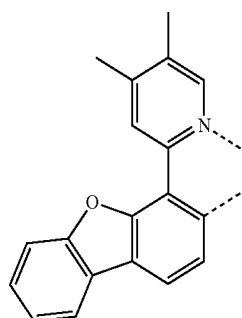
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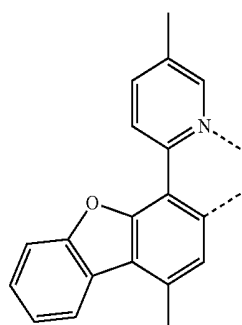
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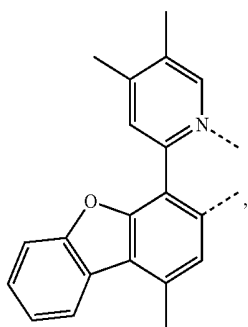


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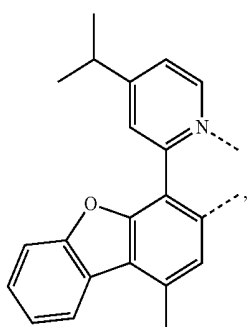


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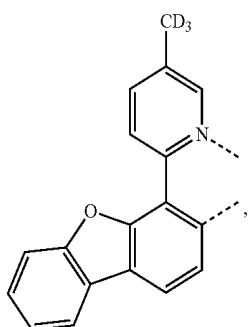
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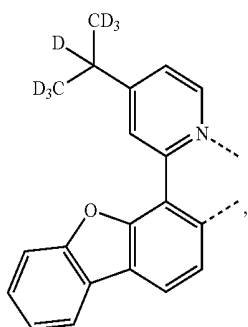
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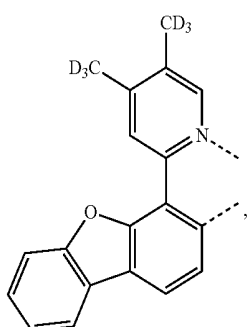
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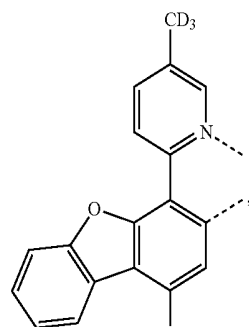


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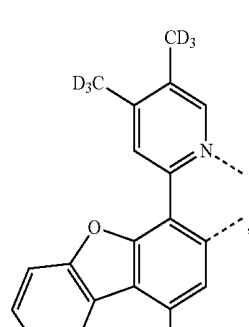


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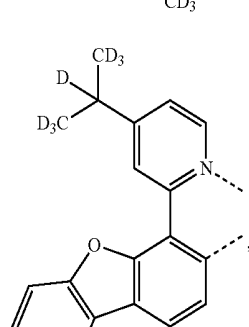
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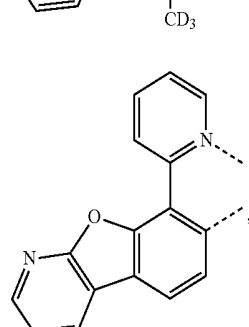
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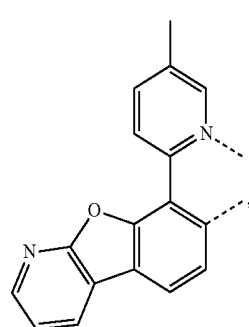
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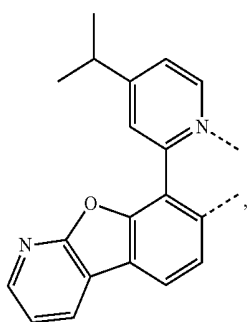


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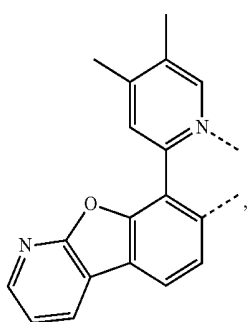


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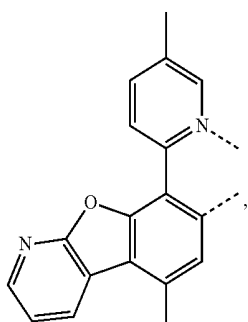
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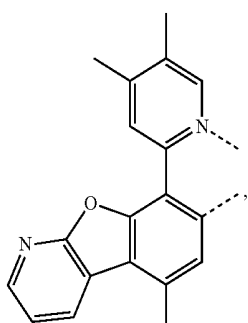
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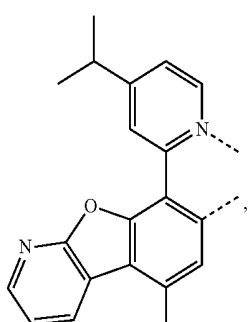
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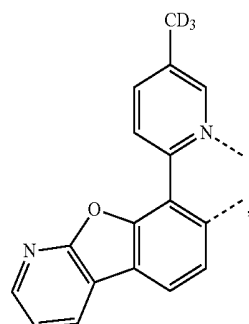


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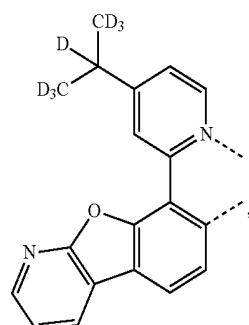


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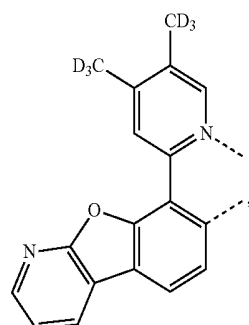
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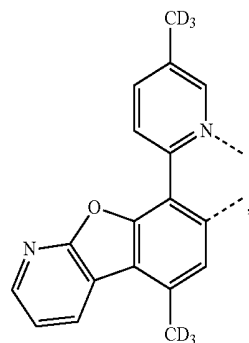
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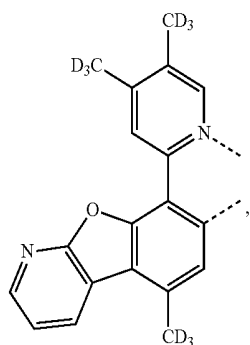


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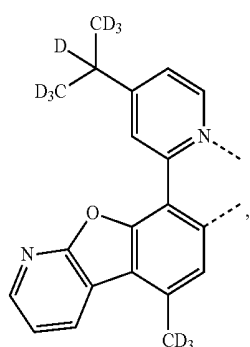


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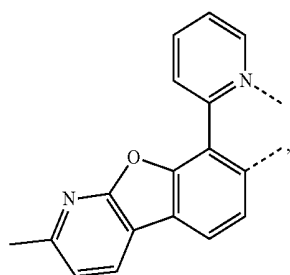
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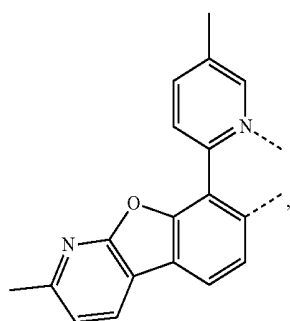
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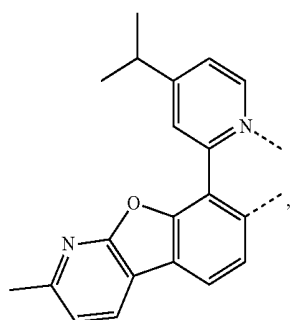
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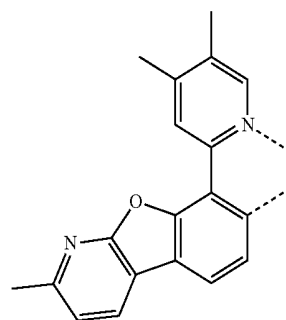


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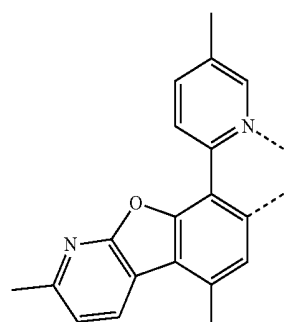


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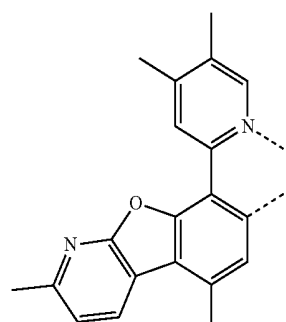
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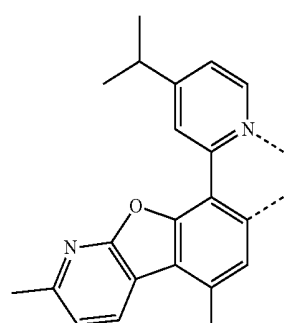
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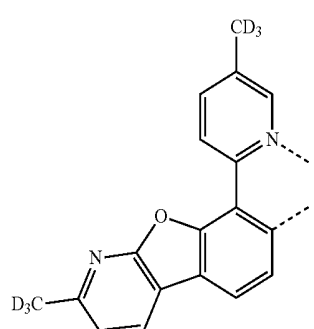
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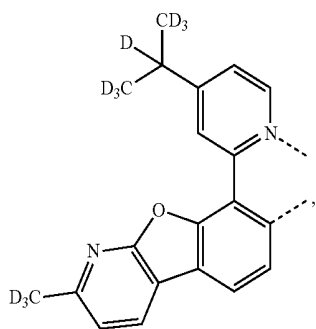


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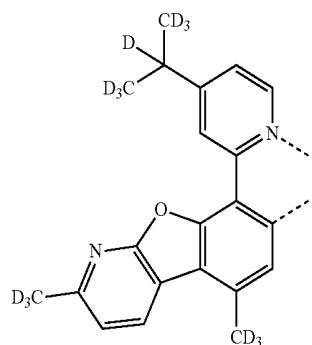
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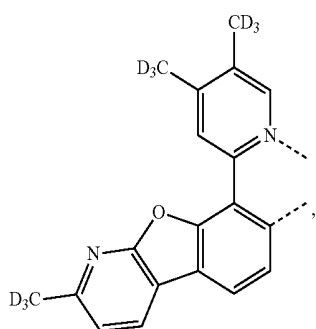


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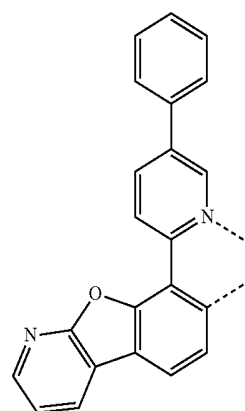
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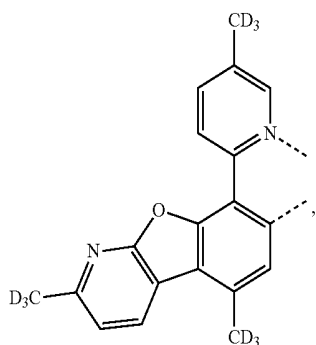
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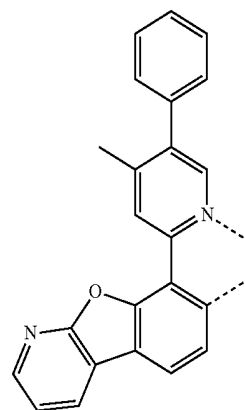
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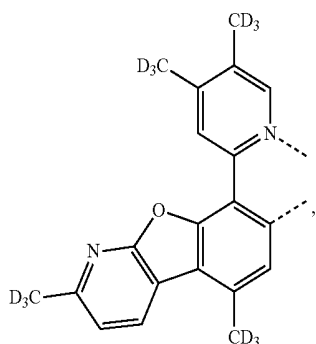
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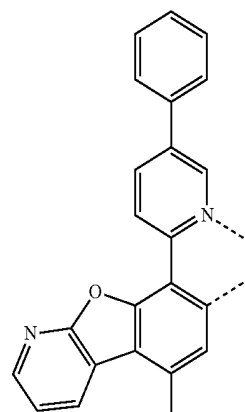
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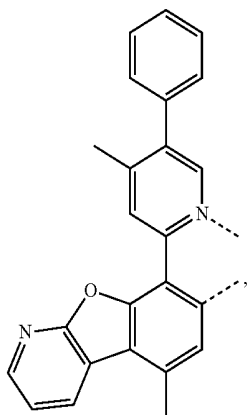


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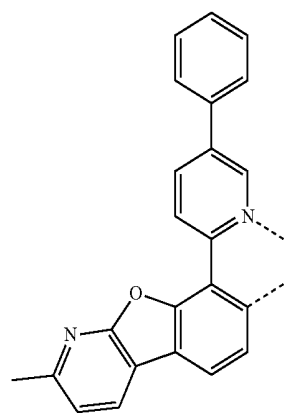
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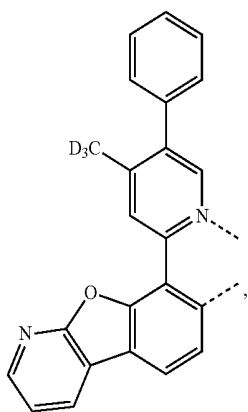


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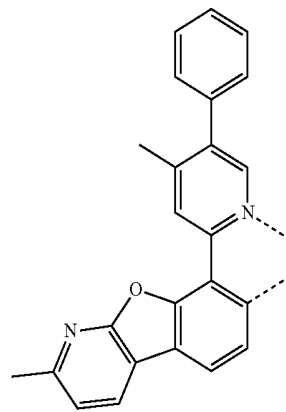
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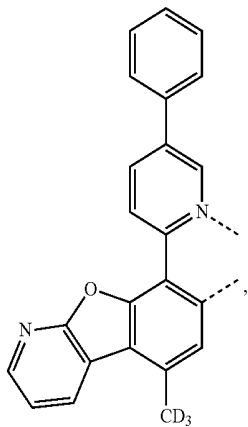
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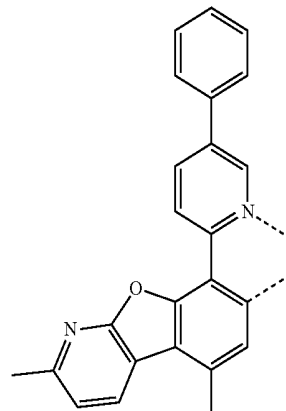
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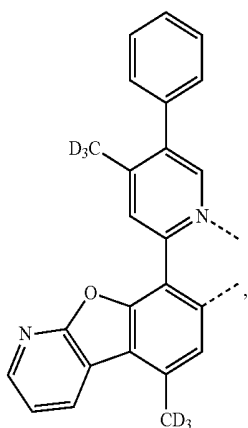
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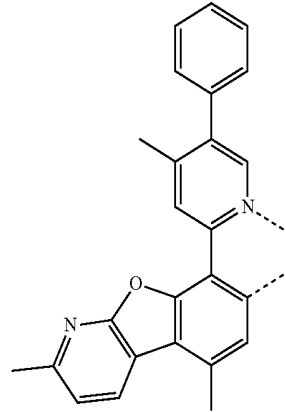
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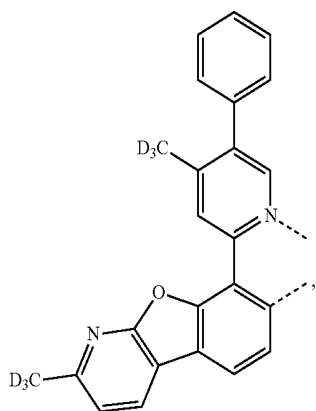


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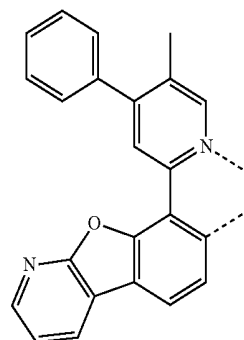
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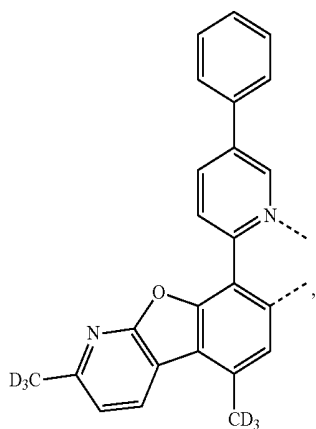


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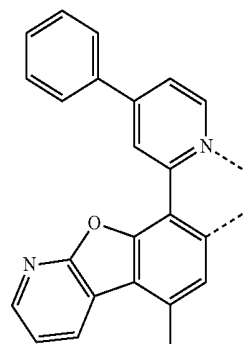
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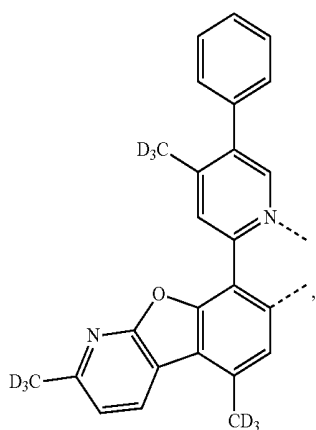
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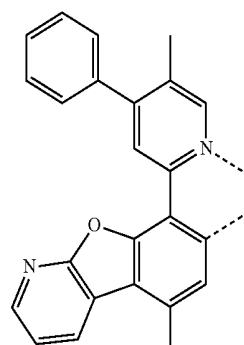
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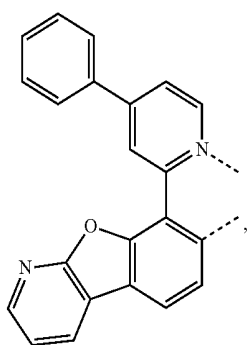
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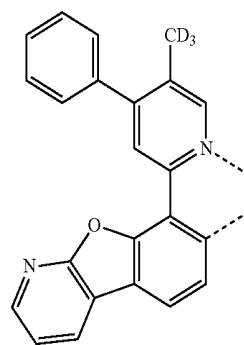
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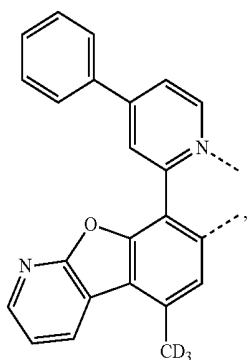


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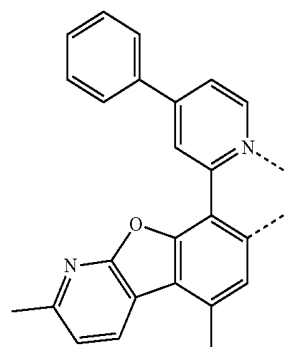
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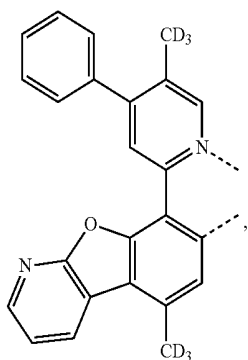


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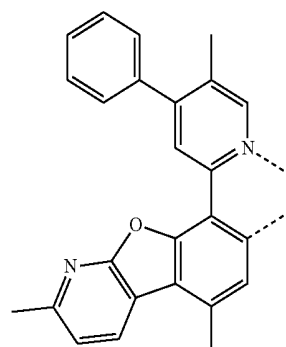
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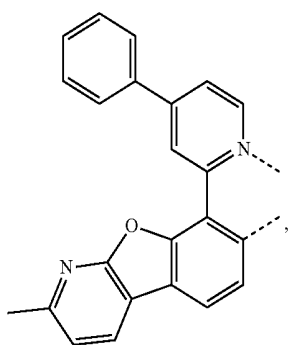
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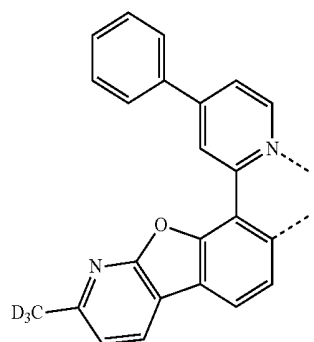
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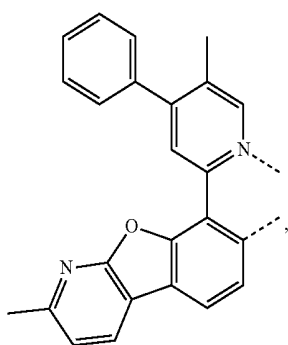
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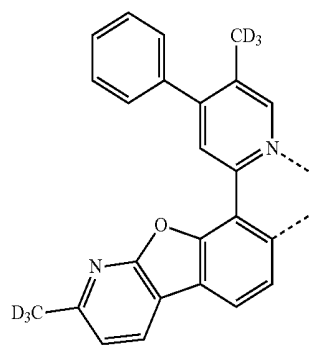
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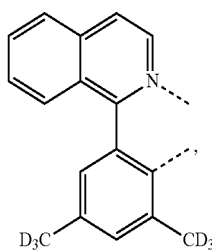
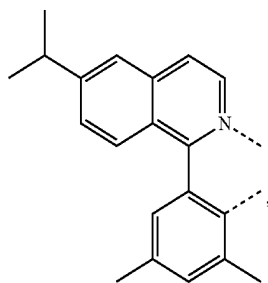
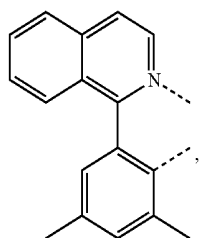
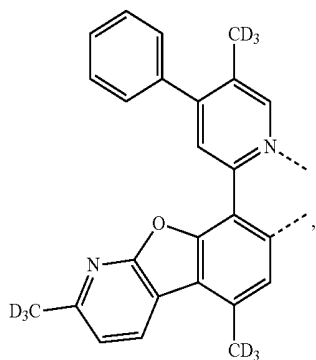
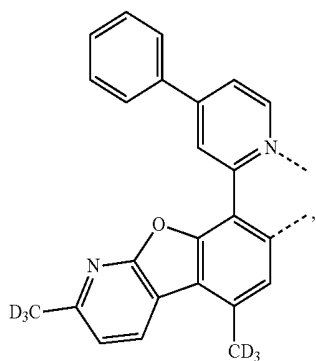


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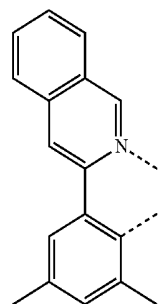
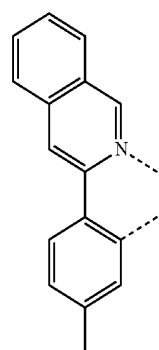
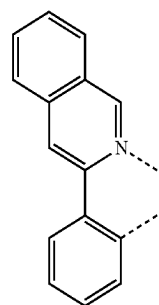
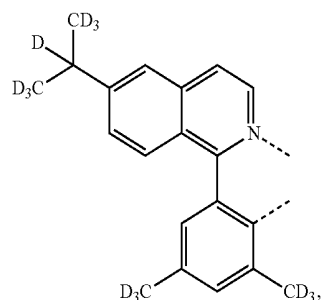
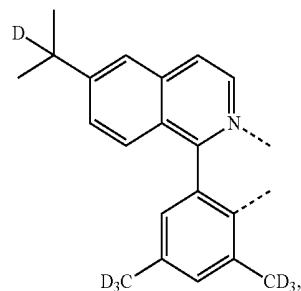


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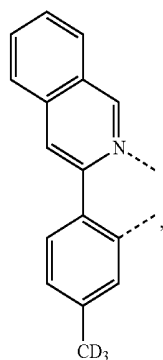
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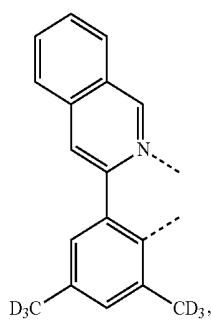
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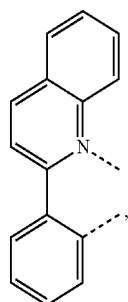
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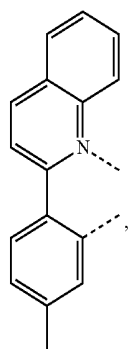
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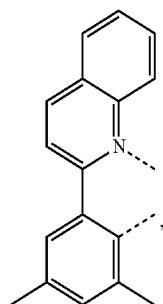
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LB438

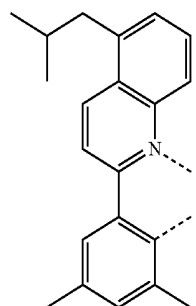


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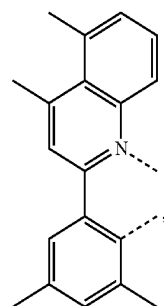


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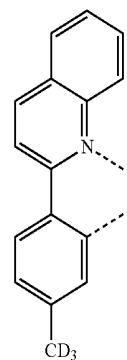
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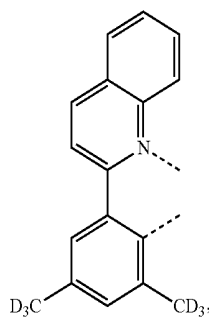
LB441



LB442

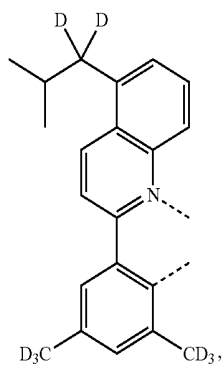


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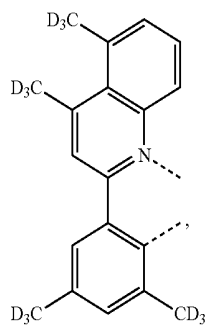


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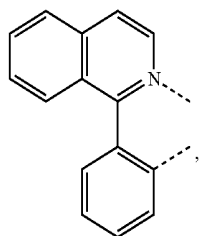
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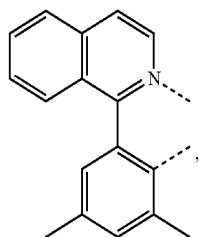
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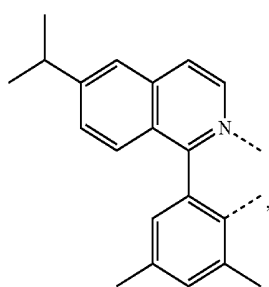
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L_{B447}

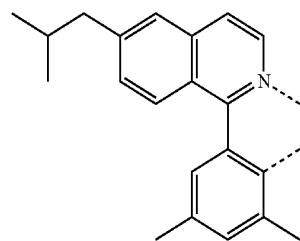


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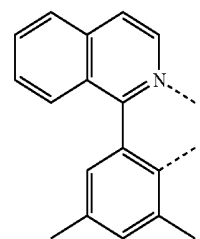


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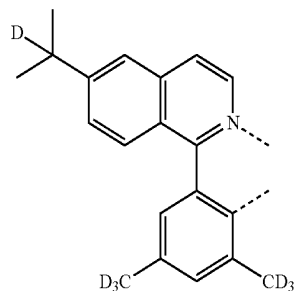
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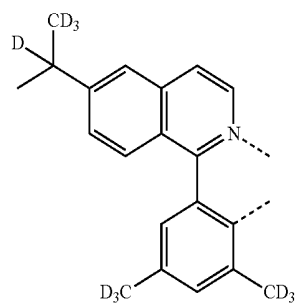
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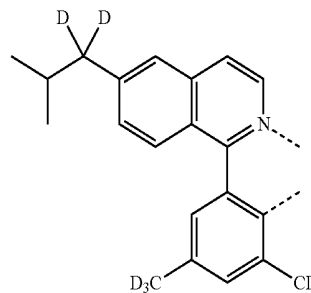
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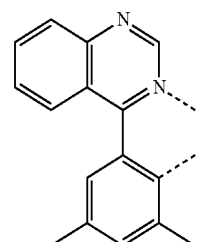
L_{B452}



L_{B453}

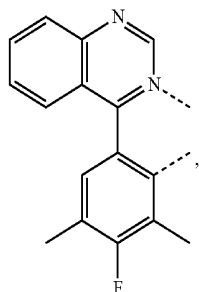


L_{B454}



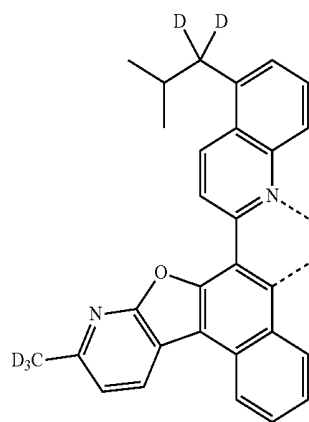
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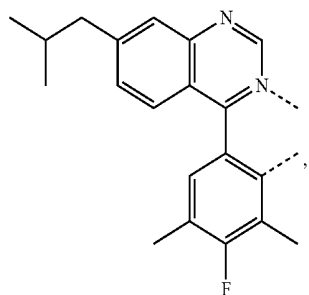


L_{B456}

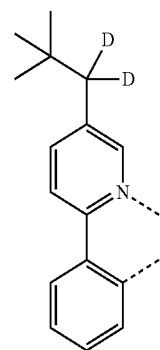
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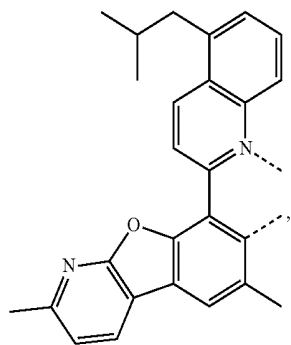
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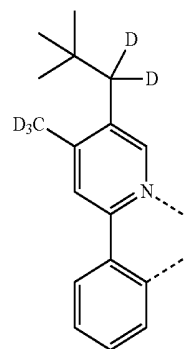
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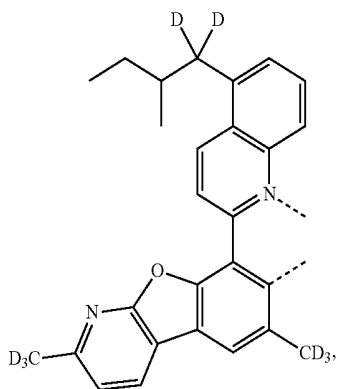
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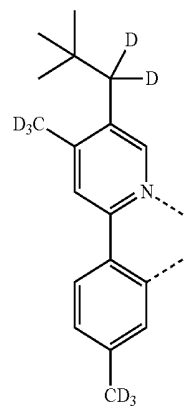
L_{B458}



L_{B462}

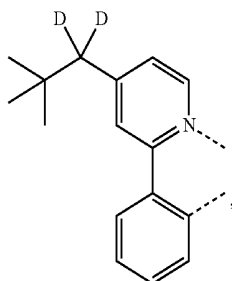
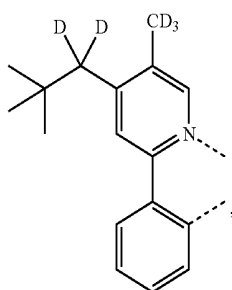
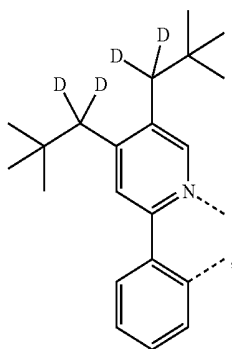
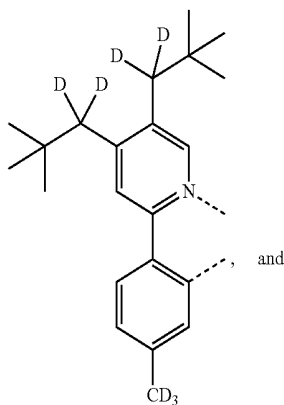


L_{B459}

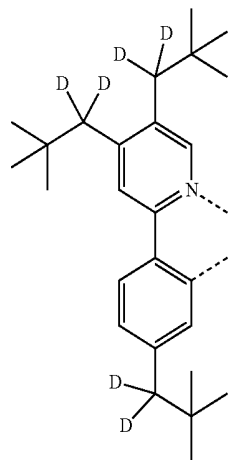


L_{B463}

-continued

L_{B464}L_{B465}L_{B466}L_{B467}

-continued

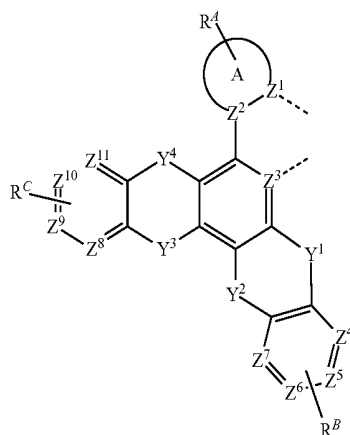
L_{B468}

18. The compound of claim 1, wherein each R^A, R^B, R^C, R and R' is independently selected from the group consisting of hydrogen, deuterium, fluorine, alkyl, cycloalkyl, heteroalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, aryl, heteroaryl, nitrile, isonitrile, and combinations thereof.

19. An organic light emitting device (OLED) comprising:
an anode;
a cathode; and

an organic layer, disposed between the anode and the cathode, comprising a compound comprising a first ligand L_A of Formula I

Formula I



wherein A is a 5- or 6-membered aryl or heteroaryl ring;
wherein R^A, R^B, and R^C each represent mono to a maximum possible number of substitutions, or no substitution;

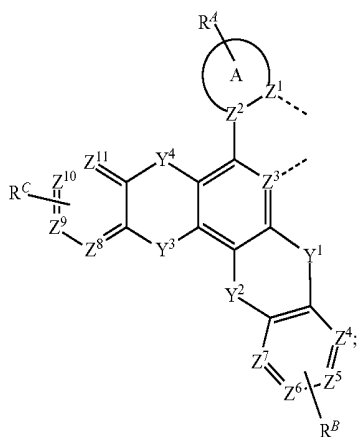
wherein Z¹-Z¹¹ are each independently selected from the group consisting of C and N;

wherein Y¹, Y², Y³, and Y⁴ are each independently selected from the group consisting of a direct bond, BR, NR, PR, O, S, Se, C=O, S=O, SO₂, CRR', SiRR', and GeRR';

wherein at least one of Y¹ and Y² is not a direct bond;
wherein at least one of Y³ and Y⁴ is not a direct bond;

wherein R^A, R^B, R^C, R, and R' are each independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl,

- aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof;
- wherein any two adjacent substitutions in R^A , R^B and R^C are optionally joined or fused into a ring;
- wherein the ligand L_A is coordinated to a metal M;
- wherein L_A is optionally linked with other ligands to comprise a tridentate, tetradentate, pentadentate, or hexadentate ligand; and
- wherein M is optionally coordinated to other ligands.
20. A consumer product comprising an organic light-emitting device (OLED) comprising:
- an anode;
 - a cathode; and
 - an organic layer, disposed between the anode and the cathode, comprising a compound comprising a first ligand L_A of Formula I



Formula I

- wherein A is a 5- or 6-membered aryl or heteroaryl ring;
- wherein R^A , R^B , and R^C each represent mono to a maximum possible number of substitutions, or no substitution;
- wherein Z^1 - Z^{11} are each independently selected from the group consisting of C and N;
- wherein Y^1 , Y^2 , Y^3 , and Y^4 are each independently selected from the group consisting of a direct bond, BR, NR, PR, O, S, Se, C=O, S=O, SO₂, CRR', SiRR', and GeRR';
- wherein at least one of Y^1 and Y^2 is not a direct bond;
- wherein at least one of Y^3 and Y^4 is not a direct bond;
- wherein R^A , R^B , R^C , R, and R' are each independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, heterocycloalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof;
- wherein any two adjacent substitutions in R^A , R^B and R^C are optionally joined or fused into a ring;
- wherein the ligand L_A is coordinated to a metal M;
- wherein L_A is optionally linked with other ligands to comprise a tridentate, tetradentate, pentadentate, or hexadentate ligand; and
- wherein M is optionally coordinated to other ligands.

* * * * *

专利名称(译)	有机电致发光材料和器件		
公开(公告)号	US20180375035A1	公开(公告)日	2018-12-27
申请号	US16/009455	申请日	2018-06-15
[标]申请(专利权)人(译)	环球展览公司		
申请(专利权)人(译)	通用显示器公司		
当前申请(专利权)人(译)	通用显示器公司		
[标]发明人	JI ZHIQIANG DYATKIN ALEXEY BORISOVICH TSAI JUI YI		
发明人	JI, ZHIQIANG DYATKIN, ALEXEY BORISOVICH TSAI, JUI-YI		
IPC分类号	H01L51/00 C07F15/00 C09K11/06		
CPC分类号	H01L51/0085 C07F15/0033 C09K11/06 H01L51/5016 C09K2211/185 C09K2211/1029 C09K2211/1088 H01L51/0073 H01L51/0087		
优先权	62/524071 2017-06-23 US		
外部链接	Espacenet USPTO		

摘要(译)

包含式I的第一配体LA的化合物 提供。在式I中，A是5-或6-元芳基或杂芳基环；Z1-Z11各自为C或N；Y1-Y4各自选自直接键，BR，NR，PR，O，S，Se，C=O，S=O，SO₂，CRR'，SiRR'和GeRR'；Y1和Y2中的至少一个不是直接键；Y3和Y4中的至少一个不是直接键；每个RA，RB，RC，R和R'独立地为氢或各种取代基；RA，RB和RC中的任何两个相邻取代可以连接或融合成环；配体LA与金属M配位；LA任选地与其他配体连接；M任选与其他配体配位。还公开了有机发光器件和含有这些化合物的消费品。

