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(54) **ORGANIC ELECTROLUMINESCENT MATERIALS AND DEVICES**

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CPC **C07F 15/0033** (2013.01); **C07D 491/048**
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CPC **C07F 15/0033**; **H01L 51/0084**; **H01L**
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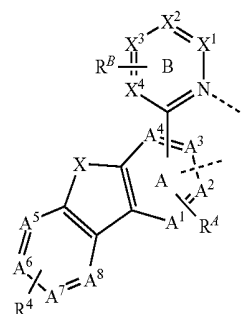
Primary Examiner — Andrew K Bohaty

Assistant Examiner — Dylan C Kershner

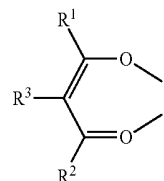
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(57) **ABSTRACT**

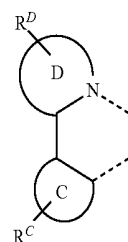
A compound that has the structure according to Formula
 $M(L_A)_x(L_B)_y(L_C)_z$:
wherein ligand L_A is



ligand L_B is



and
ligand L_C is



and devices and formulations containing these compounds
are disclosed. In Formula $M(L_A)_x(L_B)_y(L_C)_z$:

M is a metal having an atomic number greater than 40;
x is 1 or 2;

x+y+z is the oxidation state of the metal M;

X^1-X^4 and A^1-A^8 are C or N;

at least one of A^1-A^8 is N;

X is O, S, or Se;

two adjacent R^B form a six-member aromatic ring E fused
to ring B; wherein ring E can be substituted by R^E ;

each R^A-R^E and R^1-R^4 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

(Continued)

acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof.

19 Claims, 3 Drawing Sheets

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CPC .. **H01L 51/0085** (2013.01); **C09K 2211/1007** (2013.01); **C09K 2211/1029** (2013.01); **C09K 2211/1033** (2013.01); **C09K 2211/1044** (2013.01); **C09K 2211/185** (2013.01); **H01L 51/5004** (2013.01); **H01L 51/5016** (2013.01); **H01L 51/5024** (2013.01); **H01L 51/5056** (2013.01); **H01L 51/5072** (2013.01); **H01L 51/5088** (2013.01); **H01L 51/5096** (2013.01); **H01L 51/5206** (2013.01); **H01L 51/5221** (2013.01); **H01L 2251/301** (2013.01); **H01L 2251/308** (2013.01); **H01L 2251/552** (2013.01)

(58) Field of Classification Search

CPC **H01L 51/0088**; **H01L 51/0089**; **H01L 51/0091**; **H01L 51/0092**; **H01L 51/5016**; **H01L 2251/301**; **H01L 2251/308**; **H01L 2251/552**; **H01L 51/5004**; **H01L 51/5024**; **H01L 51/5056**; **H01L 51/5072**; **H01L 51/5088**; **H01L 51/5096**; **H01L 51/5206**; **H01L 51/5221**; **C09K 11/06**; **C09K 2211/18**; **C09K 2211/1007**; **C09K 2211/1029**; **C09K 2211/1033**; **C09K 2211/1044**; **C07D 491/048**
USPC 428/690, 691, 917, 411; 427/58, 66; 313/500–512; 257/40, 88–104, 257/E51.001–E51.052; 252/301.16–301.35

See application file for complete search history.

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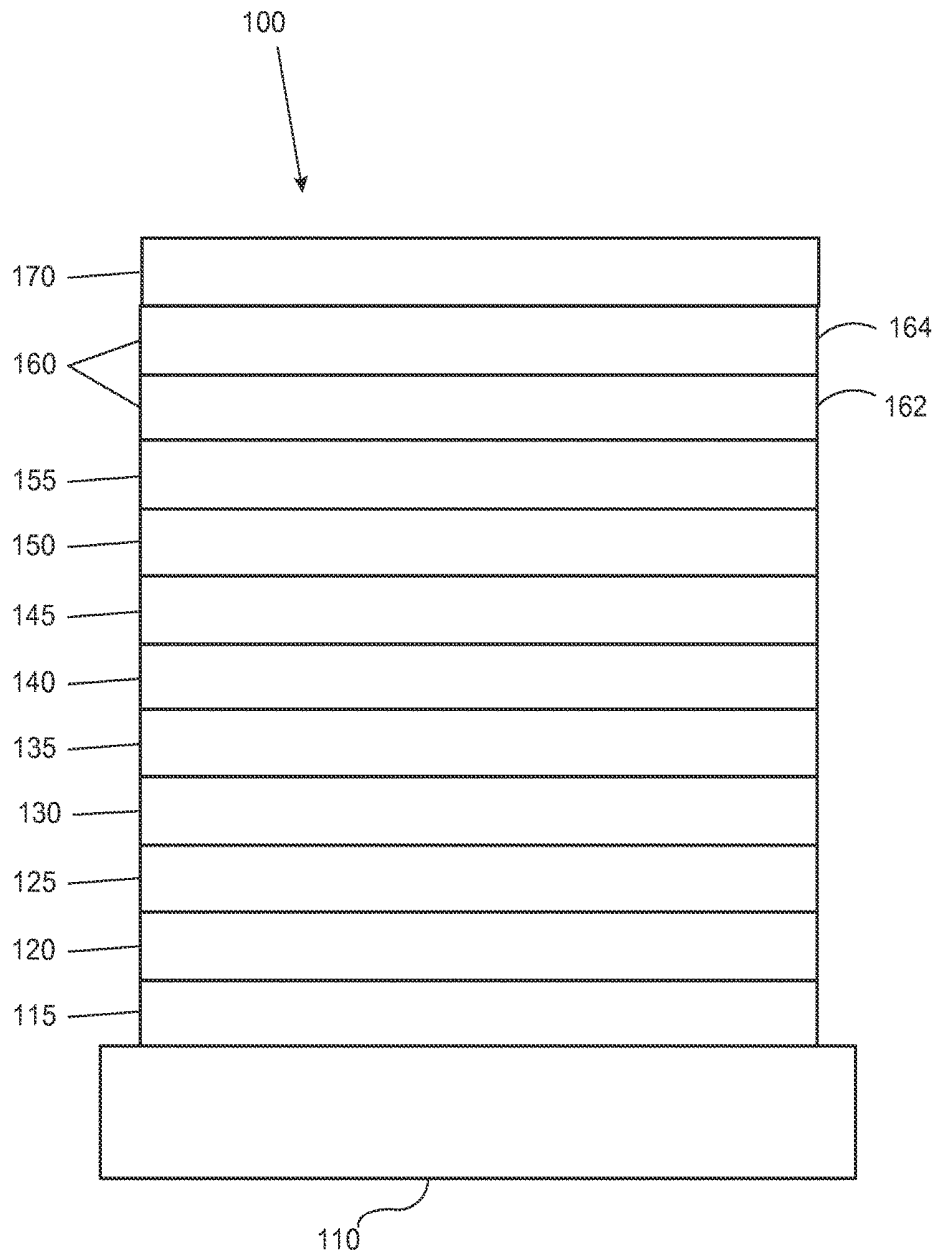


FIGURE 1

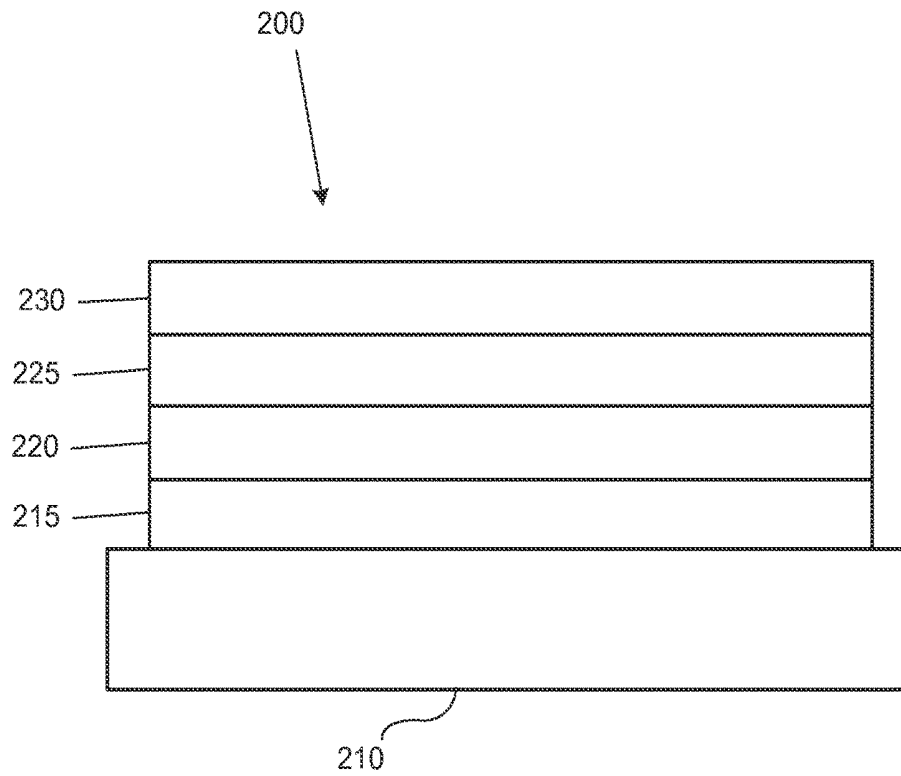


FIGURE 2

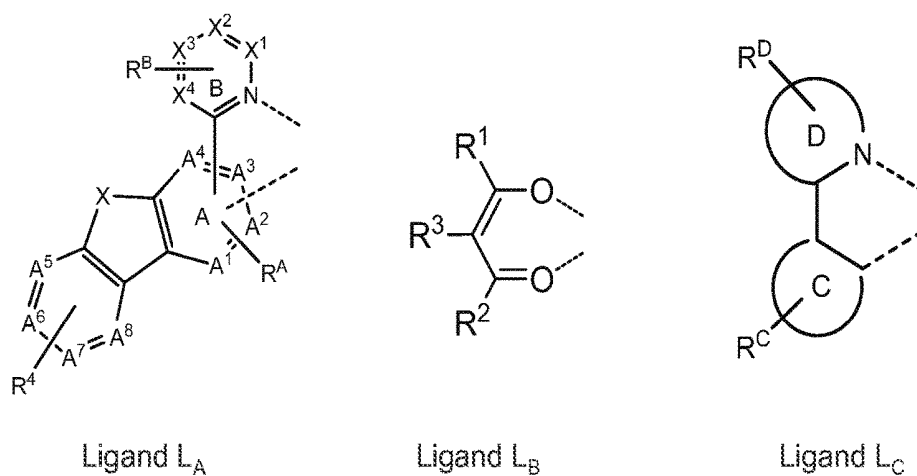


FIGURE 3

1

ORGANIC ELECTROLUMINESCENT
MATERIALS AND DEVICESPARTIES TO A JOINT RESEARCH
AGREEMENT

The claimed invention was made by, on behalf of, and/or in connection with one or more of the following parties to a joint university corporation research agreement: Regents of the University of Michigan, Princeton University, University of Southern California, and the Universal Display Corporation. The agreement was in effect on and before the date the claimed invention was made, and the claimed invention was made as a result of activities undertaken within the scope of the agreement.

FIELD OF THE INVENTION

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

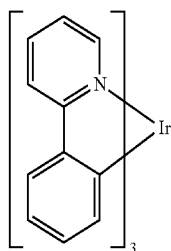
BACKGROUND

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 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.

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.

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. Color may be measured using CIE coordinates, which are well known to the art.

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



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

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 pendent 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.

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.

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.

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.

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.

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

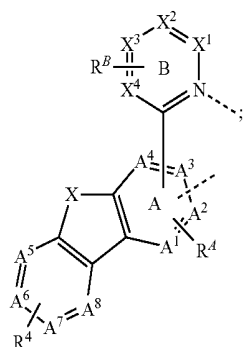
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downward direction. Thus, the definitions of HOMO and LUMO energy levels follow a different convention than work functions.

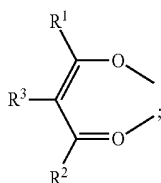
More details on OLEDs, and the definitions described above, can be found in U.S. Pat. No. 7,279,704, which is incorporated herein by reference in its entirety.

SUMMARY OF THE INVENTION

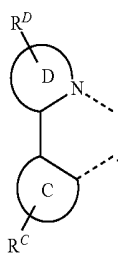
According to an embodiment, a compound is provided that has the structure of Formula M(L_A)_x(L_B)_y(L_C)_z:



wherein ligand L_A is



ligand L_B is



and

ligand L_C is

In the compound of Formula M(L_A)_x(L_B)_y(L_C)_z:

M is a metal having an atomic number greater than 40;

x is 1, or 2;

y is 0, 1, or 2;

z is 0, 1, or 2;

x+y+z is the oxidation state of the metal M;

X¹, X², X³, X⁴, A¹, A², A³, A⁴, A⁵, A⁶, A⁷, and A⁸ are C or N;

at least one of A¹, A², A³, A⁴, A⁵, A⁶, A⁷, and A⁸ is N;

ring B is bonded to ring A through a C—C bond;

M is bonded to ring A through a M—C bond;

X is O, S, or Se;

rings C and D are each independently a 5 or 6-membered carbocyclic or heterocyclic ring;

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R⁴ represents mono, or di-substitution, or no substitution; R^B represents di, tri, or tetra-substitution;

R^C, R^D, and R⁴ each independently represent mono, di, tri, or tetra-substitution, or no substitution;

two adjacent R^B form a six-member aromatic carbocyclic or heterocyclic ring E fused to ring B; wherein, when ring E is heterocyclic, the only heteroatom is nitrogen; wherein ring E can be further substituted by R^E; and wherein R^E represents mono, di, tri, or tetra-substitution, or no substitution;

each of R^A, R^B, R^C, R^D, R^E, R¹, R², R³, and R⁴ are independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, aryl-alkyl, 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

any adjacent substituents of R^C, and R^D are optionally joined to form a fused ring.

According to another embodiment, a first device comprising a first organic light emitting device is also provided. The first organic light emitting device can include an anode, a cathode, and an organic layer, disposed between the anode and the cathode. The organic layer can include a compound of Formula M(L_A)_x(L_B)_y(L_C)_z. The first device can be a consumer product, an organic light-emitting device, and/or a lighting panel.

According to another embodiment, a formulation that includes a compound of Formula M(L_A)_x(L_B)_y(L_C)_z is also provided.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows an organic light emitting device.

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

FIG. 3 shows ligands L_A, L_B, and L_C as disclosed herein.

DETAILED DESCRIPTION

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.

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.

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”), which 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.

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.

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. 2004/017411.6, 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.

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**.

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.

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.

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 (OVPD), 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 OVJD. 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 processability 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.

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.

Devices fabricated in accordance with embodiments of the invention may be incorporated into a wide variety of consumer products, including flat panel displays, computer monitors, medical monitors, televisions, billboards, lights for interior or exterior illumination and/or signaling, heads up displays, fully transparent displays, flexible displays, laser printers, telephones, cell phones, personal digital assistants (PDAs), laptop computers, digital cameras, camcorders, viewfinders, micro-displays, 3-D displays, vehicles, a large area wall, theater or stadium screen, or 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.

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.

The term "halo" or "halogen" as used herein includes fluorine, chlorine, bromine, and iodine.

The term "alkyl" as used herein contemplates both straight and branched chain alkyl radicals. Preferred alkyl groups are those containing from one to fifteen carbon atoms and includes methyl, ethyl, propyl, isopropyl, butyl, isobutyl, tert-butyl, and the like. Additionally, the alkyl group may be optionally substituted.

The term "cycloalkyl" as used herein contemplates cyclic alkyl radicals. Preferred cycloalkyl groups are those containing 3 to 7 carbon atoms and includes cyclopropyl, cyclopentyl, cyclohexyl, and the like. Additionally, the cycloalkyl group may be optionally substituted.

The term "alkenyl" as used herein contemplates both straight and branched chain alkene radicals. Preferred alk-

enyl groups are those containing two to fifteen carbon atoms. Additionally, the alkenyl group may be optionally substituted.

The term "alkynyl" as used herein contemplates both straight and branched chain alkyne radicals. Preferred alkyl groups are those containing two to fifteen carbon atoms. Additionally, the alkynyl group may be optionally substituted.

The terms "aralkyl" or "arylalkyl" as used herein are used interchangeably and contemplate an alkyl group that has as a substituent an aromatic group. Additionally, the aralkyl group may be optionally substituted.

The term "heterocyclic group" as used herein contemplates aromatic and non-aromatic cyclic radicals. Hetero-aromatic cyclic radicals also means heteroaryl. Preferred hetero-non-aromatic cyclic groups are those containing 3 or 7 ring atoms which includes at least one hetero atom, and includes cyclic amines such as morpholino, piperidino, pyrrolidine, and the like, and cyclic ethers, such as tetrahydrofuran, tetrahydropyran, and the like. Additionally, the heterocyclic group may be optionally substituted.

The term "aryl" or "aromatic group" as used herein contemplates single-ring groups and polycyclic 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 aromatic, e.g., the other rings can be cycloalkyls, cycloalkenyls, aryl, heterocycles, and/or heteroaryls. Additionally, the aryl group may be optionally substituted.

The term "heteroaryl" as used herein contemplates single-ring hetero-aromatic groups that may include from one to three heteroatoms, for example, pyrrole, furan, thiophene, imidazole, oxazole, thiazole, triazole, pyrazole, pyridine, pyrazine and pyrimidine, and the like. The term heteroaryl also includes polycyclic hetero-aromatic systems having 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. Additionally, the heteroaryl group may be optionally substituted.

The alkyl, cycloalkyl, alkenyl, alkynyl, aralkyl, heterocyclic group, aryl, and heteroaryl may be optionally substituted with one or more substituents selected from the group consisting of hydrogen, deuterium, halogen, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, cyclic amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acid, ether, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof.

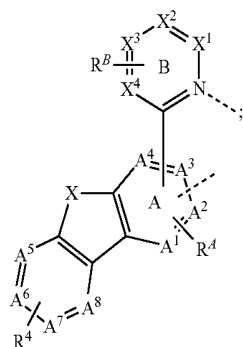
As used herein, "substituted" indicates that a substituent other than H is bonded to the relevant position, such as carbon. Thus, for example, where R¹ is mono-substituted, then one R¹ must be other than H. Similarly, where R¹ is di-substituted, then two of R¹ must be other than H. Similarly, where R¹ is unsubstituted, R¹ is hydrogen for all available positions.

The "aza" designation in the fragments described herein, i.e. aza-dibenzofuran, aza-dibenzonethiophene, 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.

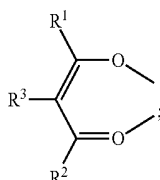
It is to be understood that when a molecular fragment is described as being a substituent or otherwise attached to another moiety, its name may be written as if it were a fragment (e.g. naphthyl, dibenzofuryl) or as if it were the whole molecule (e.g. naphthalene, dibenzofuran). As used

herein, these different ways of designating a substituent or attached fragment are considered to be equivalent. The novel ligands disclosed herein can be used to produce metal complexes that are useful in emissive devices. The incorporation of these ligands allows red phosphorescent materials with good external quantum efficiency (EQE), good color, and good lifetime.

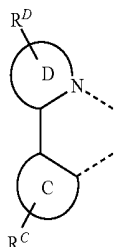
According to one embodiment, a compound is disclosed that has a structure according to Formula $M(L_A)_x(L_B)_y(L_C)_z$: wherein ligand L_A is



ligand L_B is



and
ligand L_C is



In the compound of Formula $M(L_A)_x(L_B)_y(L_C)_z$:

M is a metal having an atomic number greater than 40;

x is 1, or 2;

y is 0, 1, or 2;

z is 0, 1, or 2;

x+y+z is the oxidation state of the metal M;

X^1 , X^2 , X^3 , X^4 , A^1 , A^2 , A^3 , A^4 , A^5 , A^6 , A^7 , and A^8 are C or N;

at least one of A^1 , A^2 , A^3 , A^4 , A^5 , A^6 , A^7 , and A^8 is N;

ring B is bonded to ring A through a C—C bond;

M is bonded to ring A through a M—C bond;

X is O, S, or Se;

rings C, and D are each independently a 5 or 6-membered carbocyclic or heterocyclic ring;

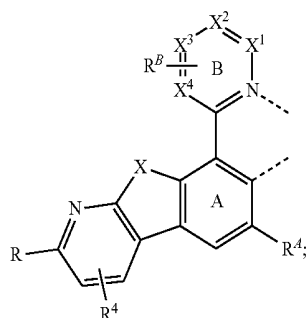
R^A represents mono, or di-substitution, or no substitution;

R^B represents di, tri, or tetra-substitution;

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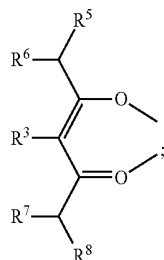
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In some more specific embodiments, wherein L_A has the formula:



wherein R is selected from the group consisting of alkyl, cycloalkyl, and combinations thereof. In some embodiments, R is selected from the group consisting of 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, cyclopentyl, cyclohexyl, partially or fully deuterated variants thereof, and combinations thereof.

In some embodiments, L_B has the formula:

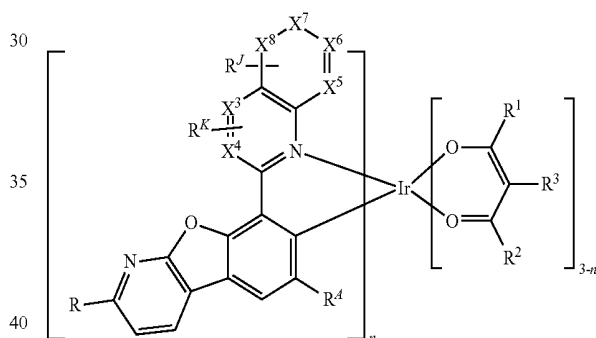
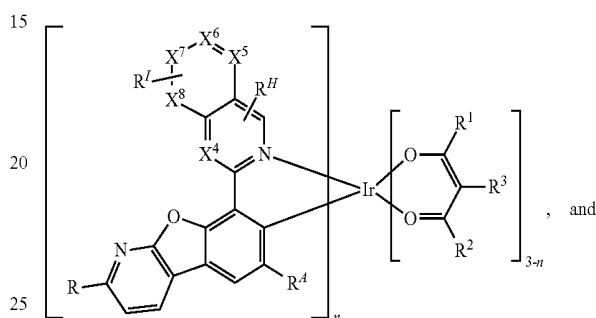
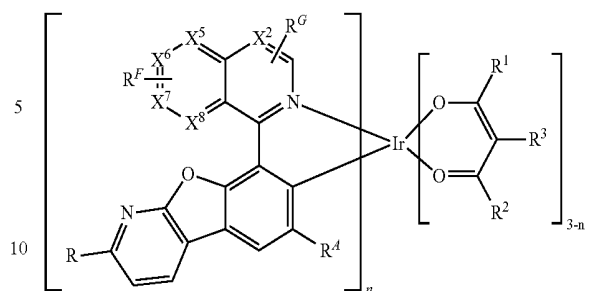


wherein R^5 , R^6 , R^7 , and R^8 are independently selected from group consisting of alkyl, cycloalkyl, aryl, and heteroaryl; and wherein at least one of R^5 , R^6 , R^7 , and R^8 has at least two C atoms.

In some embodiments, each R^1 , R^2 , R^3 , R^C , and R^D is independently selected from group consisting of hydrogen, deuterium, alkyl, cycloalkyl, and combinations thereof. In some embodiments, R^3 is hydrogen. In some embodiments, each R^1 , R^2 , R^3 , R^C , and R^D is independently selected from the group consisting of 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, cyclobutyl, cyclopentyl, cyclohexyl, partially or fully deuterated variants thereof, and combinations thereof.

In some more specific embodiments, the compound is selected from the group consisting of:

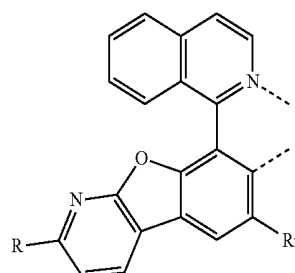
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wherein each of R^F , R^G , R^H , R^I , R^J , and R^K are independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof; and wherein X^5 , X^6 , X^7 , and X^8 are C or N.

In some specific embodiments, L_A is selected from the group consisting of:

L_{A1} through L_{A13} , each represented by the formula

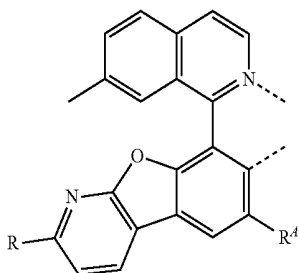


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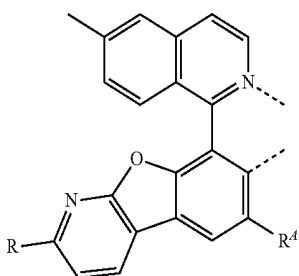
wherein L_{A11} , $R = H$, and $R^A = H$,
 in L_{A12} , $R = H$, and $R^A = CH_3$,
 in L_{A13} , $R = H$, and $R^A = CD_3$,
 in L_{A14} , $R = CH_3$, and $R^A = H$,
 in L_{A15} , $R = CD_3$, and $R^A = H$,
 in L_{A16} , $R = CH_3$, and $R^A = CH_3$,
 in L_{A17} , $R = CD_3$, and $R^A = CD_3$,
 in L_{A18} , $R = Ethyl$, and $R^A = H$,
 in L_{A19} , $R = Ethyl$, and $R^A = CH_3$,
 in L_{A20} , $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A21} , $R = isopropyl$, and $R^A = H$,
 in L_{A22} , $R = isopropyl$, and $R^A = CH_3$,
 in L_{A23} , $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A14} through L_{A26} , each represented by the formula



wherein L_{A14} , $R = H$, and $R^A = H$,
 in L_{A15} , $R = H$, and $R^A = CH_3$,
 in L_{A16} , $R = H$, and $R^A = CD_3$,
 in L_{A17} , $R = CH_3$, and $R^A = H$,
 in L_{A18} , $R = CD_3$, and $R^A = H$,
 in L_{A19} , $R = CH_3$, and $R^A = CH_3$,
 in L_{A20} , $R = CD_3$, and $R^A = CD_3$,
 in L_{A21} , $R = Ethyl$, and $R^A = H$,
 in L_{A22} , $R = Ethyl$, and $R^A = CH_3$,
 in L_{A23} , $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A24} , $R = isopropyl$, and $R^A = H$,
 in L_{A25} , $R = isopropyl$, and $R^A = CH_3$,
 in L_{A26} , $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A27} through L_{A39} , each represented by the formula

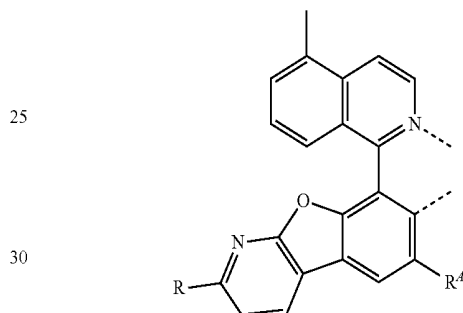


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wherein L_{A27} , $R = H$, and $R^A = H$,
 in L_{A28} , $R = H$, and $R^A = CH_3$,
 5 in L_{A29} , $R = H$, and $R^A = CD_3$,
 in L_{A30} , $R = CH_3$, and $R^A = H$,
 in L_{A31} , $R = CD_3$, and $R^A = H$,
 in L_{A32} , $R = CH_3$, and $R^A = CH_3$,
 in L_{A33} , $R = CD_3$, and $R^A = CD_3$,
 10 in L_{A34} , $R = Ethyl$, and $R^A = H$,
 in L_{A35} , $R = Ethyl$, and $R^A = CH_3$,
 in L_{A36} , $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A37} , $R = isopropyl$, and $R^A = H$,
 in L_{A38} , $R = isopropyl$, and $R^A = CH_3$,
 15 in L_{A39} , $R = isopropyl-d7$, and $R^A = CD_3$,

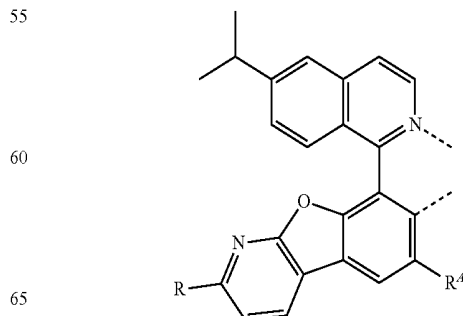
20 L_{A40} through L_{A52} , each represented by the formula



wherein L_{A40} , $R = H$, and $R^A = H$,
 in L_{A41} , $R = H$, and $R^A = CH_3$,
 35 in L_{A42} , $R = H$, and $R^A = CD_3$,
 in L_{A43} , $R = CH_3$, and $R^A = H$,
 in L_{A44} , $R = CD_3$, and $R^A = H$,
 in L_{A45} , $R = CH_3$, and $R^A = CH_3$,
 in L_{A46} , $R = CD_3$, and $R^A = CD_3$,
 40 in L_{A47} , $R = Ethyl$, and $R^A = H$,
 in L_{A48} , $R = Ethyl$, and $R^A = CH_3$,
 in L_{A49} , $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A50} , $R = isopropyl$, and $R^A = H$,
 in L_{A51} , $R = isopropyl$, and $R^A = CH_3$,
 45 in L_{A52} , $R = isopropyl-d7$, and $R^A = CD_3$,

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L_{A53} through L_{A65} , each represented by the formula

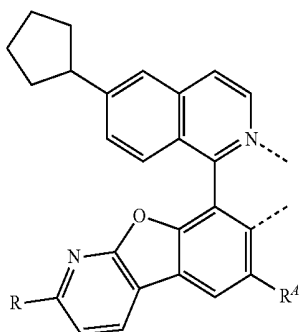


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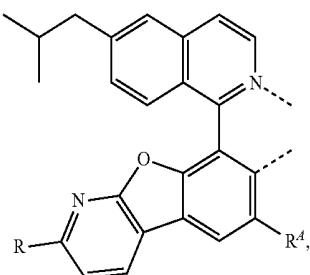
wherein L_{A53} : $R = H$, and $R^A = H$,
 in L_{A54} : $R = H$, and $R^A = CH_3$,
 in L_{A55} : $R = H$, and $R^A = CD_3$,
 in L_{A56} : $R = CH_3$, and $R^A = H$,
 in L_{A57} : $R = CD_3$, and $R^A = H$,
 in L_{A58} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A59} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A60} : $R = Ethyl$, and $R^A = H$,
 in L_{A61} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A62} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A63} : $R = isopropyl$, and $R^A = H$,
 in L_{A64} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A65} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A66} through L_{A78} , each represented by the formula



wherein L_{A66} : $R = H$, and $R^A = H$,
 in L_{A67} : $R = H$, and $R^A = CH_3$,
 in L_{A68} : $R = H$, and $R^A = CD_3$,
 in L_{A69} : $R = CH_3$, and $R^A = H$,
 in L_{A70} : $R = CD_3$, and $R^A = H$,
 in L_{A71} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A72} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A73} : $R = Ethyl$, and $R^A = H$,
 in L_{A74} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A75} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A76} : $R = isopropyl$, and $R^A = H$,
 in L_{A77} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A78} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A79} through L_{A91} , each represented by the formula



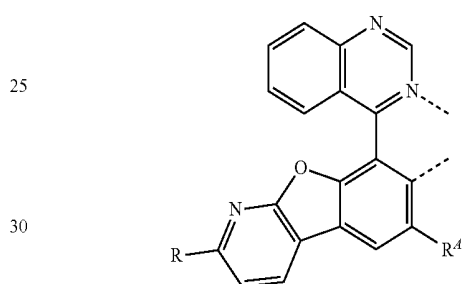
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wherein L_{A79} : $R = H$, and $R^A = H$,
 in L_{A80} : $R = H$, and $R^A = CH_3$,
 in L_{A81} : $R = H$, and $R^A = CD_3$,
 in L_{A82} : $R = CH_3$, and $R^A = H$,
 in L_{A83} : $R = CD_3$, and $R^A = H$,
 in L_{A84} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A85} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A86} : $R = Ethyl$, and $R^A = H$,
 in L_{A87} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A88} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A89} : $R = isopropyl$, and $R^A = H$,
 in L_{A90} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A91} : $R = isopropyl-d7$, and $R^A = CD_3$

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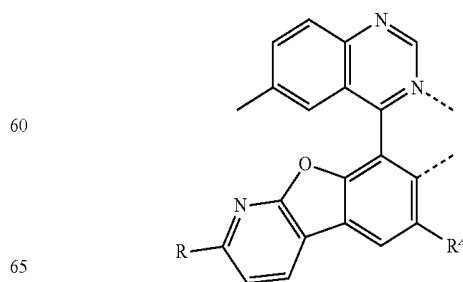
L_{A92} through L_{A104} , each represented by the formula



wherein L_{A92} : $R = H$, and $R^A = H$,
 in L_{A93} : $R = H$, and $R^A = CH_3$,
 in L_{A94} : $R = H$, and $R^A = CD_3$,
 in L_{A95} : $R = CH_3$, and $R^A = H$,
 in L_{A96} : $R = CD_3$, and $R^A = H$,
 in L_{A97} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A98} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A99} : $R = Ethyl$, and $R^A = H$,
 in L_{A100} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A101} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A102} : $R = isopropyl$, and $R^A = H$,
 in L_{A103} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A104} : $R = isopropyl-d7$, and $R^A = CD_3$,

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L_{A105} through L_{A117} , each represented by the formula

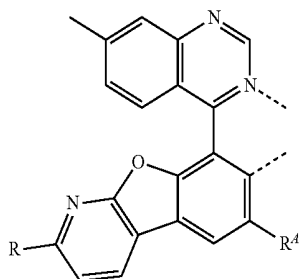


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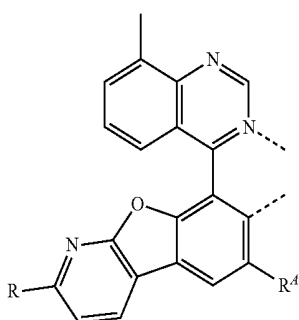
wherein L_{A105} : $R = H$, and $R^A = H$,
 in L_{A106} : $R = H$, and $R^A = CH_3$,
 in L_{A107} : $R = H$, and $R^A = CD_3$,
 in L_{A108} : $R = CH_3$, and $R^A = H$,
 in L_{A109} : $R = CD_3$, and $R^A = H$,
 in L_{A110} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A111} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A112} : $R = Ethyl$, and $R^A = H$,
 in L_{A113} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A114} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A115} : $R = isopropyl$, and $R^A = H$,
 in L_{A116} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A117} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A118} through L_{A130} , each represented by the formula



wherein L_{A118} : $R = H$, and $R^A = H$,
 in L_{A119} : $R = H$, and $R^A = CH_3$,
 in L_{A120} : $R = H$, and $R^A = CD_3$,
 in L_{A121} : $R = CH_3$, and $R^A = H$,
 in L_{A122} : $R = CD_3$, and $R^A = H$,
 in L_{A123} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A124} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A125} : $R = Ethyl$, and $R^A = H$,
 in L_{A126} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A127} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A128} : $R = isopropyl$, and $R^A = H$,
 in L_{A129} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A130} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A131} through L_{A143} , each represented by the formula

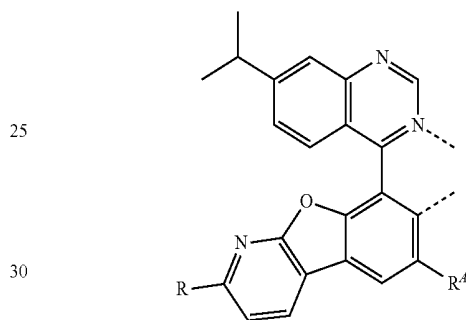


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wherein L_{A131} : $R = H$, and $R^A = H$,
 in L_{A132} : $R = H$, and $R^A = CH_3$,
 in L_{A133} : $R = H$, and $R^A = CD_3$,
 in L_{A134} : $R = CH_3$, and $R^A = H$,
 in L_{A135} : $R = CD_3$, and $R^A = H$,
 in L_{A136} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A137} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A138} : $R = Ethyl$, and $R^A = H$,
 in L_{A139} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A140} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A141} : $R = isopropyl$, and $R^A = H$,
 in L_{A142} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A143} : $R = isopropyl-d7$, and $R^A = CD_3$,

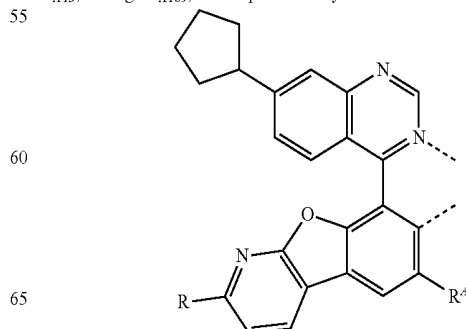
L_{A144} through L_{A156} , each represented by the formula



wherein L_{A144} : $R = H$, and $R^A = H$,
 in L_{A145} : $R = H$, and $R^A = CH_3$,
 in L_{A146} : $R = H$, and $R^A = CD_3$,
 in L_{A147} : $R = CH_3$, and $R^A = H$,
 in L_{A148} : $R = CD_3$, and $R^A = H$,
 in L_{A149} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A150} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A151} : $R = Ethyl$, and $R^A = H$,
 in L_{A152} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A153} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A154} : $R = isopropyl$, and $R^A = H$,
 in L_{A155} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A156} : $R = isopropyl-d7$, and $R^A = CD_3$,

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L_{A157} through L_{A169} , each represented by the formula

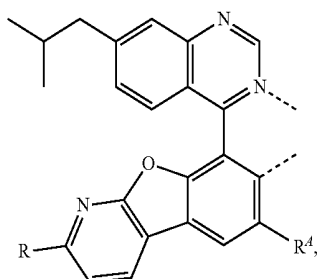


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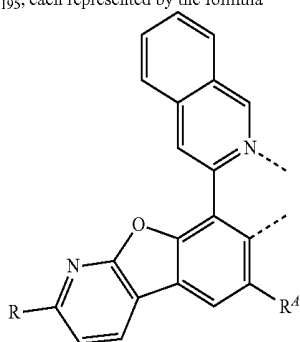
wherein L_{A157} : R = H, and R^A = H,
 in L_{A158} : R = H, and R^A = CH₃,
 in L_{A159} : R = H, and R^A = CD₃,
 in L_{A160} : R = CH₃, and R^A = H,
 in L_{A161} : R = CD₃, and R^A = H,
 in L_{A162} : R = CH₃, and R^A = CH₃,
 in L_{A163} : R = CD₃, and R^A = CD₃,
 in L_{A164} : R = Ethyl, and R^A = H,
 in L_{A165} : R = Ethyl, and R^A = CH₃,
 in L_{A166} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A167} : R = isopropyl, and R^A = H,
 in L_{A168} : R = isopropyl, and R^A = CH₃,
 in L_{A169} : R = isopropyl-d7, and R^A = CD₃,

L_{A170} through L_{A182} , each represented by the formula



wherein L_{A170} : R = H, and R^A = H,
 in L_{A171} : R = H, and R^A = CH₃,
 in L_{A172} : R = H, and R^A = CD₃,
 in L_{A173} : R = CH₃, and R^A = H,
 in L_{A174} : R = CD₃, and R^A = H,
 in L_{A175} : R = CH₃, and R^A = CH₃,
 in L_{A176} : R = CD₃, and R^A = CD₃,
 in L_{A177} : R = Ethyl, and R^A = H,
 in L_{A178} : R = Ethyl, and R^A = CH₃,
 in L_{A179} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A180} : R = isopropyl, and R^A = H,
 in L_{A181} : R = isopropyl, and R^A = CH₃,
 in L_{A182} : R = isopropyl-d7, and R^A = CD₃

L_{A183} through L_{A195} , each represented by the formula

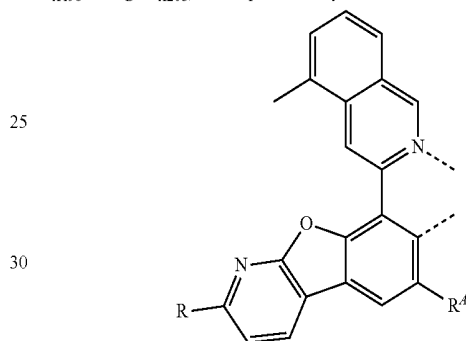


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wherein L_{A183} : R = H, and R^A = H,
 in L_{A184} : R = H, and R^A = CH₃,
 in L_{A185} : R = H, and R^A = CD₃,
 in L_{A186} : R = CH₃, and R^A = H,
 in L_{A187} : R = CD₃, and R^A = H,
 in L_{A188} : R = CH₃, and R^A = CH₃,
 in L_{A189} : R = CD₃, and R^A = CD₃,
 in L_{A190} : R = Ethyl, and R^A = H,
 in L_{A191} : R = Ethyl, and R^A = CH₃,
 in L_{A192} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A193} : R = isopropyl, and R^A = H,
 in L_{A194} : R = isopropyl, and R^A = CH₃,
 in L_{A195} : R = isopropyl-d7, and R^A = CD₃,

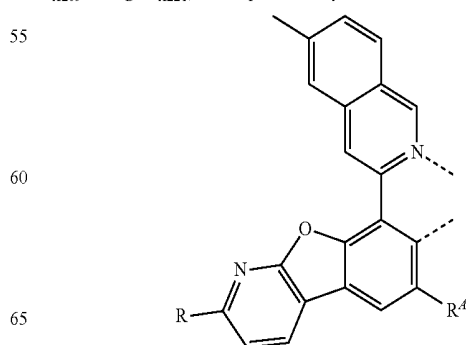
L_{A196} through L_{A208} , each represented by the formula



wherein L_{A196} : R = H, and R^A = H,
 in L_{A197} : R = H, and R^A = CH₃,
 in L_{A198} : R = H, and R^A = CD₃,
 in L_{A199} : R = CH₃, and R^A = H,
 in L_{A200} : R = CD₃, and R^A = H,
 in L_{A201} : R = CH₃, and R^A = CH₃,
 in L_{A202} : R = CD₃, and R^A = CD₃,
 in L_{A203} : R = Ethyl, and R^A = H,
 in L_{A204} : R = Ethyl, and R^A = CH₃,
 in L_{A205} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A206} : R = isopropyl, and R^A = H,
 in L_{A207} : R = isopropyl, and R^A = CH₃,
 in L_{A208} : R = isopropyl-d7, and R^A = CD₃,

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L_{A209} through L_{A221} , each represented by the formula



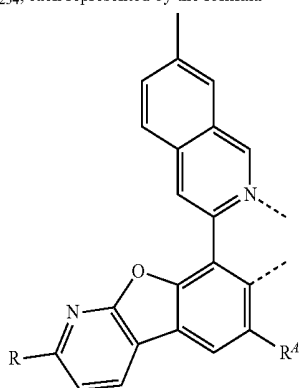
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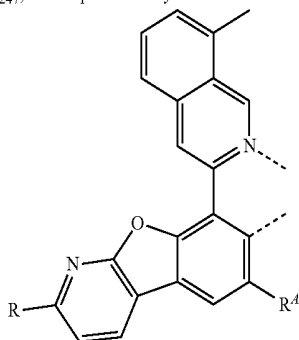
wherein L_{A209} : $R = H$, and $R^A = H$,
 in L_{A210} : $R = H$, and $R^A = CH_3$,
 in L_{A211} : $R = H$, and $R^A = CD_3$,
 in L_{A212} : $R = CH_3$, and $R^A = H$,
 in L_{A213} : $R = CD_3$, and $R^A = H$,
 in L_{A214} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A215} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A216} : $R = Ethyl$, and $R^A = H$,
 in L_{A217} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A218} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A219} : $R = isopropyl$, and $R^A = H$,
 in L_{A220} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A221} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A222} through L_{A234} , each represented by the formula



wherein L_{A222} : $R = H$, and $R^A = H$,
 in L_{A223} : $R = H$, and $R^A = CH_3$,
 in L_{A224} : $R = H$, and $R^A = CD_3$,
 in L_{A225} : $R = CH_3$, and $R^A = H$,
 in L_{A226} : $R = CD_3$, and $R^A = H$,
 in L_{A227} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A228} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A229} : $R = Ethyl$, and $R^A = H$,
 in L_{A230} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A231} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A232} : $R = isopropyl$, and $R^A = H$,
 in L_{A233} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A234} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A235} through L_{A247} , each represented by the formula

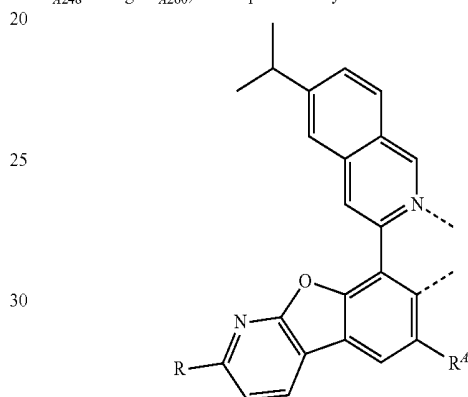


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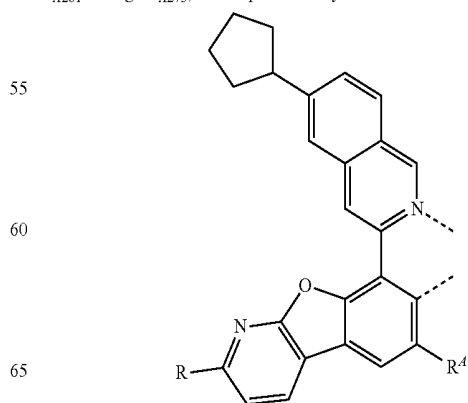
wherein L_{A235} : $R = H$, and $R^A = H$,
 in L_{A236} : $R = H$, and $R^A = CH_3$,
 in L_{A237} : $R = H$, and $R^A = CD_3$,
 in L_{A238} : $R = CH_3$, and $R^A = H$,
 in L_{A239} : $R = CD_3$, and $R^A = H$,
 in L_{A240} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A241} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A242} : $R = Ethyl$, and $R^A = H$,
 in L_{A243} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A244} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A245} : $R = isopropyl$, and $R^A = H$,
 in L_{A246} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A247} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A248} through L_{A260} , each represented by the formula



wherein L_{A248} : $R = H$, and $R^A = H$,
 in L_{A249} : $R = H$, and $R^A = CH_3$,
 in L_{A250} : $R = H$, and $R^A = CD_3$,
 in L_{A251} : $R = CH_3$, and $R^A = H$,
 in L_{A252} : $R = CD_3$, and $R^A = H$,
 in L_{A253} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A254} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A255} : $R = Ethyl$, and $R^A = H$,
 in L_{A256} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A257} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A258} : $R = isopropyl$, and $R^A = H$,
 in L_{A259} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A260} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A261} through L_{A273} , each represented by the formula

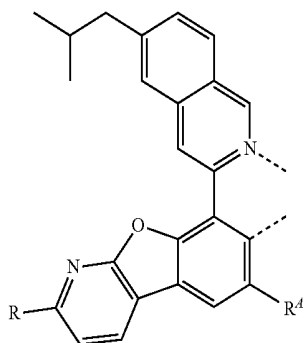


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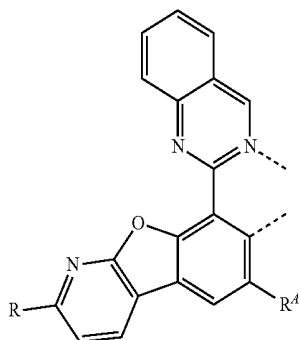
wherein L_{A261} : R = H, and R^A = H,
 in L_{A262} : R = H, and R^A = CH₃,
 in L_{A263} : R = H, and R^A = CD₃,
 in L_{A264} : R = CH₃, and R^A = H,
 in L_{A265} : R = CD₃, and R^A = H,
 in L_{A266} : R = CH₃, and R^A = CH₃,
 in L_{A267} : R = CD₃, and R^A = CD₃,
 in L_{A268} : R = Ethyl, and R^A = H,
 in L_{A269} : R = Ethyl, and R^A = CH₃,
 in L_{A270} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A271} : R = isopropyl, and R^A = H,
 in L_{A272} : R = isopropyl, and R^A = CH₃,
 in L_{A273} : R = isopropyl-d7, and R^A = CD₃,

L_{A274} through L_{A286} , each represented by the formula



wherein L_{A274} : R = H, and R^A = H,
 in L_{A275} : R = H, and R^A = CH₃,
 in L_{A276} : R = H, and R^A = CD₃,
 in L_{A277} : R = CH₃, and R^A = H,
 in L_{A278} : R = CD₃, and R^A = H,
 in L_{A279} : R = CH₃, and R^A = CH₃,
 in L_{A280} : R = CD₃, and R^A = CD₃,
 in L_{A281} : R = Ethyl, and R^A = H,
 in L_{A282} : R = Ethyl, and R^A = CH₃,
 in L_{A283} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A284} : R = isopropyl, and R^A = H,
 in L_{A285} : R = isopropyl, and R^A = CH₃,
 in L_{A286} : R = isopropyl-d7, and R^A = CD₃,

L_{A287} through L_{A299} , each represented by the formula

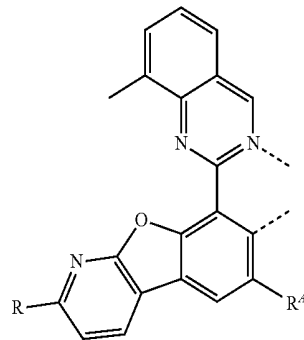


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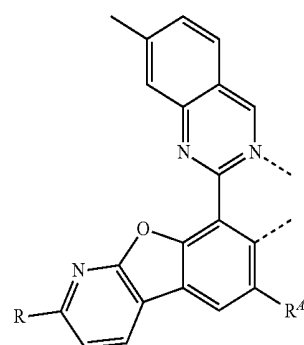
wherein L_{A287} : R = H, and R^A = H,
 in L_{A288} : R = H, and R^A = CH₃,
 in L_{A289} : R = H, and R^A = CD₃,
 in L_{A290} : R = CH₃, and R^A = H,
 in L_{A291} : R = CD₃, and R^A = H,
 in L_{A292} : R = CH₃, and R^A = CH₃,
 in L_{A293} : R = CD₃, and R^A = CD₃,
 in L_{A294} : R = Ethyl, and R^A = H,
 in L_{A295} : R = Ethyl, and R^A = CH₃,
 in L_{A296} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A297} : R = isopropyl, and R^A = H,
 in L_{A298} : R = isopropyl, and R^A = CH₃,
 in L_{A299} : R = isopropyl-d7, and R^A = CD₃,

L_{A300} through L_{A312} , each represented by the formula



wherein L_{A300} : R = H, and R^A = H,
 in L_{A301} : R = H, and R^A = CH₃,
 in L_{A302} : R = H, and R^A = CD₃,
 in L_{A303} : R = CH₃, and R^A = H,
 in L_{A304} : R = CD₃, and R^A = H,
 in L_{A305} : R = CH₃, and R^A = CH₃,
 in L_{A306} : R = CD₃, and R^A = CD₃,
 in L_{A307} : R = Ethyl, and R^A = H,
 in L_{A308} : R = Ethyl, and R^A = CH₃,
 in L_{A309} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A310} : R = isopropyl, and R^A = H,
 in L_{A311} : R = isopropyl, and R^A = CH₃,
 in L_{A312} : R = isopropyl-d7, and R^A = CD₃,

L_{A313} through L_{A325} , each represented by the formula

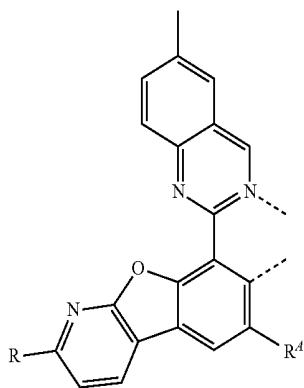


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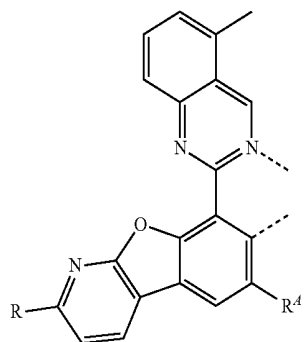
wherein L_{A313} : $R = H$, and $R^A = H$,
 in L_{A314} : $R = H$, and $R^A = CH_3$,
 in L_{A315} : $R = H$, and $R^A = CD_3$,
 in L_{A316} : $R = CH_3$, and $R^A = H$,
 in L_{A317} : $R = CD_3$, and $R^A = H$,
 in L_{A318} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A319} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A320} : $R = Ethyl$, and $R^A = H$,
 in L_{A321} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A322} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A323} : $R = isopropyl$, and $R^A = H$,
 in L_{A324} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A325} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A326} through L_{A338} , each represented by the formula



wherein L_{A326} : $R = H$, and $R^A = H$,
 in L_{A327} : $R = H$, and $R^A = CH_3$,
 in L_{A328} : $R = H$, and $R^A = CD_3$,
 in L_{A329} : $R = CH_3$, and $R^A = H$,
 in L_{A330} : $R = CD_3$, and $R^A = H$,
 in L_{A331} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A332} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A333} : $R = Ethyl$, and $R^A = H$,
 in L_{A334} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A335} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A336} : $R = isopropyl$, and $R^A = H$,
 in L_{A337} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A338} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A339} through L_{A351} , each represented by the formula

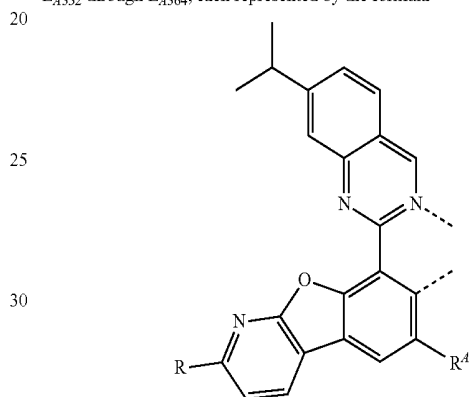


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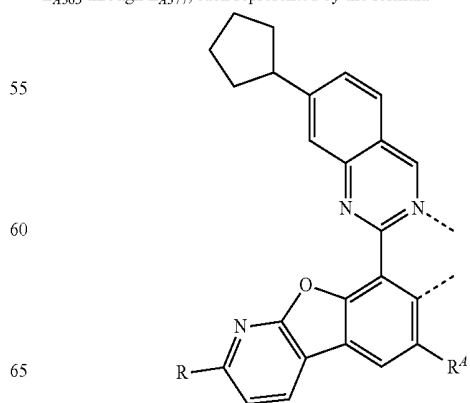
wherein L_{A339} : $R = H$, and $R^A = H$,
 in L_{A340} : $R = H$, and $R^A = CH_3$,
 in L_{A341} : $R = H$, and $R^A = CD_3$,
 in L_{A342} : $R = CH_3$, and $R^A = H$,
 in L_{A343} : $R = CD_3$, and $R^A = H$,
 in L_{A344} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A345} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A346} : $R = Ethyl$, and $R^A = H$,
 in L_{A347} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A348} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A349} : $R = isopropyl$, and $R^A = H$,
 in L_{A350} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A351} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A352} through L_{A364} , each represented by the formula



wherein L_{A352} : $R = H$, and $R^A = H$,
 in L_{A353} : $R = H$, and $R^A = CH_3$,
 in L_{A354} : $R = H$, and $R^A = CD_3$,
 in L_{A355} : $R = CH_3$, and $R^A = H$,
 in L_{A356} : $R = CD_3$, and $R^A = H$,
 in L_{A357} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A358} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A359} : $R = Ethyl$, and $R^A = H$,
 in L_{A360} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A361} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A362} : $R = isopropyl$, and $R^A = H$,
 in L_{A363} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A364} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A365} through L_{A377} , each represented by the formula

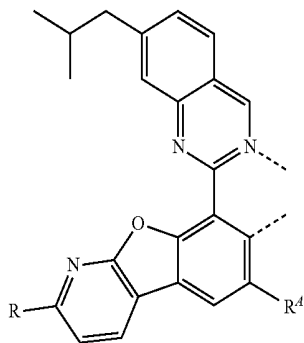


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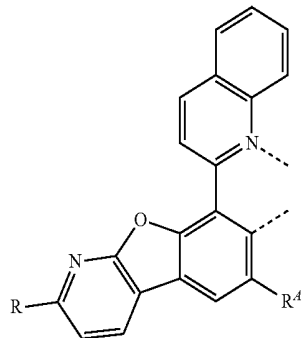
wherein L_{A365} : $R = H$, and $R^A = H$,
 in L_{A366} : $R = H$, and $R^A = CH_3$,
 in L_{A367} : $R = H$, and $R^A = CD_3$,
 in L_{A368} : $R = CH_3$, and $R^A = H$,
 in L_{A369} : $R = CD_3$, and $R^A = H$,
 in L_{A370} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A371} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A372} : $R = Ethyl$, and $R^A = H$,
 in L_{A373} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A374} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A375} : $R = isopropyl$, and $R^A = H$,
 in L_{A376} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A377} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A378} through L_{A390} , each represented by the formula



wherein L_{A378} : $R = H$, and $R^A = H$,
 in L_{A379} : $R = H$, and $R^A = CH_3$,
 in L_{A380} : $R = H$, and $R^A = CD_3$,
 in L_{A381} : $R = CH_3$, and $R^A = H$,
 in L_{A382} : $R = CD_3$, and $R^A = H$,
 in L_{A383} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A384} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A385} : $R = Ethyl$, and $R^A = H$,
 in L_{A386} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A387} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A388} : $R = isopropyl$, and $R^A = H$,
 in L_{A389} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A390} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A391} through L_{A403} , each represented by the formula

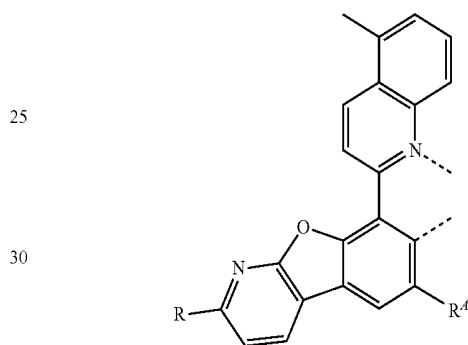


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wherein L_{A391} : $R = H$, and $R^A = H$,
 in L_{A392} : $R = H$, and $R^A = CH_3$,
 in L_{A393} : $R = H$, and $R^A = CD_3$,
 in L_{A394} : $R = CH_3$, and $R^A = H$,
 in L_{A395} : $R = CD_3$, and $R^A = H$,
 in L_{A396} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A397} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A398} : $R = Ethyl$, and $R^A = H$,
 in L_{A399} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A400} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A401} : $R = isopropyl$, and $R^A = H$,
 in L_{A402} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A403} : $R = isopropyl-d7$, and $R^A = CD_3$,

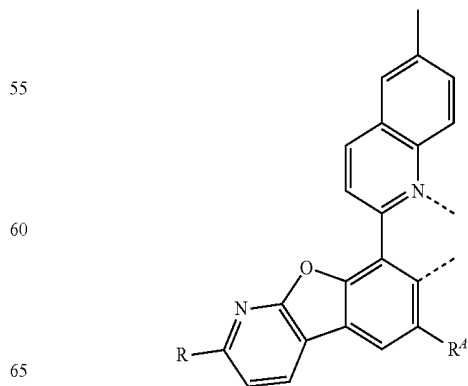
L_{A404} through L_{A416} , each represented by the formula



wherein L_{A404} : $R = H$, and $R^A = H$,
 in L_{A405} : $R = H$, and $R^A = CH_3$,
 in L_{A406} : $R = H$, and $R^A = CD_3$,
 in L_{A407} : $R = CH_3$, and $R^A = H$,
 in L_{A408} : $R = CD_3$, and $R^A = H$,
 in L_{A409} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A410} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A411} : $R = Ethyl$, and $R^A = H$,
 in L_{A412} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A413} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A414} : $R = isopropyl$, and $R^A = H$,
 in L_{A415} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A416} : $R = isopropyl-d7$, and $R^A = CD_3$,

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L_{A417} through L_{A429} , each represented by the formula

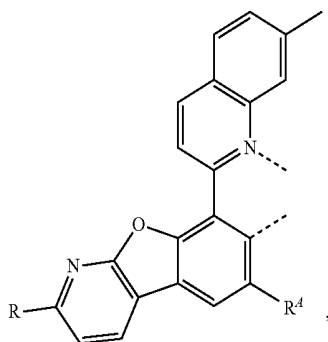


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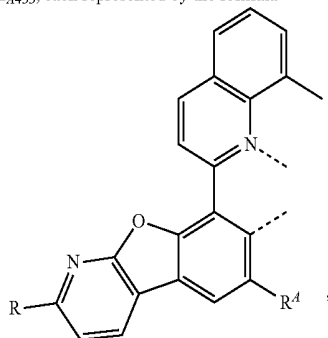
wherein L_{A417} : $R = H$, and $R^A = H$,
 in L_{A418} : $R = H$, and $R^A = CH_3$,
 in L_{A419} : $R = H$, and $R^A = CD_3$,
 in L_{A420} : $R = CH_3$, and $R^A = H$,
 in L_{A421} : $R = CD_3$, and $R^A = H$,
 in L_{A422} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A423} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A424} : $R = Ethyl$, and $R^A = H$,
 in L_{A425} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A426} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A427} : $R = isopropyl$, and $R^A = H$,
 in L_{A428} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A429} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A430} through L_{A442} , each represented by the formula



wherein L_{A430} : $R = H$, and $R^A = H$,
 in L_{A431} : $R = H$, and $R^A = CH_3$,
 in L_{A432} : $R = H$, and $R^A = CD_3$,
 in L_{A433} : $R = CH_3$, and $R^A = H$,
 in L_{A434} : $R = CD_3$, and $R^A = H$,
 in L_{A435} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A436} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A437} : $R = Ethyl$, and $R^A = H$,
 in L_{A438} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A439} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A440} : $R = isopropyl$, and $R^A = H$,
 in L_{A441} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A442} : $R = isopropyl-d7$, and $R^A = CD_3$

L_{A443} through L_{A455} , each represented by the formula

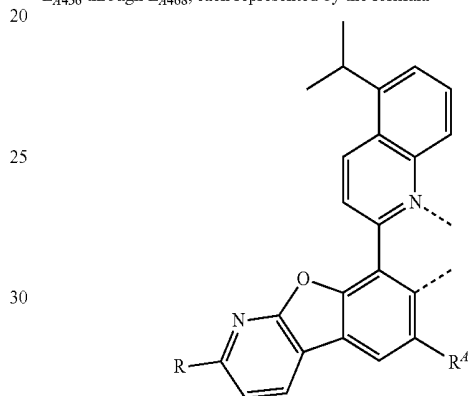


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wherein L_{A443} : $R = H$, and $R^A = H$,
 in L_{A444} : $R = H$, and $R^A = CH_3$,
 in L_{A445} : $R = H$, and $R^A = CD_3$,
 in L_{A446} : $R = CH_3$, and $R^A = H$,
 in L_{A447} : $R = CD_3$, and $R^A = H$,
 in L_{A448} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A449} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A450} : $R = Ethyl$, and $R^A = H$,
 in L_{A451} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A452} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A453} : $R = isopropyl$, and $R^A = H$,
 in L_{A454} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A455} : $R = isopropyl-d7$, and $R^A = CD_3$

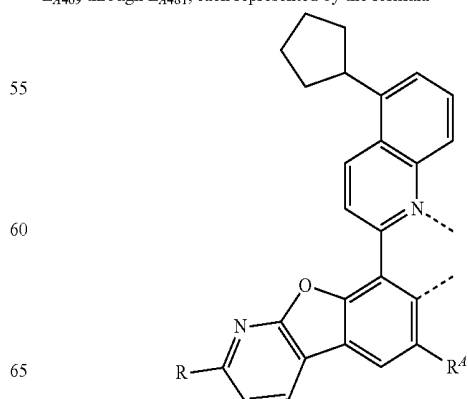
L_{A456} through L_{A468} , each represented by the formula



wherein L_{A456} : $R = H$, and $R^A = H$,
 in L_{A457} : $R = H$, and $R^A = CH_3$,
 in L_{A458} : $R = H$, and $R^A = CD_3$,
 in L_{A459} : $R = CH_3$, and $R^A = H$,
 in L_{A460} : $R = CD_3$, and $R^A = H$,
 in L_{A461} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A462} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A463} : $R = Ethyl$, and $R^A = H$,
 in L_{A464} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A465} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A466} : $R = isopropyl$, and $R^A = H$,
 in L_{A467} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A468} : $R = isopropyl-d7$, and $R^A = CD_3$

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L_{A469} through L_{A481} , each represented by the formula

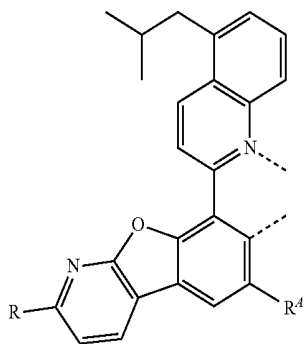


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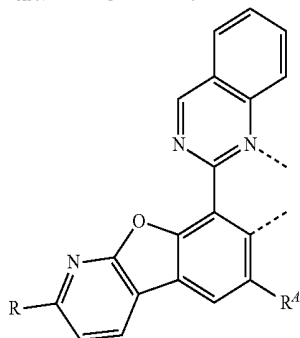
wherein L_{A469} : R = H, and R^A = H,
 in L_{A470} : R = H, and R^A = CH₃,
 in L_{A471} : R = H, and R^A = CD₃,
 in L_{A472} : R = CH₃, and R^A = H,
 in L_{A473} : R = CD₃, and R^A = H,
 in L_{A474} : R = CH₃, and R^A = CH₃,
 in L_{A475} : R = CD₃, and R^A = CD₃,
 in L_{A476} : R = Ethyl, and R^A = H,
 in L_{A477} : R = Ethyl, and R^A = CH₃,
 in L_{A478} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A479} : R = isopropyl, and R^A = H,
 in L_{A480} : R = isopropyl, and R^A = CH₃,
 in L_{A481} : R = isopropyl-d7, and R^A = CD₃,

L_{A482} through L_{A494} , each represented by the formula



wherein L_{A482} : R = H, and R^A = H,
 in L_{A483} : R = H, and R^A = CH₃,
 in L_{A484} : R = H, and R^A = CD₃,
 in L_{A485} : R = CH₃, and R^A = H,
 in L_{A486} : R = CD₃, and R^A = H,
 in L_{A487} : R = CH₃, and R^A = CH₃,
 in L_{A488} : R = CD₃, and R^A = CD₃,
 in L_{A489} : R = Ethyl, and R^A = H,
 in L_{A490} : R = Ethyl, and R^A = CH₃,
 in L_{A491} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A492} : R = isopropyl, and R^A = H,
 in L_{A493} : R = isopropyl, and R^A = CH₃,
 in L_{A494} : R = isopropyl-d7, and R^A = CD₃,

L_{A495} through L_{A507} , each represented by the formula

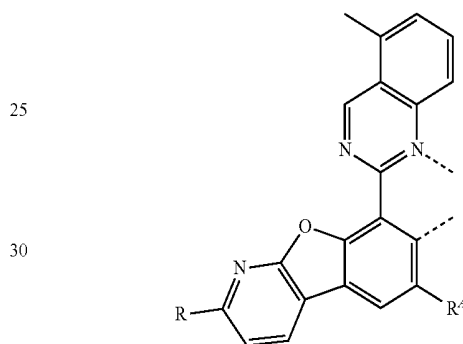


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wherein in L_{A495} : R = H, and R^A = H,
 in L_{A496} : R = H, and R^A = CH₃,
 5 in L_{A497} : R = H, and R^A = CD₃,
 in L_{A498} : R = CH₃, and R^A = H,
 in L_{A499} : R = CD₃, and R^A = H,
 in L_{A500} : R = CH₃, and R^A = CH₃,
 in L_{A501} : R = CD₃, and R^A = CD₃,
 10 in L_{A501} : R = Ethyl, and R^A = H,
 in L_{A503} : R = Ethyl, and R^A = CH₃,
 in L_{A504} : R = Ethyl-d5, and R^A = CD₃,
 in L_{A505} : R = isopropyl, and R^A = H,
 in L_{A506} : R = isopropyl, and R^A = CH₃,
 15 in L_{A507} : R = isopropyl-d7, and R^A = CD₃,

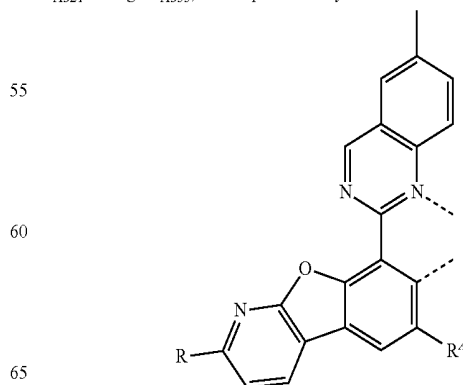
20 L_{A508} through L_{A520} , each represented by the formula



wherein in L_{A508} : R = H, and R^A = H,
 in L_{A509} : R = H, and R^A = CH₃,
 in L_{A510} : R = H, and R^A = CD₃,
 in L_{A511} : R = CH₃, and R^A = H,
 in L_{A512} : R = CD₃, and R^A = H,
 in L_{A513} : R = CH₃, and R^A = CH₃,
 40 in L_{A514} : R = CD₃, and R^A = CD₃,
 in L_{A515} : R = Ethyl, and R^A = H,
 in L_{A516} : R = Ethyl, and R^A = CH₃,
 in L_{A517} : R = Ethyl-d5, and R^A = CD₃,
 45 in L_{A518} : R = isopropyl, and R^A = H,
 in L_{A519} : R = isopropyl, and R^A = CH₃,
 in L_{A520} : R = isopropyl-d7, and R^A = CD₃,

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L_{A521} through L_{A533} , each represented by the formula



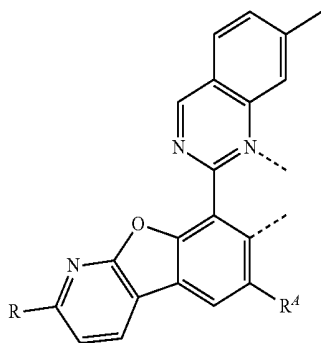
65

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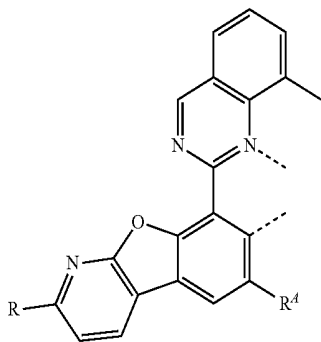
wherein in L_{A521} : $R = H$, and $R^A = H$,
 in L_{A522} : $R = H$, and $R^A = CH_3$,
 in L_{A523} : $R = H$, and $R^A = CD_3$,
 in L_{A524} : $R = CH_3$, and $R^A = H$,
 in L_{A525} : $R = CD_3$, and $R^A = H$,
 in L_{A526} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A527} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A528} : $R = Ethyl$, and $R^A = H$,
 in L_{A529} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A530} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A531} : $R = isopropyl$, and $R^A = H$,
 in L_{A532} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A533} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A534} through L_{A546} , each represented by the formula



wherein in L_{A534} : $R = H$, and $R^A = H$,
 in L_{A535} : $R = H$, and $R^A = CH_3$,
 in L_{A536} : $R = H$, and $R^A = CD_3$,
 in L_{A537} : $R = CH_3$, and $R^A = H$,
 in L_{A538} : $R = CD_3$, and $R^A = H$,
 in L_{A539} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A540} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A541} : $R = Ethyl$, and $R^A = H$,
 in L_{A542} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A543} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A544} : $R = isopropyl$, and $R^A = H$,
 in L_{A545} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A546} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A547} through L_{A559} , each represented by the formula

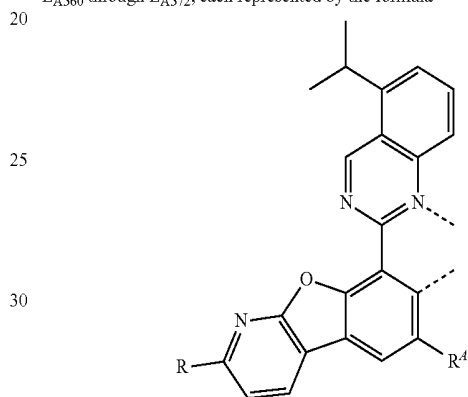


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wherein in L_{A547} : $R = H$, and $R^A = H$,
 in L_{A548} : $R = H$, and $R^A = CH_3$,
 in L_{A549} : $R = H$, and $R^A = CD_3$,
 in L_{A550} : $R = CH_3$, and $R^A = H$,
 in L_{A551} : $R = CD_3$, and $R^A = H$,
 in L_{A552} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A553} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A554} : $R = Ethyl$, and $R^A = H$,
 in L_{A555} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A556} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A557} : $R = isopropyl$, and $R^A = H$,
 in L_{A558} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A559} : $R = isopropyl-d7$, and $R^A = CD_3$,

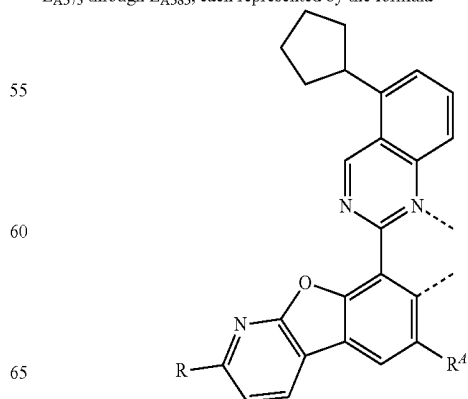
L_{A560} through L_{A572} , each represented by the formula



wherein in L_{A560} : $R = H$, and $R^A = H$,
 in L_{A561} : $R = H$, and $R^A = CH_3$,
 in L_{A562} : $R = H$, and $R^A = CD_3$,
 in L_{A563} : $R = CH_3$, and $R^A = H$,
 in L_{A564} : $R = CD_3$, and $R^A = H$,
 in L_{A565} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A566} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A567} : $R = Ethyl$, and $R^A = H$,
 in L_{A568} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A569} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A570} : $R = isopropyl$, and $R^A = H$,
 in L_{A571} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A572} : $R = isopropyl-d7$, and $R^A = CD_3$,

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L_{A573} through L_{A585} , each represented by the formula

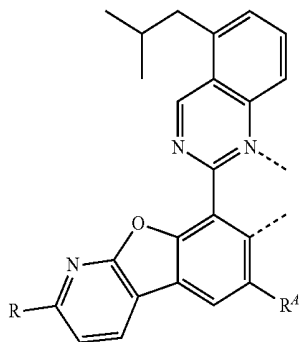


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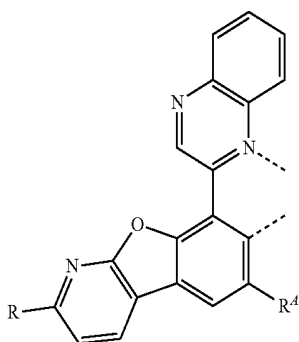
wherein in L_{A573} : $R = H$, and $R^A = H$,
 in L_{A574} : $R = H$, and $R^A = CH_3$,
 in L_{A575} : $R = H$, and $R^A = CD_3$,
 in L_{A576} : $R = CH_3$, and $R^A = H$,
 in L_{A577} : $R = CD_3$, and $R^A = H$,
 in L_{A578} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A579} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A580} : $R = \text{Ethyl}$, and $R^A = H$,
 in L_{A581} : $R = \text{Ethyl}$, and $R^A = CH_3$,
 in L_{A582} : $R = \text{Ethyl-d5}$, and $R^A = CD_3$,
 in L_{A583} : $R = \text{isopropyl}$, and $R^A = H$,
 in L_{A584} : $R = \text{isopropyl}$, and $R^A = CH_3$,
 in L_{A585} : $R = \text{isopropyl-d7}$, and $R^A = CD_3$,

L_{A586} through L_{A598} , each represented by the formula



wherein in L_{A586} : $R = H$, and $R^A = H$,
 in L_{A587} : $R = H$, and $R^A = CH_3$,
 in L_{A588} : $R = H$, and $R^A = CD_3$,
 in L_{A589} : $R = CH_3$, and $R^A = H$,
 in L_{A590} : $R = CD_3$, and $R^A = H$,
 in L_{A591} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A592} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A593} : $R = \text{Ethyl}$, and $R^A = H$,
 in L_{A594} : $R = \text{Ethyl}$, and $R^A = CH_3$,
 in L_{A595} : $R = \text{Ethyl-d5}$, and $R^A = CD_3$,
 in L_{A596} : $R = \text{isopropyl}$, and $R^A = H$,
 in L_{A597} : $R = \text{isopropyl}$, and $R^A = CH_3$,
 in L_{A598} : $R = \text{isopropyl-d7}$, and $R^A = CD_3$,

L_{A599} through L_{A611} , each represented by the formula

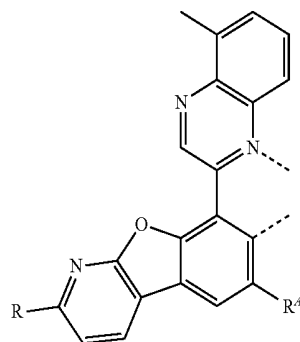


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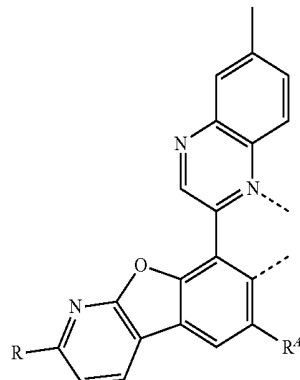
wherein in L_{A599} : $R = H$, and $R^A = H$,
 in L_{A600} : $R = H$, and $R^A = CH_3$,
 in L_{A601} : $R = H$, and $R^A = CD_3$,
 in L_{A602} : $R = CH_3$, and $R^A = H$,
 in L_{A603} : $R = CD_3$, and $R^A = H$,
 in L_{A604} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A605} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A606} : $R = \text{Ethyl}$, and $R^A = H$,
 in L_{A607} : $R = \text{Ethyl}$, and $R^A = CH_3$,
 in L_{A608} : $R = \text{Ethyl-d5}$, and $R^A = CD_3$,
 in L_{A609} : $R = \text{isopropyl}$, and $R^A = H$,
 in L_{A610} : $R = \text{isopropyl}$, and $R^A = CH_3$,
 in L_{A611} : $R = \text{isopropyl-d7}$, and $R^A = CD_3$,

L_{A612} through L_{A624} , each represented by the formula



wherein in L_{A612} : $R = H$, and $R^A = H$,
 in L_{A613} : $R = H$, and $R^A = CH_3$,
 in L_{A614} : $R = H$, and $R^A = CD_3$,
 in L_{A615} : $R = CH_3$, and $R^A = H$,
 in L_{A616} : $R = CD_3$, and $R^A = H$,
 in L_{A617} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A618} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A619} : $R = \text{Ethyl}$, and $R^A = H$,
 in L_{A620} : $R = \text{Ethyl}$, and $R^A = CH_3$,
 in L_{A621} : $R = \text{Ethyl-d5}$, and $R^A = CD_3$,
 in L_{A622} : $R = \text{isopropyl}$, and $R^A = H$,
 in L_{A623} : $R = \text{isopropyl}$, and $R^A = CH_3$,
 in L_{A624} : $R = \text{isopropyl-d7}$, and $R^A = CD_3$,

L_{A625} through L_{A637} , each represented by the formula

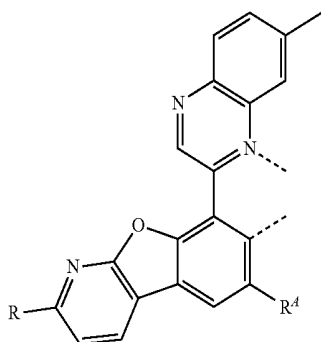


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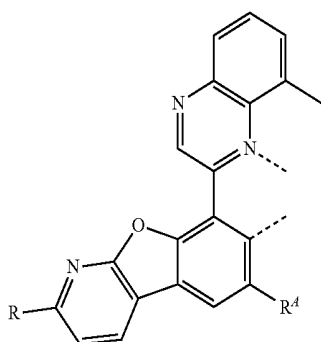
wherein in L_{A625} : $R = H$, and $R^A = H$,
 in L_{A626} : $R = H$, and $R^A = CH_3$,
 in L_{A627} : $R = H$, and $R^A = CD_3$,
 in L_{A628} : $R = CH_3$, and $R^A = H$,
 in L_{A629} : $R = CD_3$, and $R^A = H$,
 in L_{A630} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A631} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A632} : $R = Ethyl$, and $R^A = H$,
 in L_{A633} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A634} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A635} : $R = isopropyl$, and $R^A = H$,
 in L_{A636} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A637} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A638} through L_{A650} , each represented by the formula



wherein in L_{A638} : $R = H$, and $R^A = H$,
 in L_{A639} : $R = H$, and $R^A = CH_3$,
 in L_{A640} : $R = H$, and $R^A = CD_3$,
 in L_{A641} : $R = CH_3$, and $R^A = H$,
 in L_{A642} : $R = CD_3$, and $R^A = H$,
 in L_{A643} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A644} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A645} : $R = Ethyl$, and $R^A = H$,
 in L_{A646} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A647} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A648} : $R = isopropyl$, and $R^A = H$,
 in L_{A649} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A650} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A651} through L_{A663} , each represented by the formula

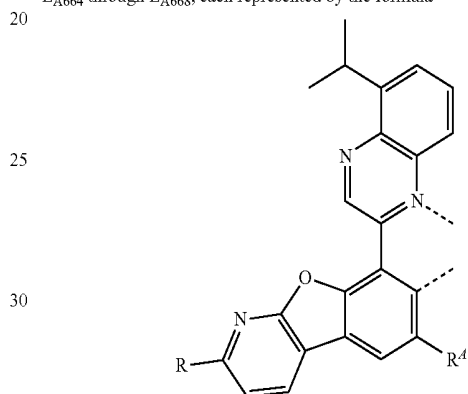


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wherein in L_{A651} : $R = H$, and $R^A = H$,
 in L_{A652} : $R = H$, and $R^A = CH_3$,
 5 in L_{A653} : $R = H$, and $R^A = CD_3$,
 in L_{A654} : $R = CH_3$, and $R^A = H$,
 in L_{A655} : $R = CD_3$, and $R^A = H$,
 in L_{A656} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A657} : $R = CD_3$, and $R^A = CD_3$,
 10 in L_{A658} : $R = Ethyl$, and $R^A = H$,
 in L_{A659} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A660} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A661} : $R = isopropyl$, and $R^A = H$,
 in L_{A662} : $R = isopropyl$, and $R^A = CH_3$,
 15 in L_{A663} : $R = isopropyl-d7$, and $R^A = CD_3$,

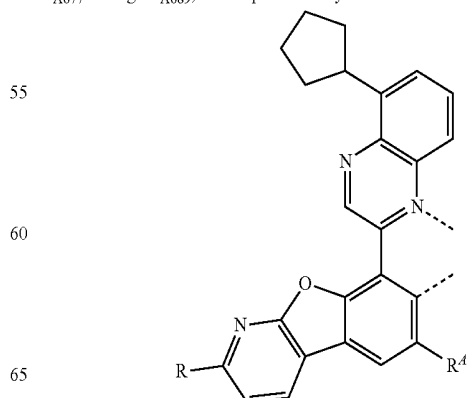
L_{A664} through L_{A668} , each represented by the formula



wherein in L_{A664} : $R = H$, and $R^A = H$,
 in L_{A665} : $R = H$, and $R^A = CH_3$,
 in L_{A666} : $R = H$, and $R^A = CD_3$,
 in L_{A667} : $R = CH_3$, and $R^A = H$,
 in L_{A668} : $R = CD_3$, and $R^A = H$,
 40 in L_{A669} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A670} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A671} : $R = Ethyl$, and $R^A = H$,
 in L_{A672} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A673} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A674} : $R = isopropyl$, and $R^A = H$,
 45 in L_{A675} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A676} : $R = isopropyl-d7$, and $R^A = CD_3$,

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L_{A677} through L_{A689} , each represented by the formula

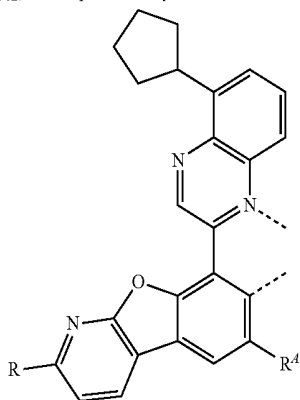


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wherein in L_{A677} : $R = H$, and $R^A = H$,
 in L_{A678} : $R = H$, and $R^A = CH_3$,
 in L_{A679} : $R = H$, and $R^A = CD_3$,
 in L_{A680} : $R = CH_3$, and $R^A = H$,
 in L_{A681} : $R = CD_3$, and $R^A = H$,
 in L_{A682} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A683} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A684} : $R = Ethyl$, and $R^A = H$,
 in L_{A685} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A686} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A687} : $R = isopropyl$, and $R^A = H$,
 in L_{A688} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A689} : $R = isopropyl-d7$, and $R^A = CD_3$,

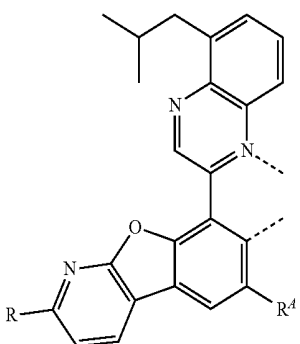
L_{A690} through L_{A702} , each represented by the formula



wherein in L_{A690} : $R = H$, and $R^A = H$,
 in L_{A691} : $R = H$, and $R^A = CH_3$,
 in L_{A692} : $R = H$, and $R^A = CD_3$,
 in L_{A693} : $R = CH_3$, and $R^A = H$,
 in L_{A694} : $R = CD_3$, and $R^A = H$,
 in L_{A695} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A696} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A697} : $R = Ethyl$, and $R^A = H$,
 in L_{A698} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A699} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A700} : $R = isopropyl$, and $R^A = H$,
 in L_{A701} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A702} : $R = isopropyl-d7$, and $R^A = CD_3$,

and

L_{A703} through L_{A715} , each represented by the formula



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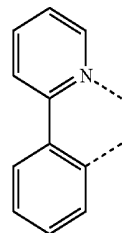
wherein in L_{A703} : $R = H$, and $R^A = H$,
 in L_{A704} : $R = H$, and $R^A = CH_3$,
 5 in L_{A705} : $R = H$, and $R^A = CD_3$,
 in L_{A706} : $R = CH_3$, and $R^A = H$,
 in L_{A707} : $R = CD_3$, and $R^A = H$,
 in L_{A708} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A709} : $R = CD_3$, and $R^A = CD_3$,
 10 in L_{A710} : $R = Ethyl$, and $R^A = H$,
 in L_{A711} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A712} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A713} : $R = isopropyl$, and $R^A = H$,
 in L_{A714} : $R = isopropyl$, and $R^A = CH_3$,
 15 in L_{A715} : $R = isopropyl-d7$, and $R^A = CD_3$.

In some specific embodiments, L_C is selected from the group consisting of:

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 L_{C1}

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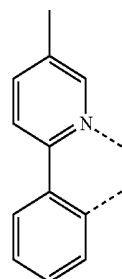


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 L_{C2}

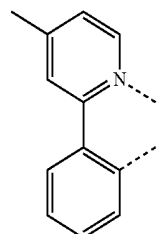
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45

 L_{C3}

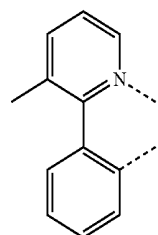
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 L_{C4}

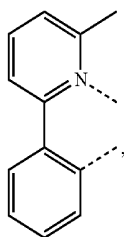
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L_{C5}

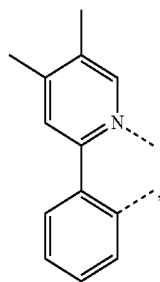
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L_{C6}

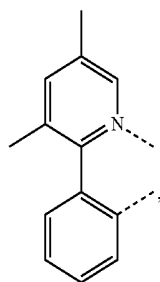
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L_{C7}

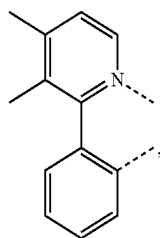
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L_{C8}

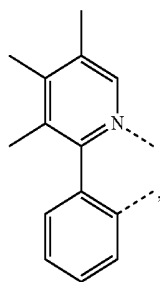
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L_{C9}

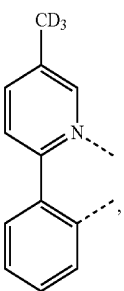
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L_{C10}

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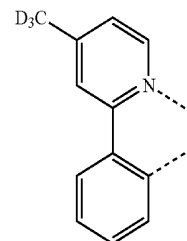
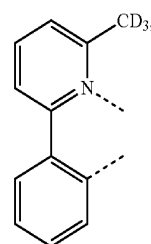
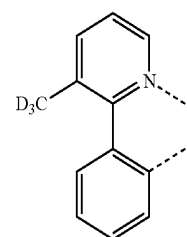
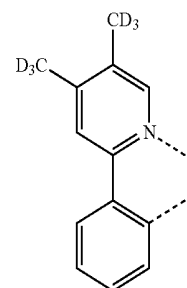
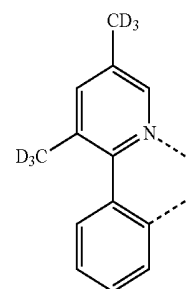
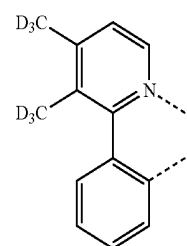
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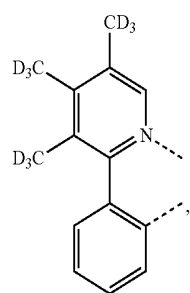
42

-continued

L_{C11}L_{C12}L_{C13}L_{C14}L_{C15}L_{C16}

43

-continued

L_{C17}

5

10

15

L_{C18}

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25

L_{C19}

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L_{C20}

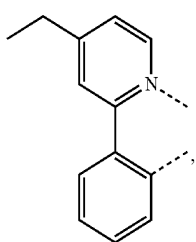
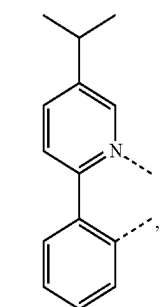
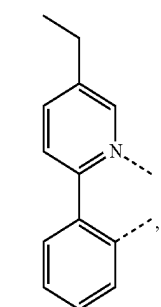
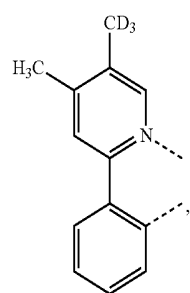
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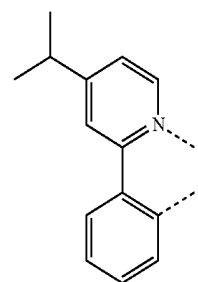
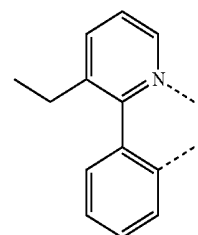
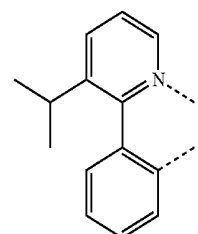
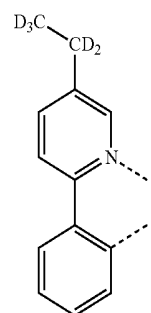
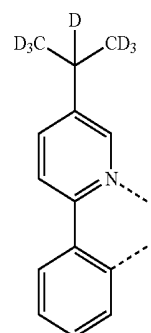
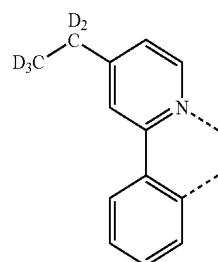
L_{C21}

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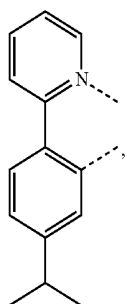
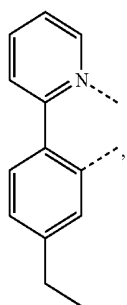
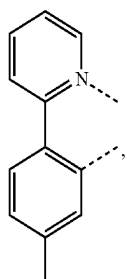
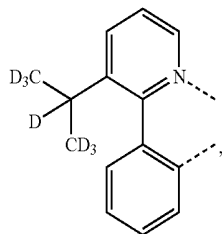
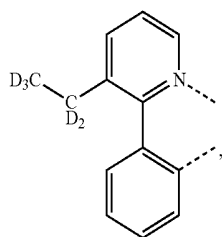
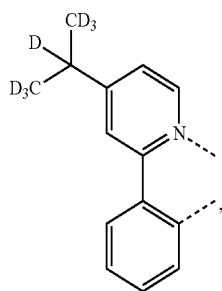
**44**

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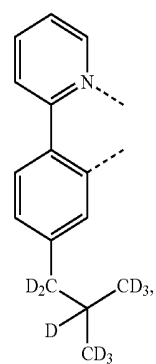
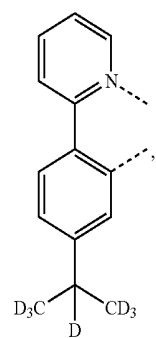
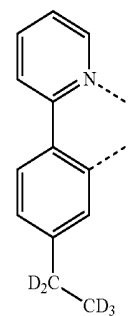
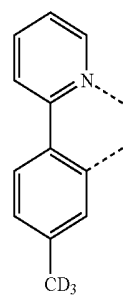
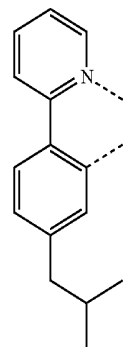
L_{C22}L_{C23}L_{C24}L_{C25}L_{C26}L_{C27}

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-continued

**46**

-continued

L_{C28}

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L_{C29}

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L_{C30}

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L_{C31}

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L_{C32}

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L_{C33}

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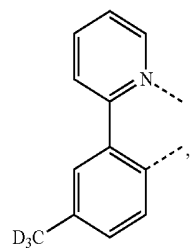
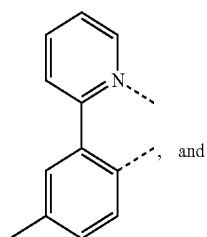
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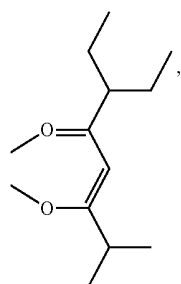
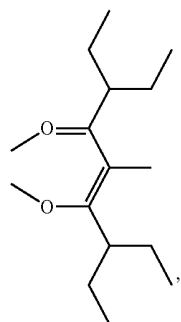
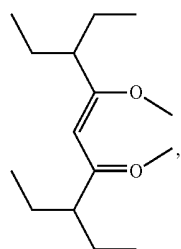
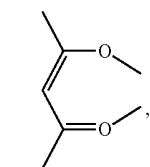
L_{C34}L_{C35}L_{C36}L_{C37}L_{C38}

47

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In some embodiments, L_B is selected from the group consisting of:

 L_{C39}

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 L_{C40}

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 L_{B42}

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 L_{B43}

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 L_{B44}

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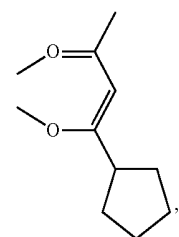
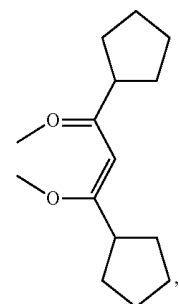
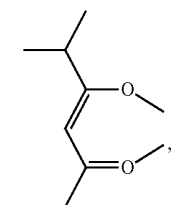
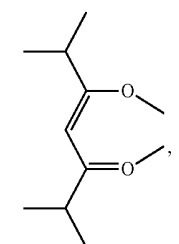
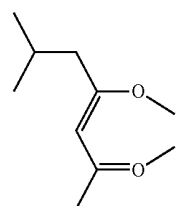
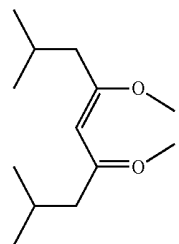
 L_{B45}

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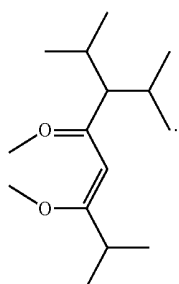
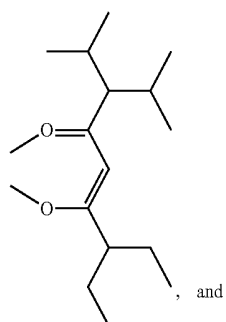
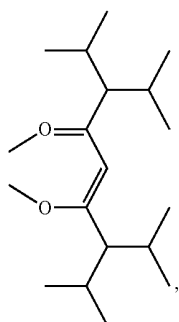
48

-continued

 L_{B46} L_{B47} L_{B48} L_{B49} L_{B50} L_{B51}

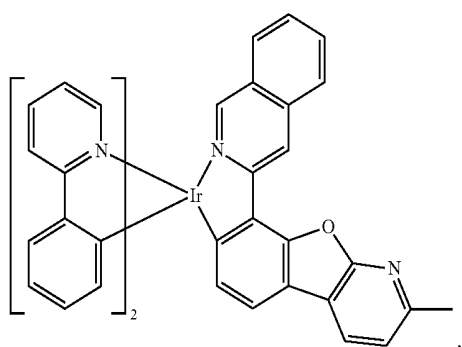
49

-continued



In some specific embodiments, the compound is selected from the group consisting of:

Compound 1



50

-continued

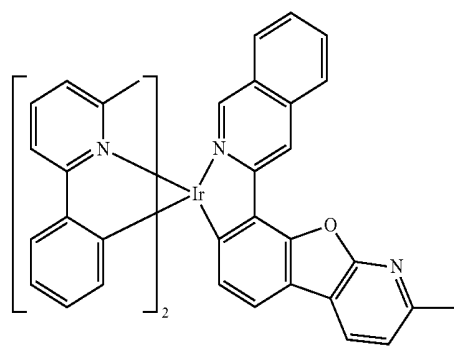
Compound 2

L_{B52}

5

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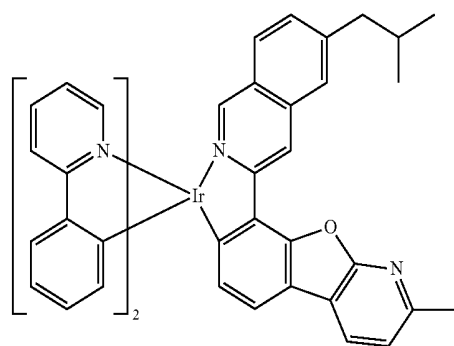
Compound 3

L_{B53}

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Compound 4

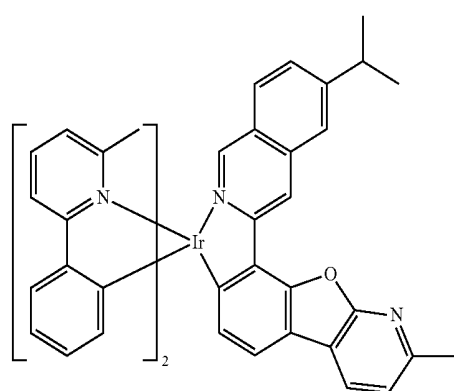
L_{B54}

35

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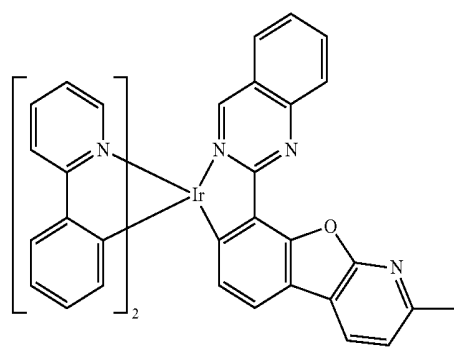


Compound 5

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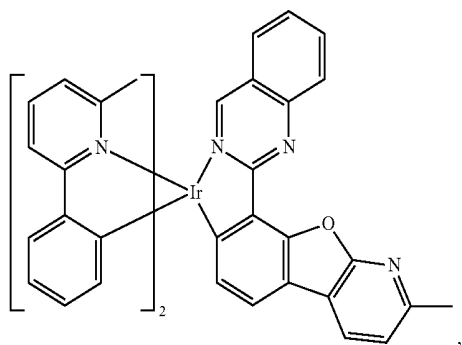
65



51

-continued

Compound 6

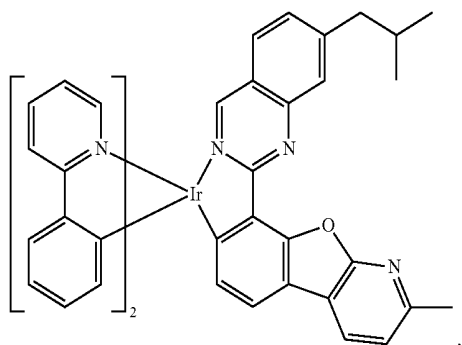


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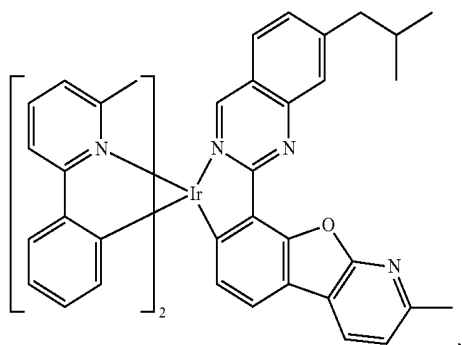
Compound 7



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Compound 8

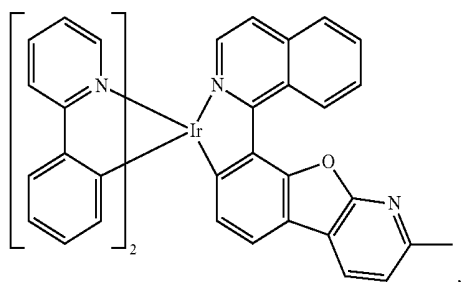


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Compound 9

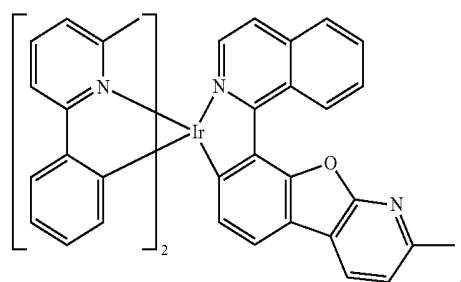


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52

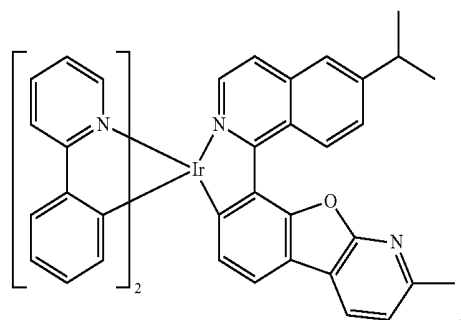
-continued

Compound 10



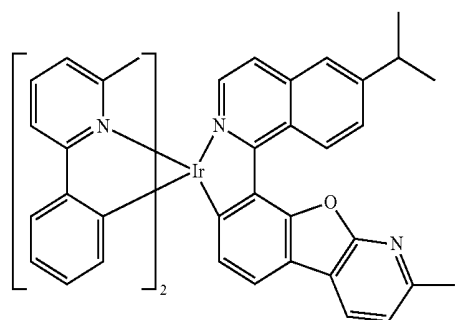
,

Compound 11



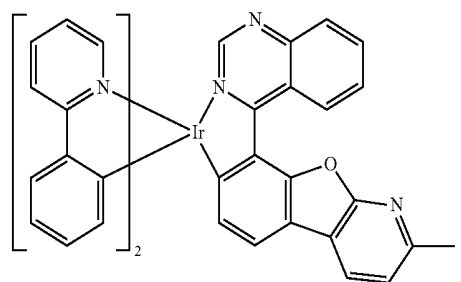
,

Compound 12



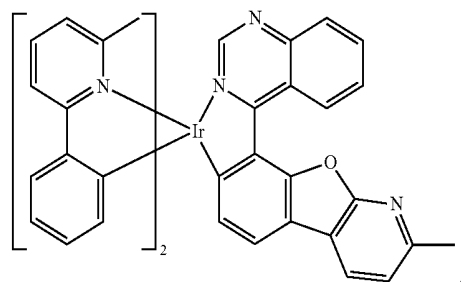
,

Compound 13



,

Compound 14

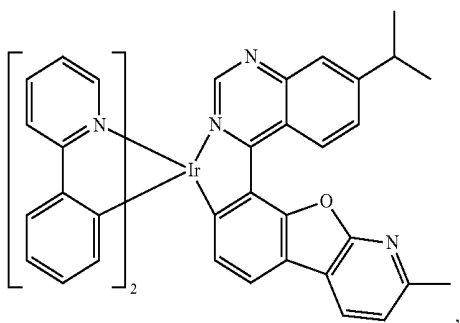


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53

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Compound 15



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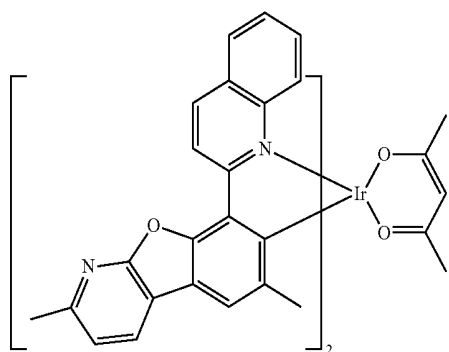
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54

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Compound 19



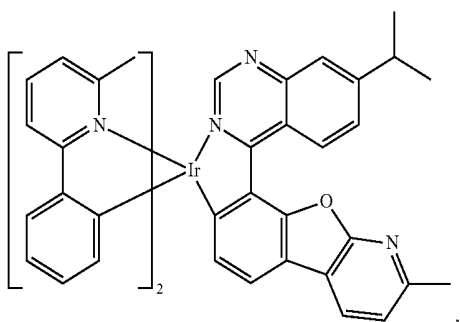
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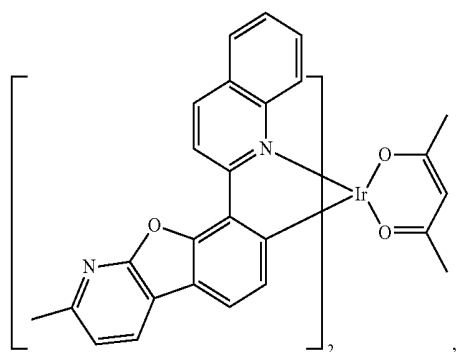
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Compound 16



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Compound 17



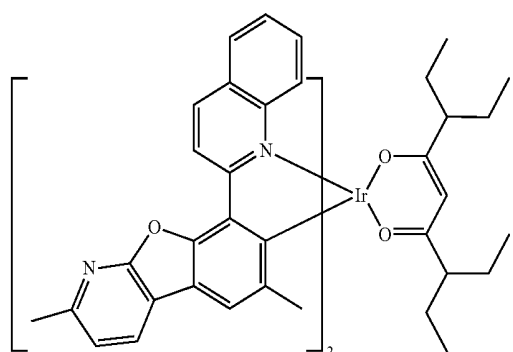
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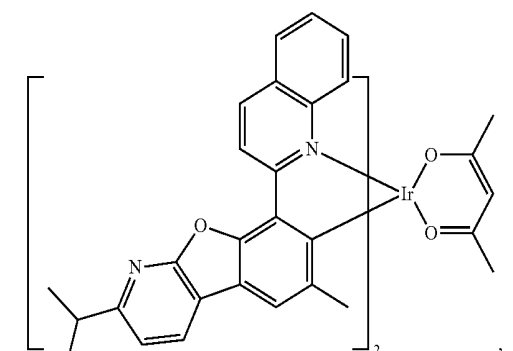
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Compound 20

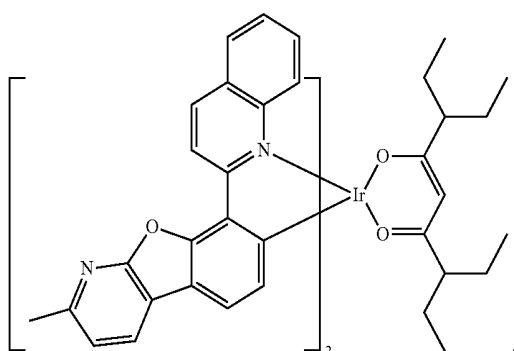


Compound 21



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Compound 18

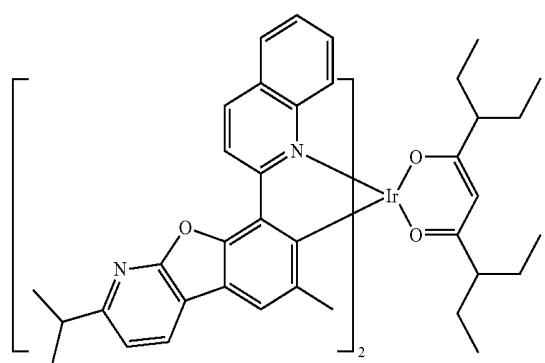


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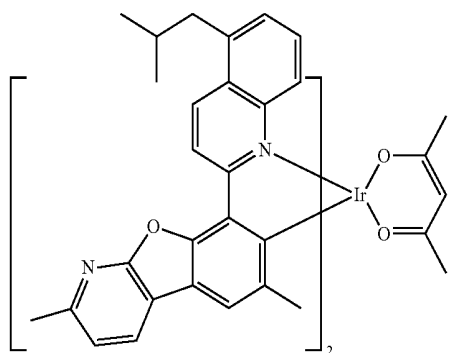
Compound 22



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-continued

Compound 23



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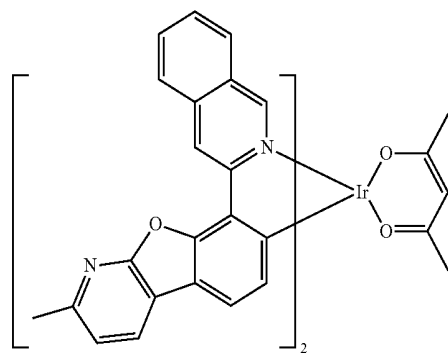
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56

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Compound 27

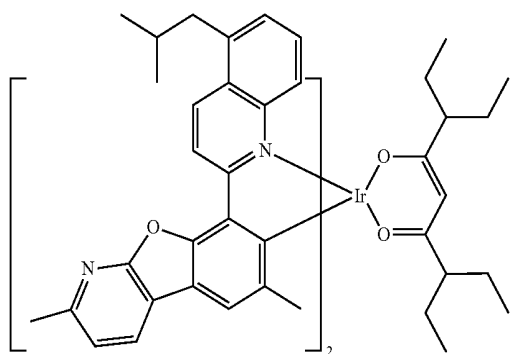


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Compound 24



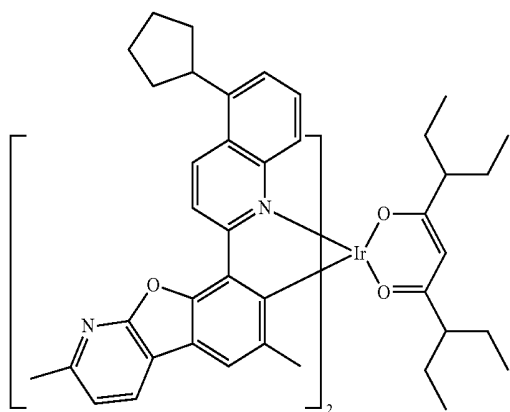
Compound 25

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Compound 26

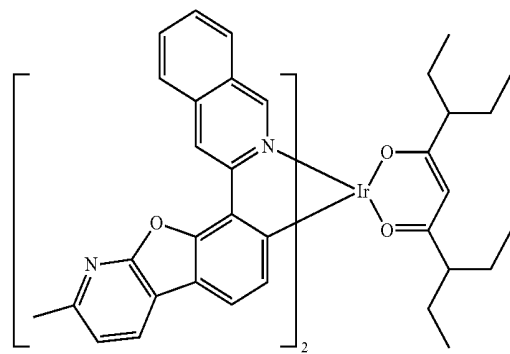


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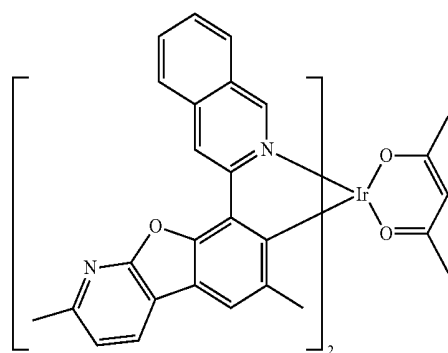
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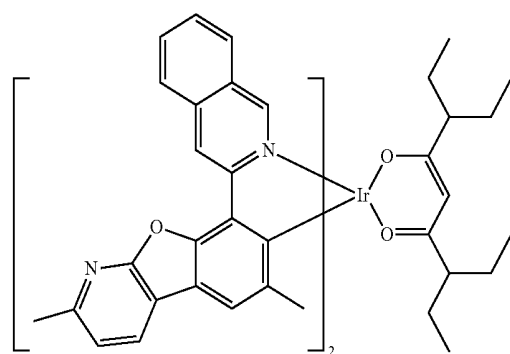
Compound 28



Compound 29



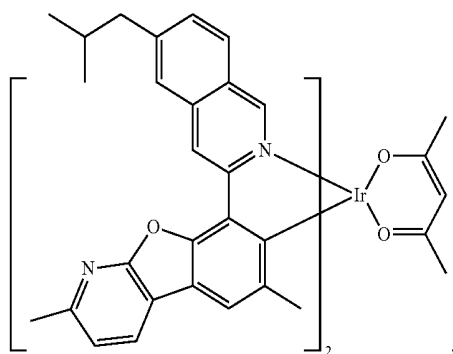
Compound 30



57

-continued

Compound 31



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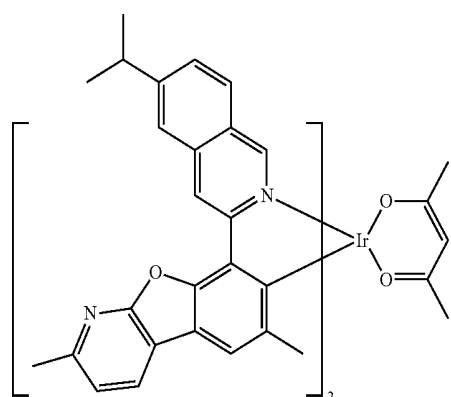
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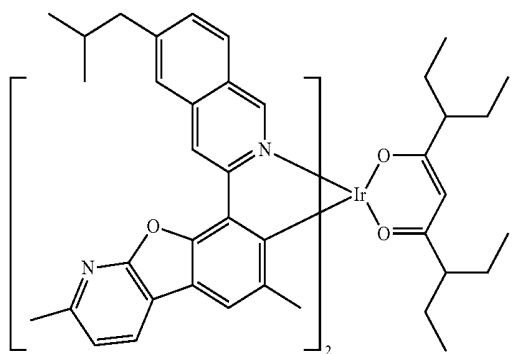
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Compound 35



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Compound 32

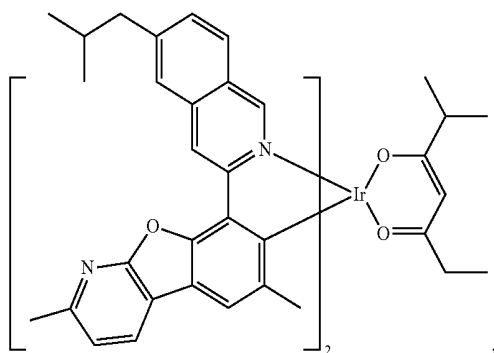


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Compound 33

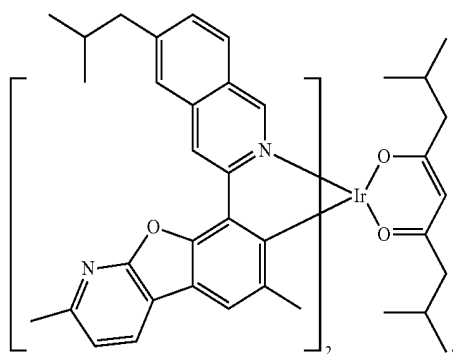


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Compound 34

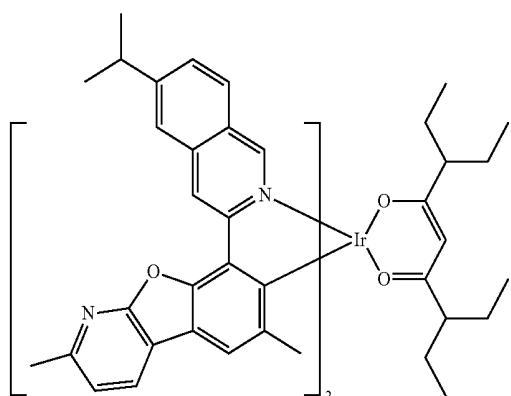


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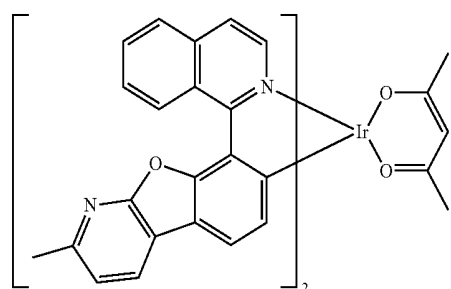
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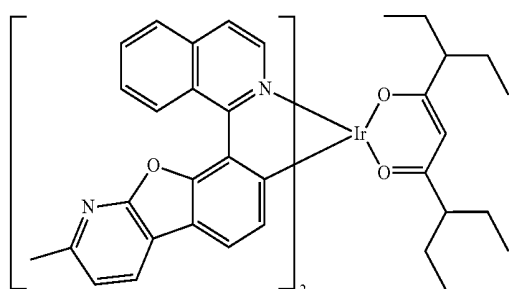
Compound 36



Compound 37



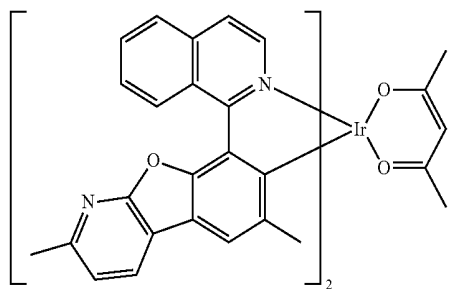
Compound 38



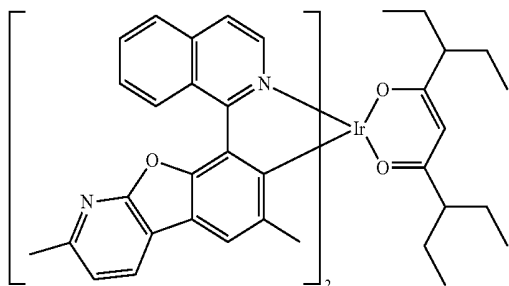
59

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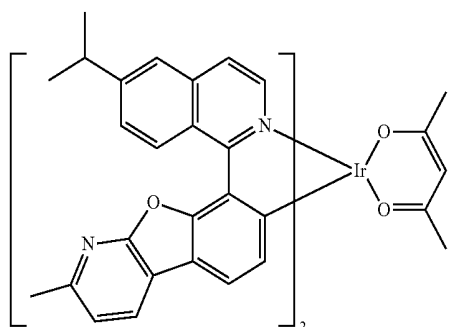
Compound 39



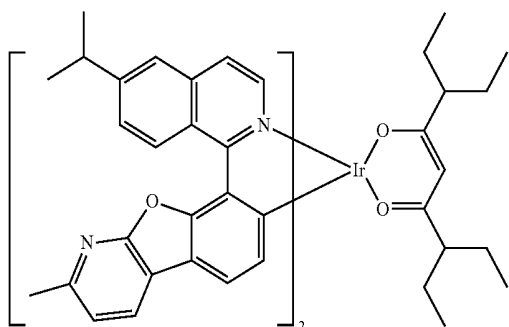
Compound 40



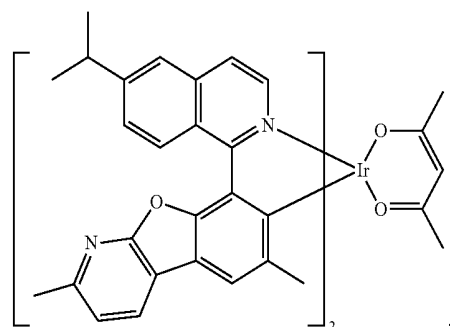
Compound 41



Compound 42

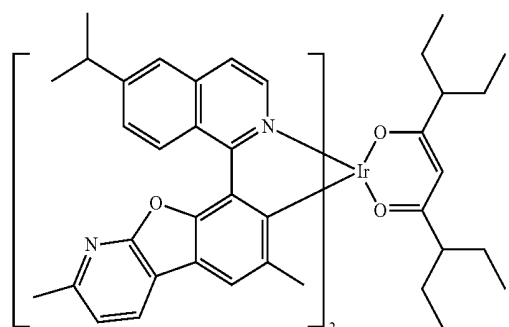


Compound 43

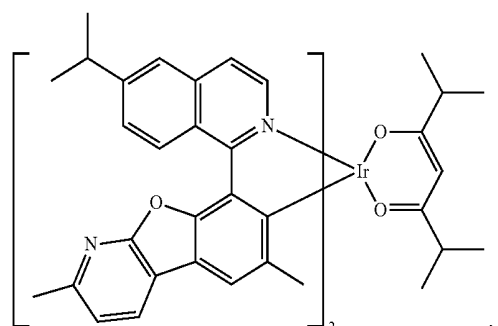
**60**

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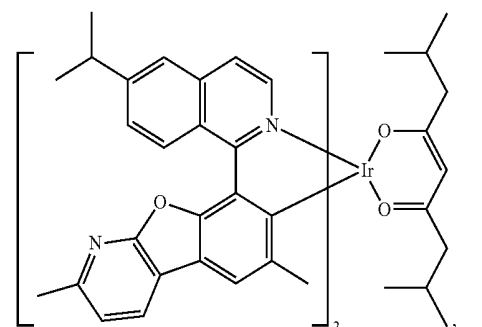
Compound 44



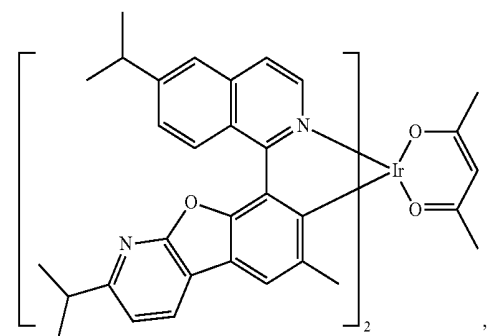
Compound 45



Compound 46



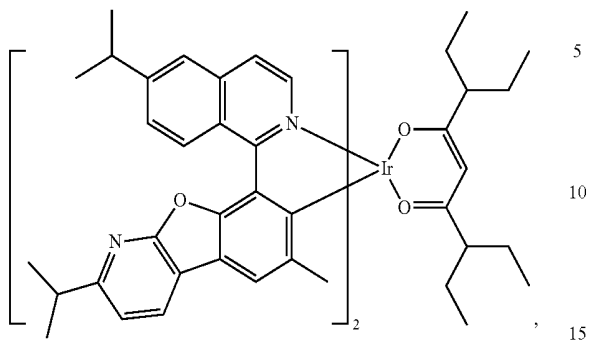
Compound 47



61

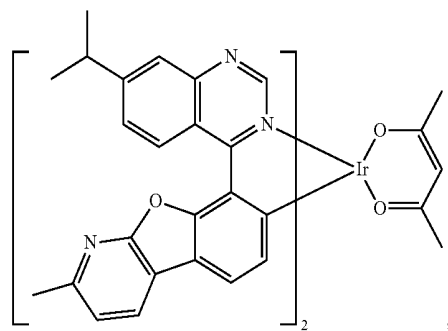
-continued

Compound 48

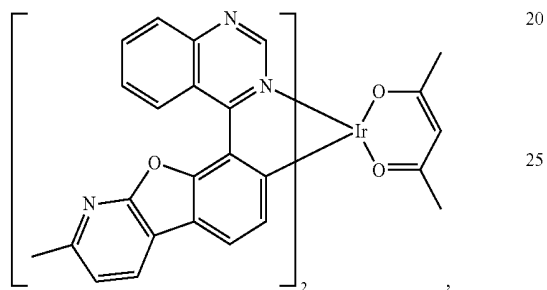
**62**

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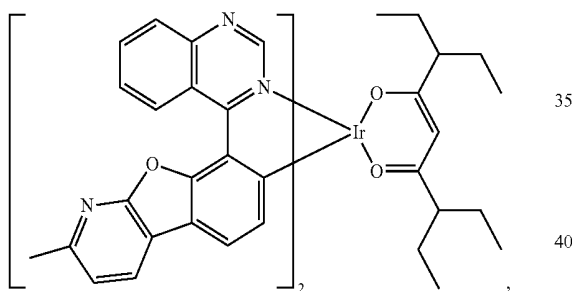
Compound 53



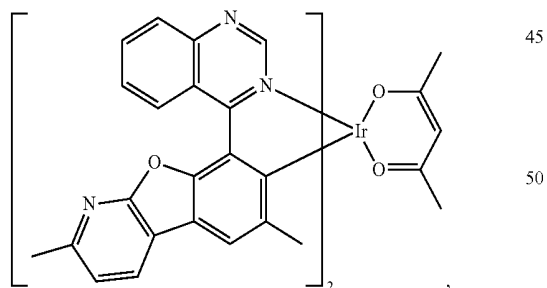
Compound 49



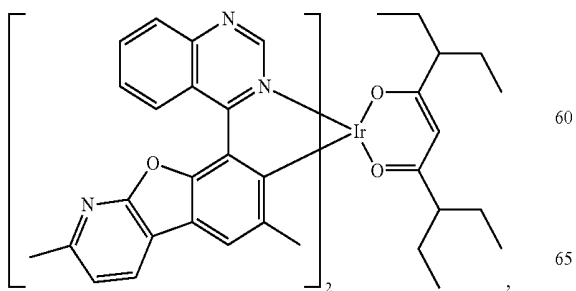
Compound 50



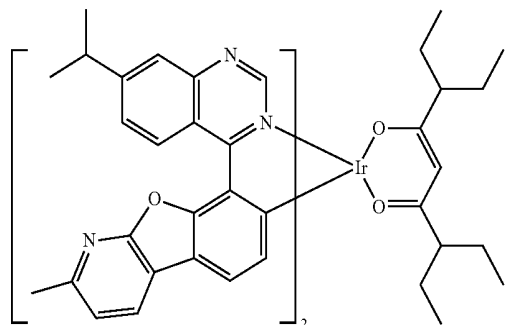
Compound 51



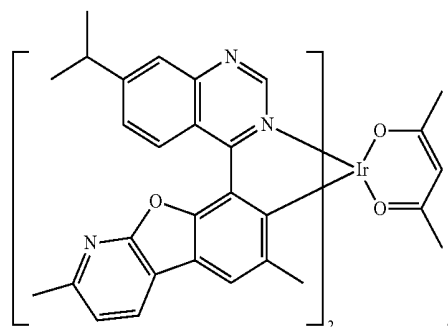
Compound 52



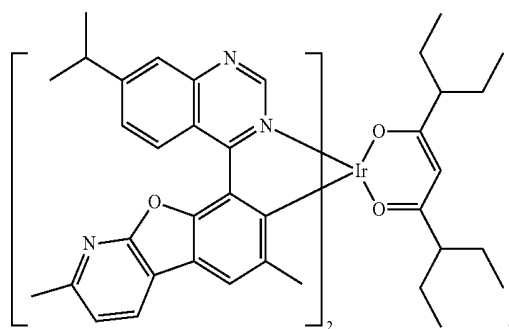
Compound 54



Compound 55



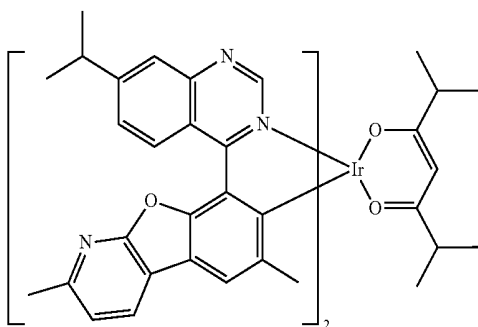
Compound 56



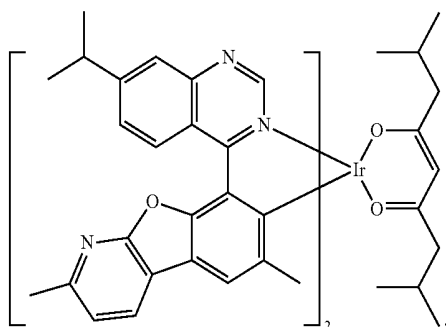
63

-continued

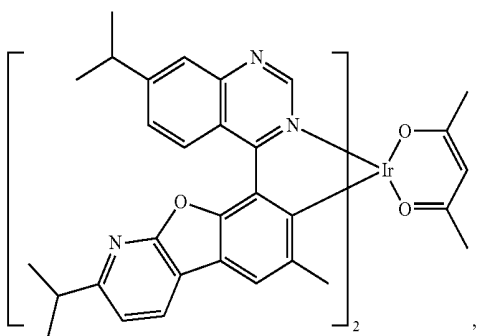
Compound 57



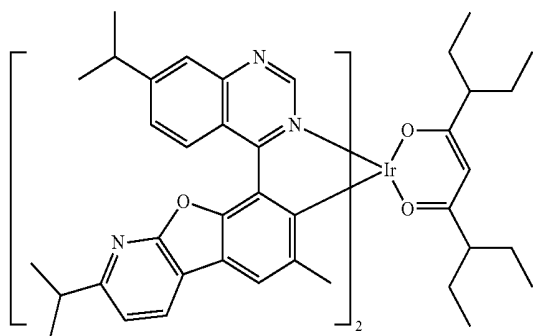
Compound 58



Compound 59



Compound 60



According to another aspect of the present disclosure, a first device is also provided. The first device includes a first organic light emitting device, that includes an anode, a cathode, and an organic layer disposed between the anode and the cathode. The organic layer may include a host and a phosphorescent dopant. The organic layer can include a compound according to Formula $M(L_A)_x(L_B)_y(L_C)_z$, and its variations as described herein.

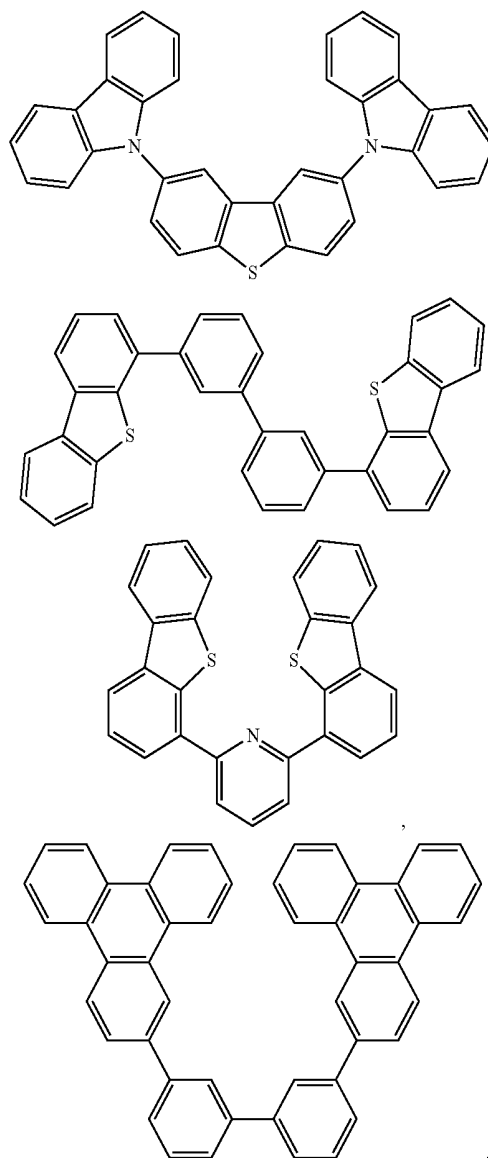
The first device can be one or more of a consumer product, an organic light-emitting device and a lighting panel. The organic layer can be an emissive layer and the

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compound can be an emissive dopant in some embodiments, while the compound can be a non-emissive dopant in other embodiments.

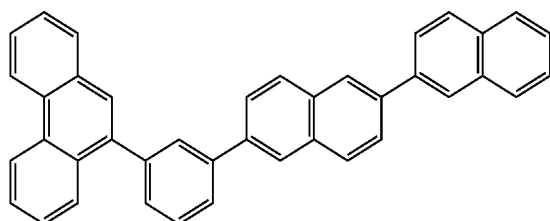
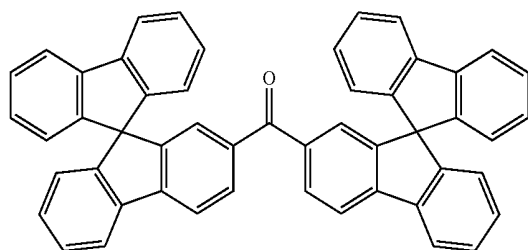
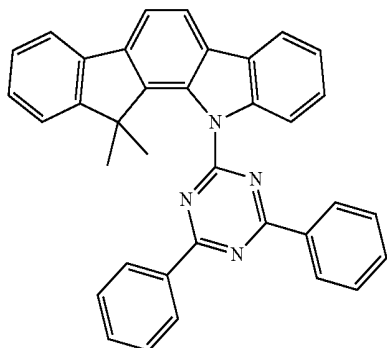
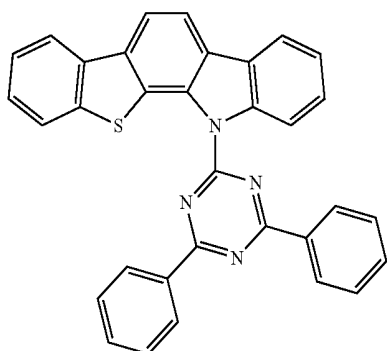
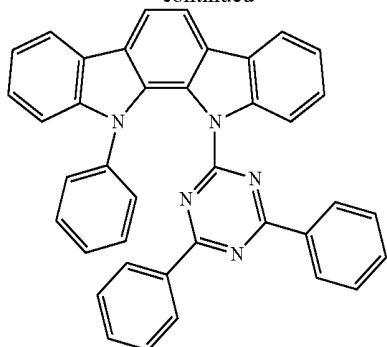
The organic layer can also include a host. In some embodiments, the host can include a metal complex. The host can be a triphenylene containing benzo-fused thiophene or benzo-fused furan. Any substituent in the host can be an unfused substituent independently selected from the group consisting of C_nH_{2n+1} , 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 , $C_nH_{2n}-Ar_1$, or no substitution. 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 a compound selected from the group consisting of carbazole, dibenzothiophene, dibenzofuran, dibenzoselenophene, azacarbazole, aza-dibenzothiophene, aza-dibenzofuran, and aza-dibenzoselenophene. The host can include a metal complex. The host can be a specific compound selected from the group consisting of:



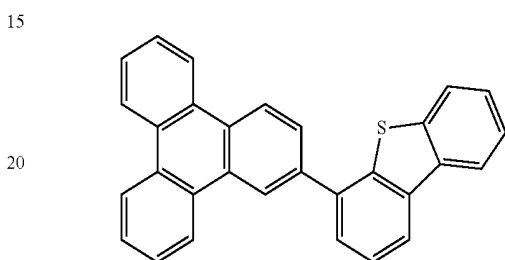
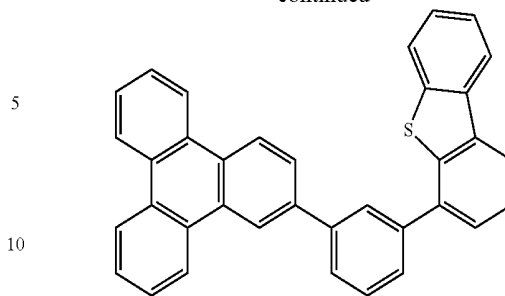
65

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-continued



and combinations thereof.

In yet another aspect of the present disclosure, a formulation that comprises a compound according to Formula $M(L_A)_x(L_B)_y(L_C)_z$ 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, and an electron transport layer material, disclosed herein.

Combination with Other Materials

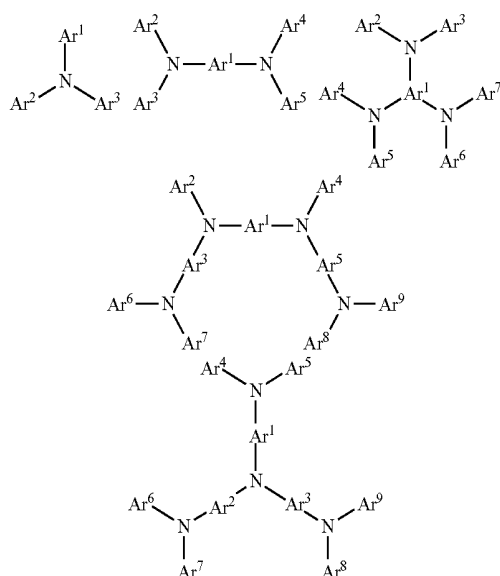
The materials described herein as useful for a particular layer in an organic light emitting device may be used in combination with a wide variety of other materials present in the device. For example, emissive dopants disclosed herein may be used in conjunction with a wide variety of hosts, transport 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.

HIL/HTL:

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 not limit 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_3 ; a p-type semiconducting organic compound, such as 1,4,5,8,9,12-Hexaazatriphenylenehexacarbonitrile; a metal complex, and a cross-linkable compounds.

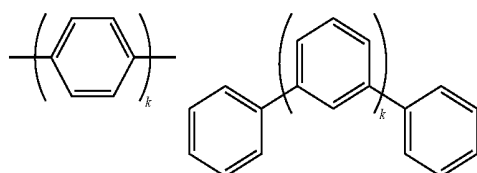
Examples of aromatic amine derivatives used in HIL or HTL include, but not limit to the following general structures:

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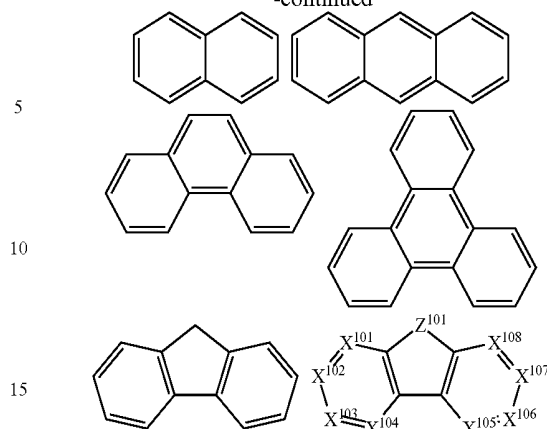
Each of Ar¹ to Ar⁹ is selected from the group consisting of aromatic hydrocarbon cyclic compounds such as benzene, biphenyl, triphenyl, triphenylene, naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, azulene; group consisting of aromatic heterocyclic compounds such as 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, benzofuropridine, furodipyrindine, benzothienopyridine, thienodipyrindine, benzoselenophenopyridine, and selenophenodipyrindine; and 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. Wherein each Ar is further substituted by a substituent 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.

In one aspect, Ar¹ to Ar⁹ is independently selected from the group consisting of:



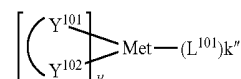
68

-continued



wherein k is an integer from 1 to 20; X¹⁰¹ to X¹⁰⁸ is C (including CH) or N; Z¹⁰¹ is NAr¹, O, or S; Ar¹ has the same group defined above.

Examples of metal complexes used in HIL or HTL include, but not limit to the following general formula:

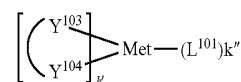


wherein Met is a metal, which can have an atomic weight greater than 40; (Y¹⁰¹-Y¹⁰²) is a bidentate ligand, Y¹⁰¹ and Y¹⁰² are independently selected from C, N, O, P, and S; L¹⁰¹ is an ancillary ligand; k' is an integer value from 1 to the maximum number of ligands that may be attached to the metal; and k'+k'' is the maximum number of ligands that may be attached to the metal.

In one aspect, (Y¹⁰¹-Y¹⁰²) is a 2-phenylpyridine derivative. In another aspect, (Y¹⁰¹-Y¹⁰²) 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.

Host: 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. While the Table below categorizes host materials as preferred for devices that emit various colors, any host material may be used with any dopant so long as the triplet criteria is satisfied.

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

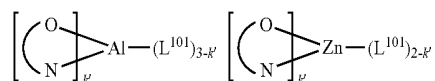


wherein Met is a metal; (Y¹⁰³-Y¹⁰⁴) is a bidentate ligand, Y¹⁰³ and Y¹⁰⁴ are independently selected from C, N, O, P, and S; L¹⁰¹ is an another ligand; k' is an integer value from 1 to the maximum number of ligands that may be attached

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

In one aspect, the metal complexes are:

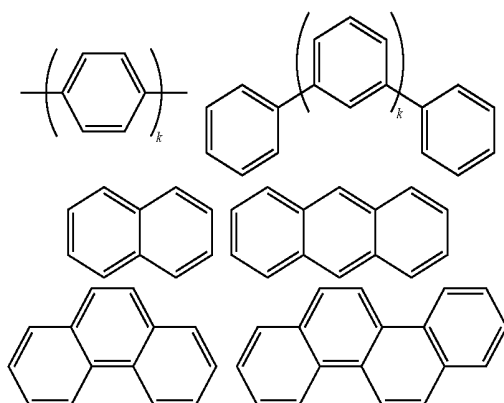


wherein (O—N) is a bidentate ligand, having metal coordinated to atoms O and N.

In another aspect, Met is selected from Ir and Pt. In a further aspect, (Y^{103} - Y^{104}) is a carbene ligand.

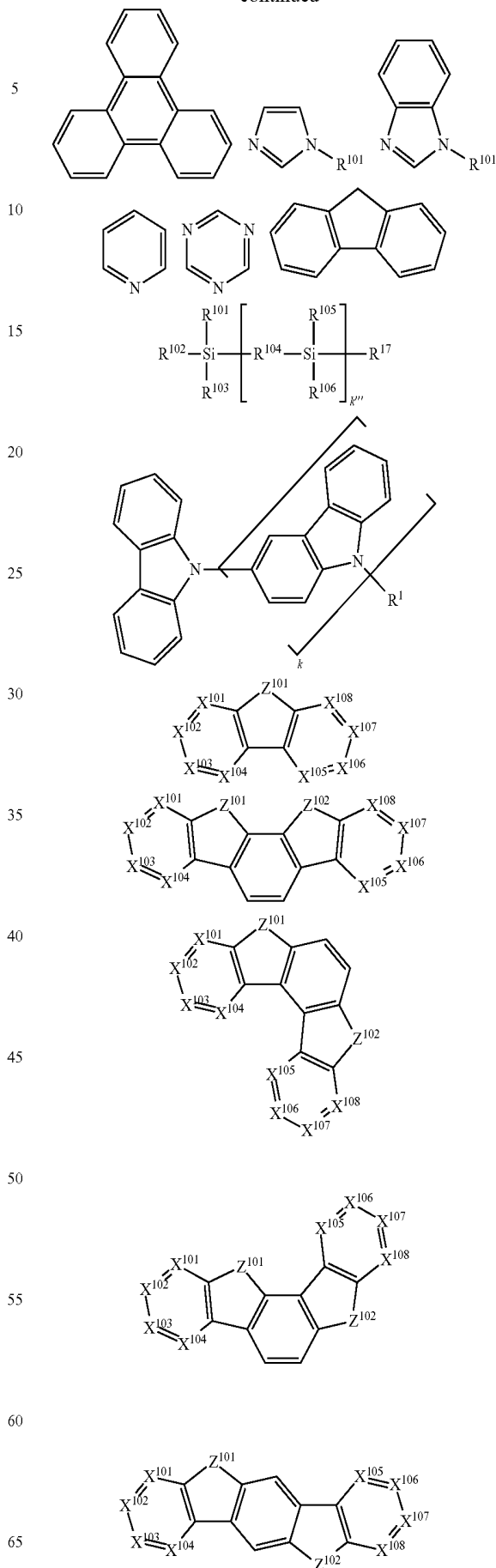
Examples of organic compounds used as host are selected from the group consisting aromatic hydrocarbon cyclic compounds such as benzene, biphenyl, triphenyl, triphenylene, naphthalene, anthracene, phenalene, phenanthrene, fluorene, pyrene, chrysene, perylene, azulene; group consisting aromatic heterocyclic compounds such as dibenzothiophene, 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 group consisting 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. Wherein each group is further substituted by a substituent 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.

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

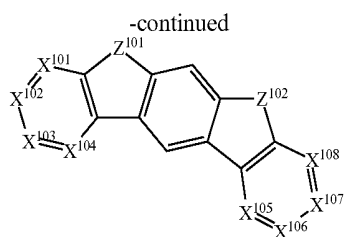


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-continued



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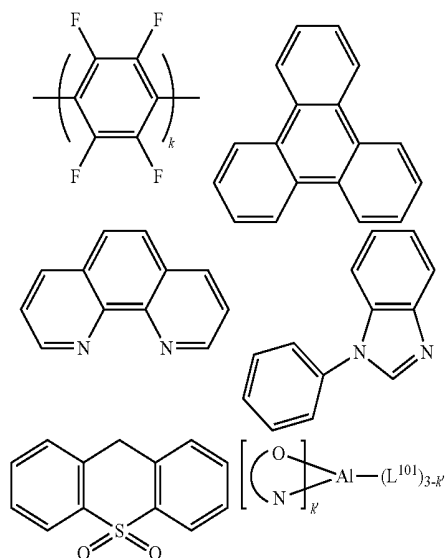
wherein R^{101} to R^{107} is independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alkenyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof, 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; k'' is an integer from 0 to 20. X^{101} to X^{108} is selected from C (including CH) or N. Z^{101} and Z^{102} is selected from NR^{101} , O, or S.

HBL:

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

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



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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. encompasses undeuterated, partially deuterated, and fully deuterated versions thereof. Similarly, classes of substituents such as, without limitation, alkyl, aryl, cycloalkyl, heteroaryl, etc. also encompass undeuterated, partially deuterated, and fully deuterated versions thereof.

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In addition to and/or in combination with the materials disclosed herein, many hole injection materials, hole transporting materials, host materials, dopant materials, exciton/hole blocking layer materials, electron transporting and electron injecting materials may be used in an OLED. Non-limiting examples of the materials that may be used in an OLED in combination with materials disclosed herein are listed in Table 1 below. Table 1 lists non-limiting classes of materials, non-limiting examples of compounds for each class, and references that disclose the materials.

TABLE 1

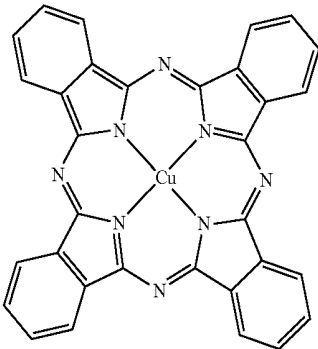
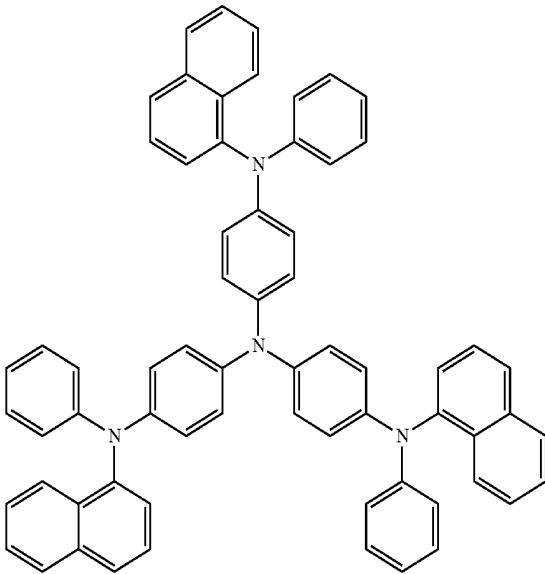
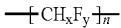
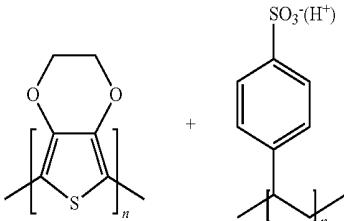
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Hole injection materials		
Phthalocyanine and porphyrin compounds		Appl. Phys. Lett. 69, 2160 (1996)
Starburst triaryl amines		J. Lumin. 72-74, 985 (1997)
CF _x Fluoro-hydrocarbon polymer		Appl. Phys. Lett. 78, 673 (2001)
Conducting polymers (e.g., PEDOT:PSS, polyaniline, polypyrrole, polythiophene)		Synth. Met. 87, 171 (1997) WO2007002683

TABLE 1-continued

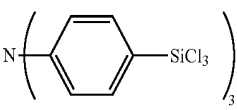
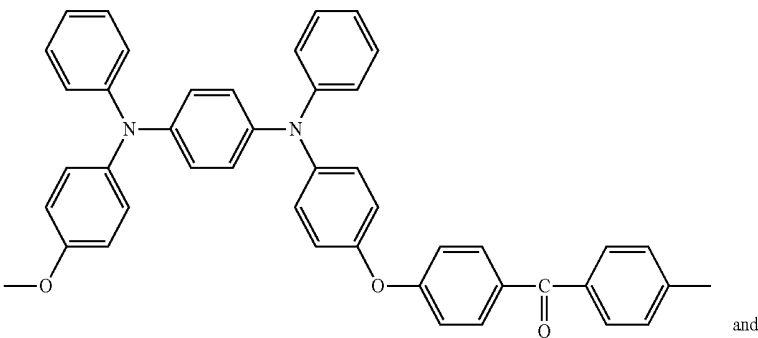
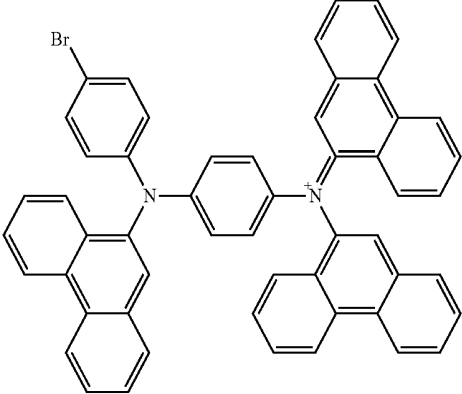
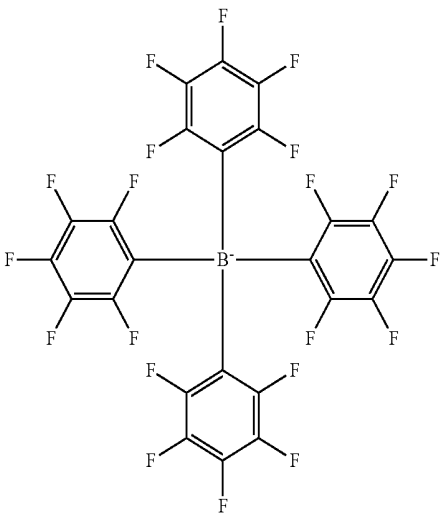
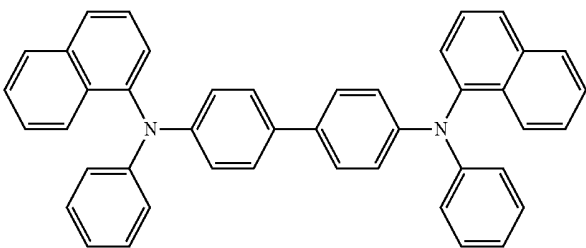
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Phosphonic acid and silane SAMs	 $\text{N} \left(\text{C}_6\text{H}_4 - \text{SiCl}_3 \right)_3$	US200301262053
Triarylamine or polythiophene polymers with conductivity dopants	 and 	EP1725079A1
Organic compounds with conductive inorganic compounds, such as molybdenum and tungsten oxides	 + MoO_x 	US20050123751 SID Symposium Digest, 37, 923 (2006) WO2009018009

TABLE 1-continued

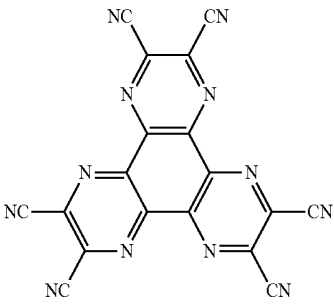
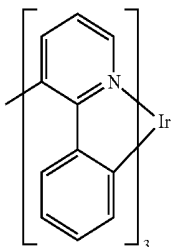
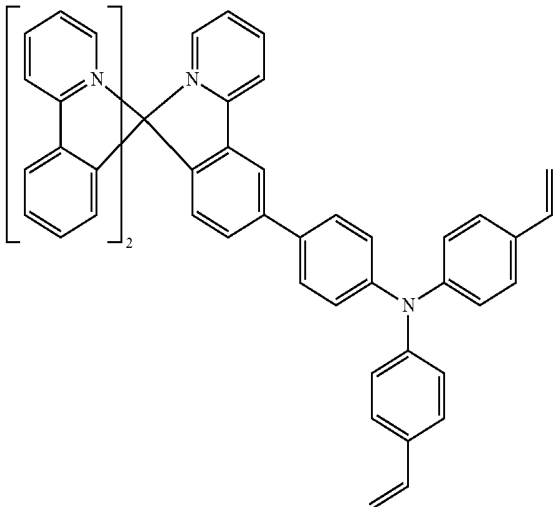
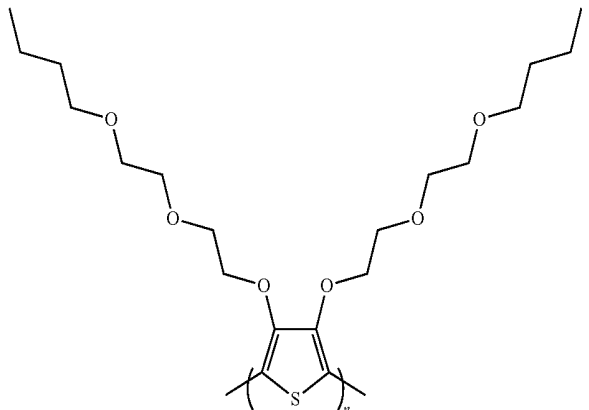
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
n-type semi- conducting organic complexes		US20020158242
Metal organo- metallic complexes		US20060240279
Cross- linkable compounds		US20080220265
Polythiophene based polymers and copolymers		WO 2011075644 EP2350216

TABLE 1-continued

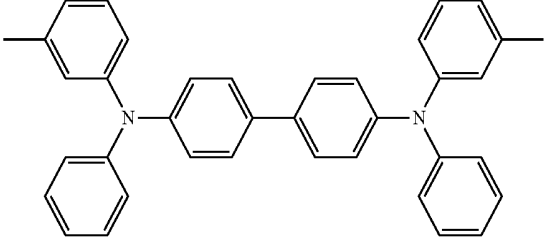
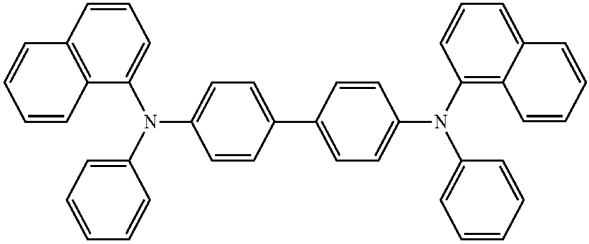
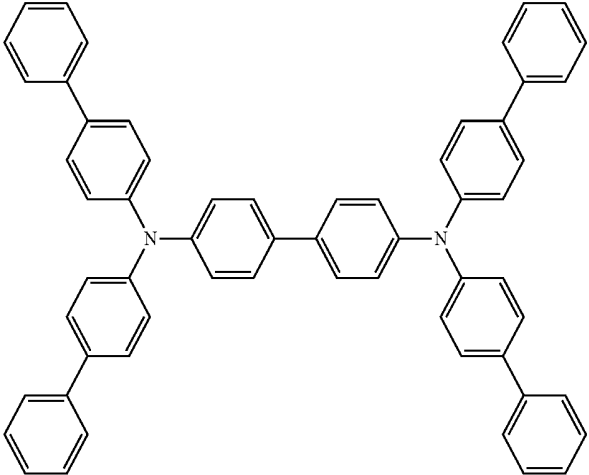
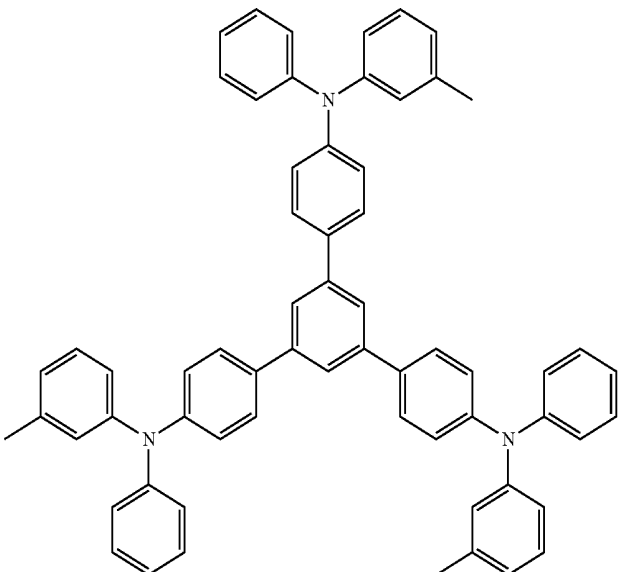
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Hole transporting materials		
Triarylamines (e.g., TPD, α -NPD)		Appl. Phys. Lett. 51, 913 (1987)
		U.S. Pat. No. 5,061,569
		EP650955
		J. Mater. Chem. 3, 319 (1993)

TABLE 1-continued

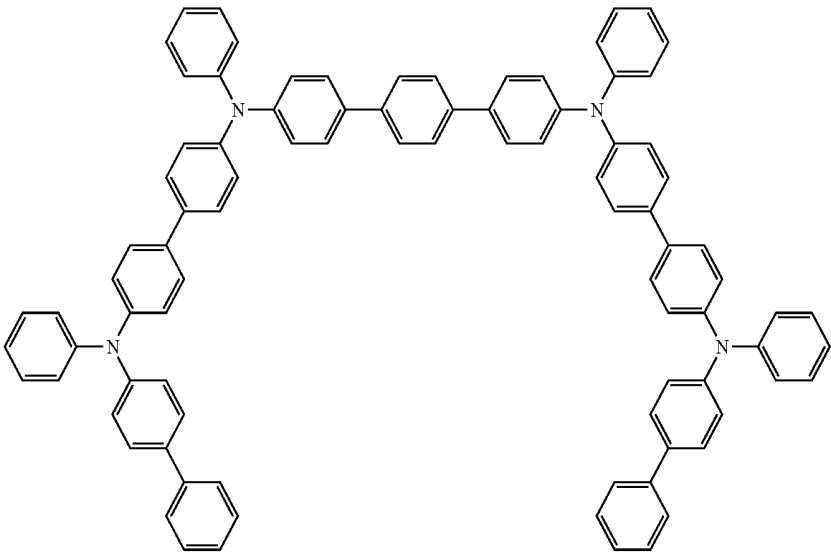
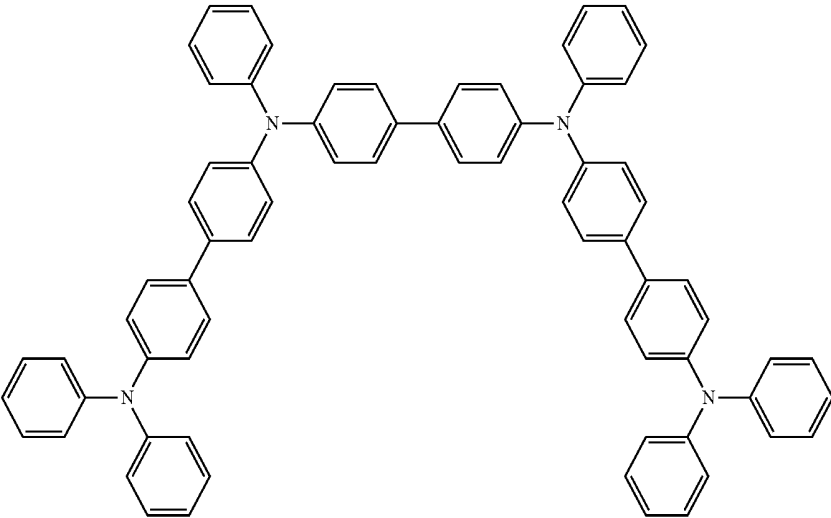
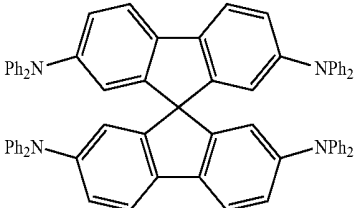
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
		Appl. Phys. Lett. 90, 183503 (2007)
		Appl. Phys. Lett. 90, 183503 (2007)
Triaylamine on spirofluorene core		Synth. Met. 91, 209 (1997)

TABLE 1-continued

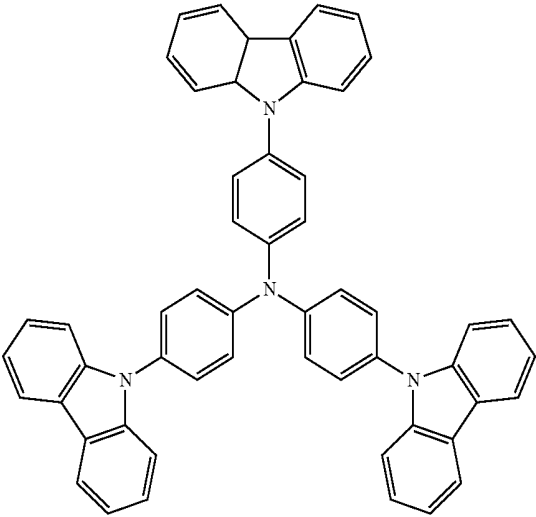
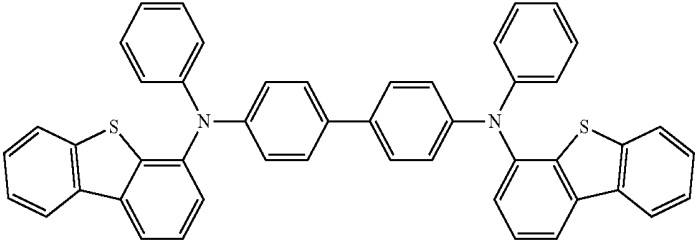
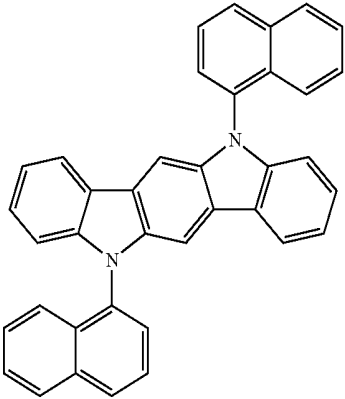
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Arylamine carbazole compounds		Adv. Mater. 6, 677 (1994), US20080124572
Triarylamine with (di)benzo- thiophene/ (di)ben- zoburan		US20070278938, US20080106190 US20110163302
Indolo- carbazoles		Synth. Met. 111, 421 (2000)

TABLE 1-continued

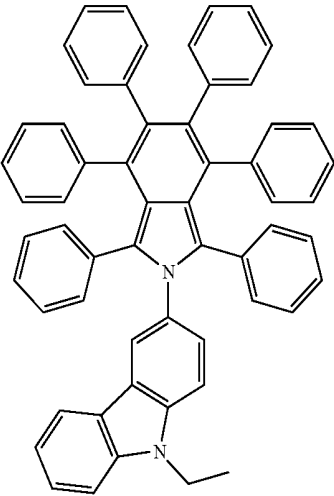
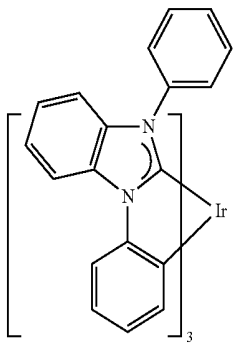
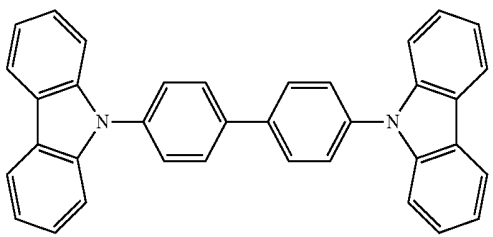
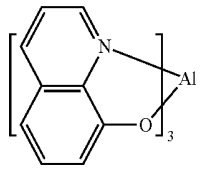
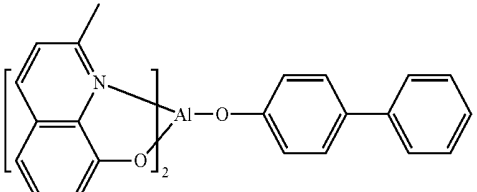
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Isoindole compounds		Chem. Mater. 15, 3148 (2003)
Metal carbene complexes		US20080018221
Phosphorescent OLED host materials Red hosts		
Arylcarbazoles		Appl. Phys. Lett., 78, 1622 (2001)
Metal 8-hydroxyquinolates (e.g., Alq ₃ , BAlq)		Nature 395, 151 (1998)
		US20060202194

TABLE 1-continued

MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Metal phenoxy- benzothiazole compounds		WO2005014551
		WO2006072002
		Appl. Phys. Lett. 90, 123509 (2007)
Conjugated oligomers and polymers (e.g., polyfluorene)		Org. Electron. 1, 15 (2000)
Aromatic fused rings		WO2009066779, WO2009066778, WO2009063833, US20090045731, US20090045730, WO2009008311, US20090008605, US20090009065
Zinc complexes		WO2010056066

TABLE 1-continued

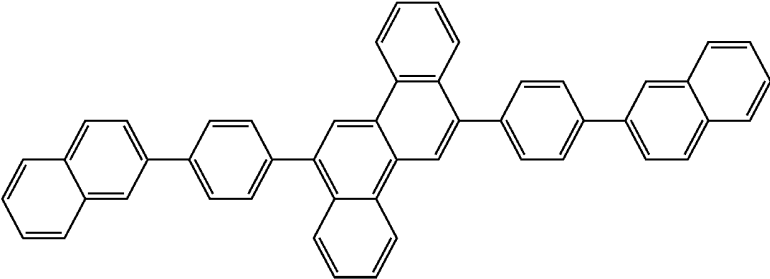
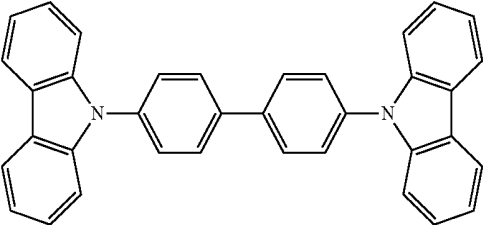
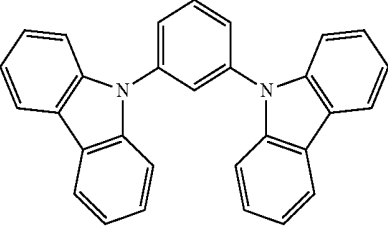
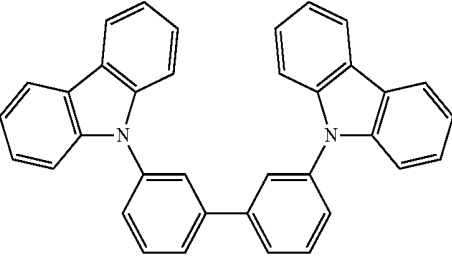
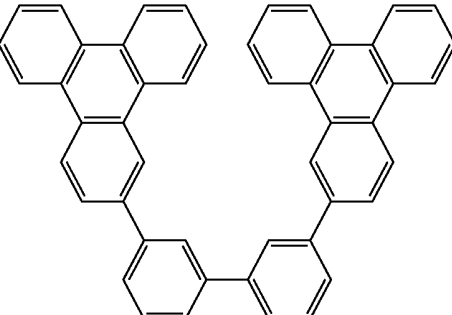
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Chrysene based compounds		WO2011086863
Green hosts		
Aryl-carbazoles		Appl. Phys. Lett. 78, 1622 (2001)
		US20030175553
		WO2001039234
Aryl-triphenylene compounds		US20060280965

TABLE 1-continued

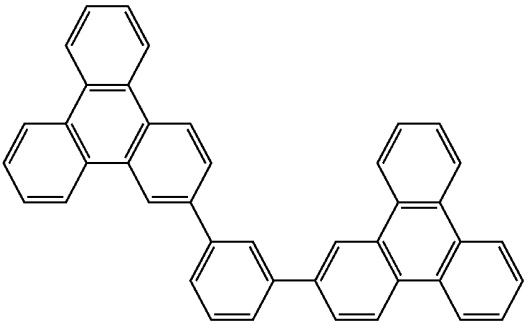
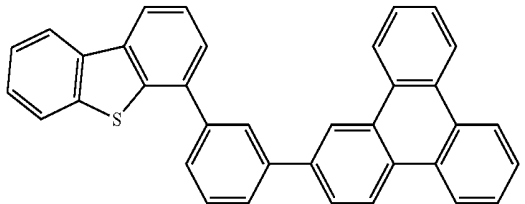
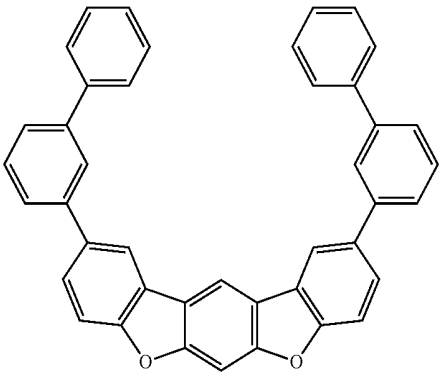
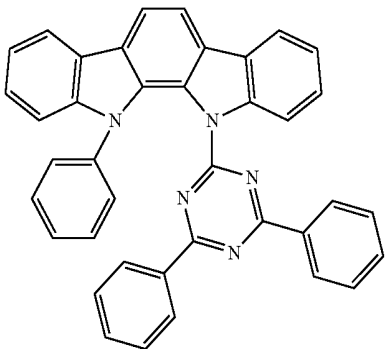
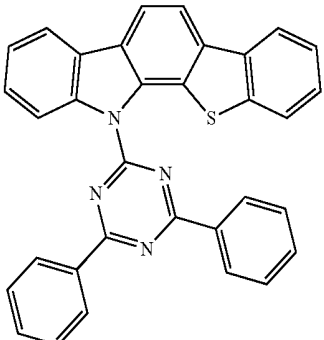
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Poly-fused heteroaryl compounds		US20060280965
		WO2009021126
		US20090309488 US20090302743 US20100012931
Donor acceptor type molecules		WO2008056746
		WO2010107244

TABLE 1-continued

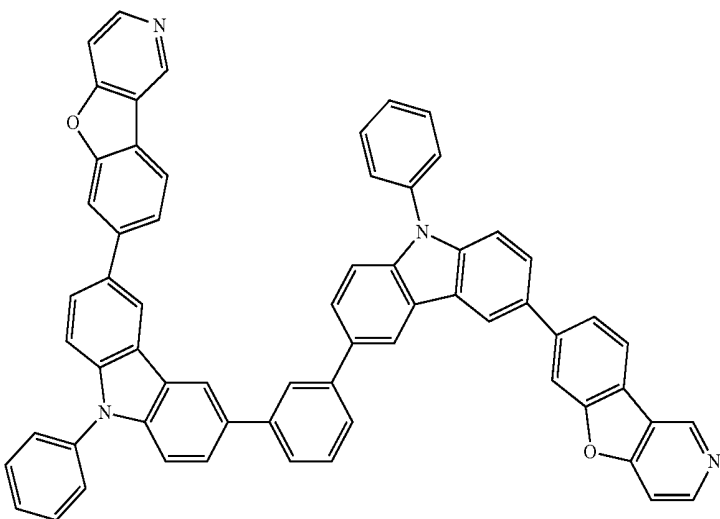
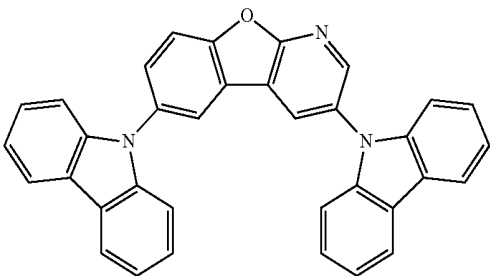
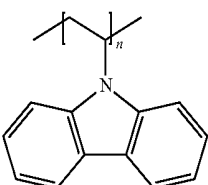
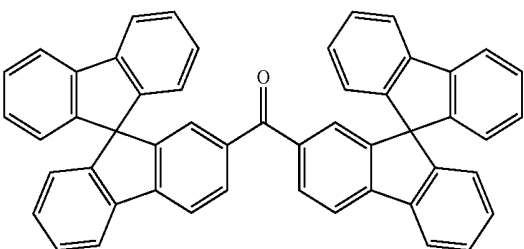
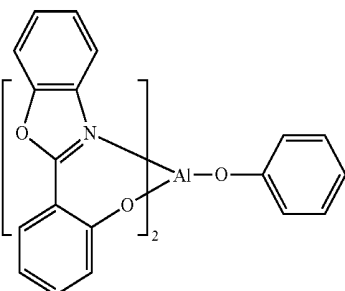
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Aza-carbazole/ DBT/DBF		JP2008074939
		US20100187984
Polymers (e.g., PVK)		Appl. Phys. Lett. 77, 2280 (2000)
Spirofluorene compounds		WO2004093207
Metal phenoxy- benzo- oxazole compounds		WO20050289025

TABLE 1-continued

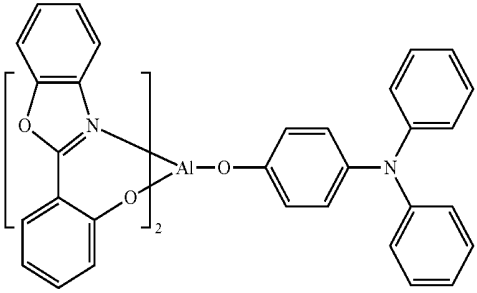
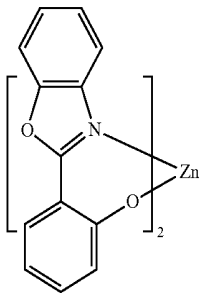
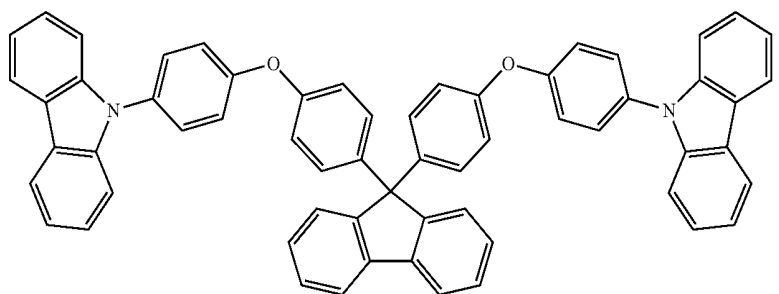
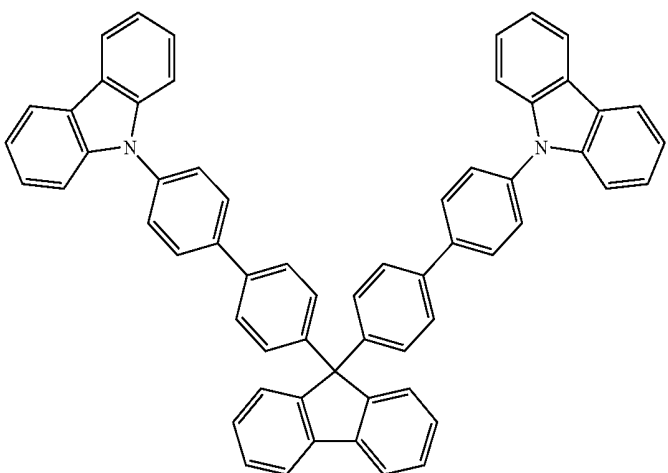
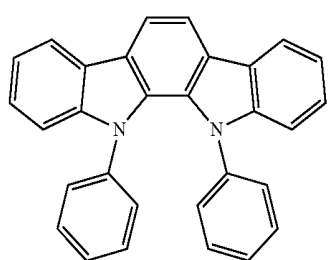
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
		WO2006132173
		JP200511610
Spiro-fluorene-carbazole compounds		JP2007254297
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Indolo-carbazoles		WO2007063796

TABLE 1-continued

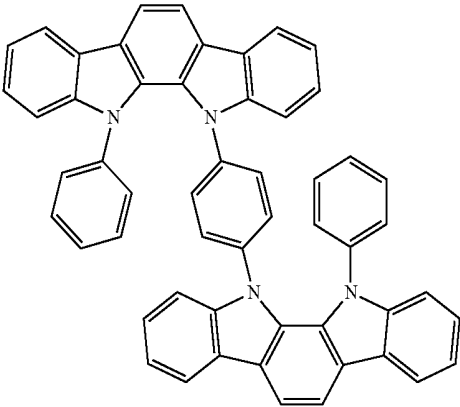
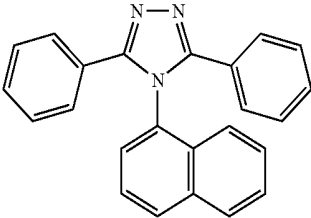
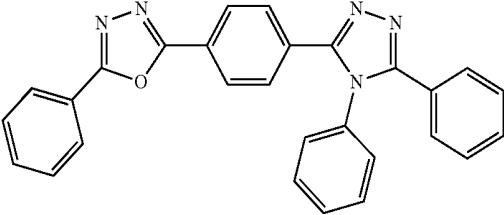
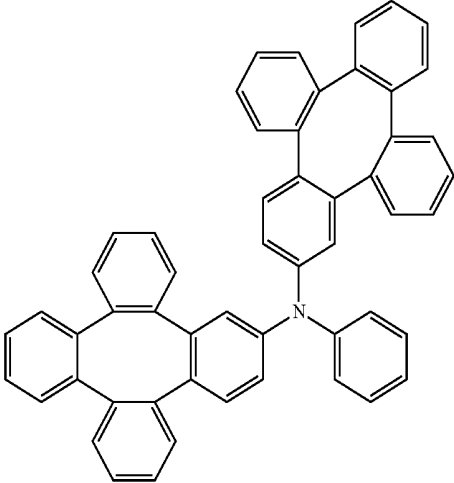
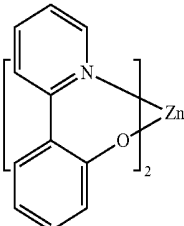
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
5-member ring electron deficient heterocycles (e.g., triazole, oxadiazole)		WO2007063754
		J. Appl. Phys. 90, 5048 (2001)
Tetra- phenylene complexes		WO2004107822
		US20050112407
Metal phenoxy- pyridine compounds		WO2005030900

TABLE 1-continued

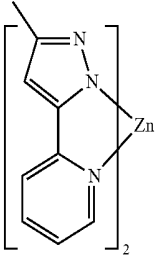
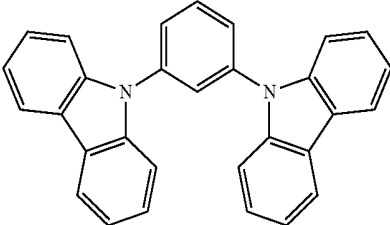
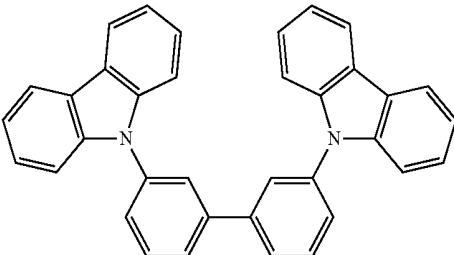
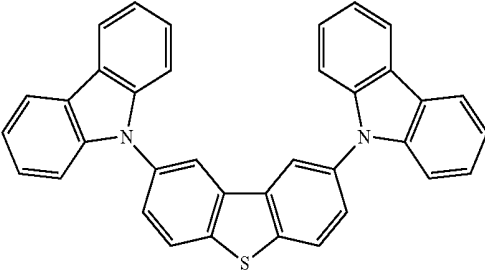
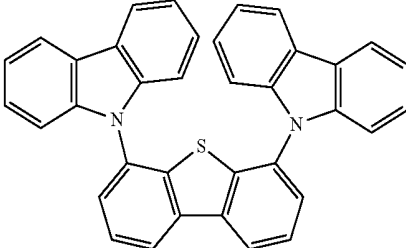
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Metal coordination complexes (e.g., Zn, Al with N`N ligands)		US20040137268, US20040137267
Blue hosts		
Aryl-carbazoles		Appl. Phys. Lett., 82, 2422 (2003)
		US20070190359
Dibenzo-thiophene/ Dibenzo-furan-carbazole compounds		WO2006114966, US20090167162
		US20090167162

TABLE 1-continued

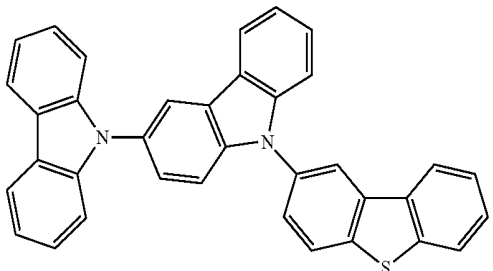
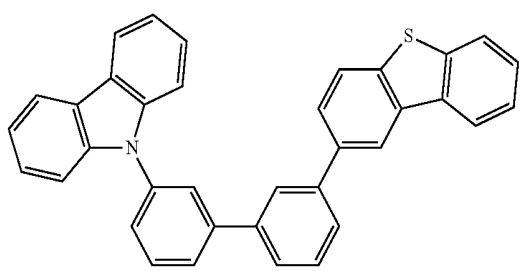
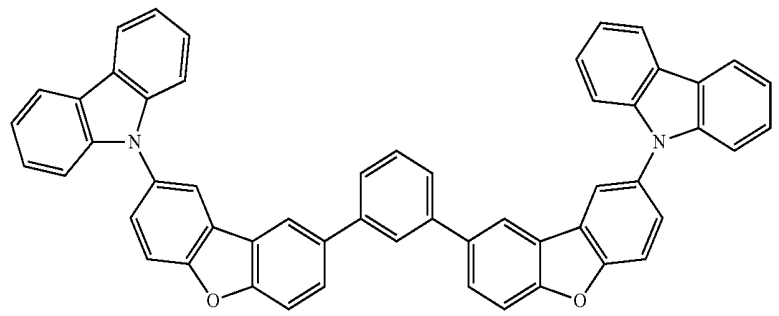
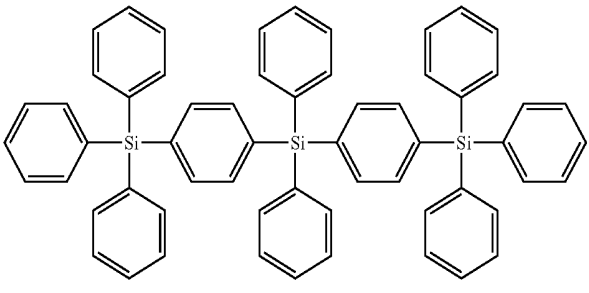
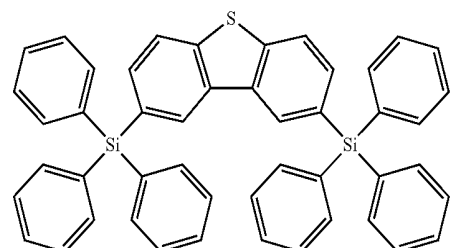
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		WO2009086028
		US20090030202, US20090017330
		US20100084966
Silicon aryl compounds		US20050238919
		WO2009003898

TABLE 1-continued

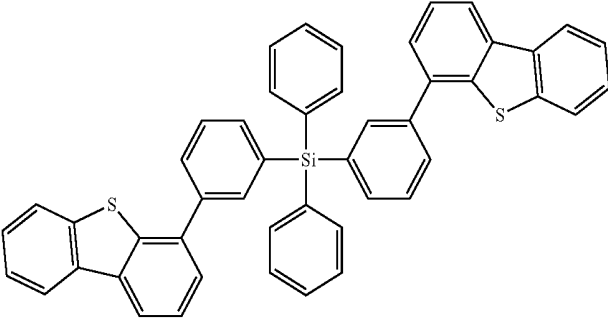
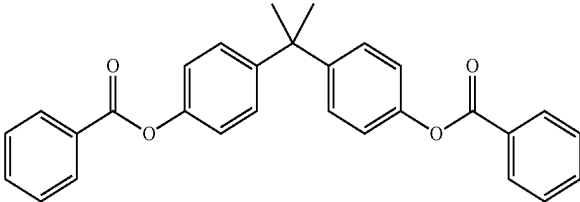
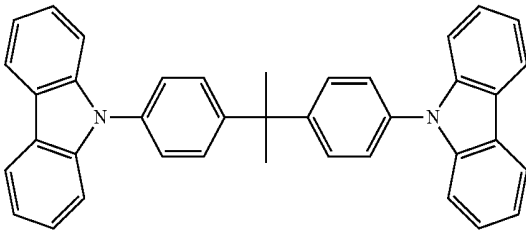
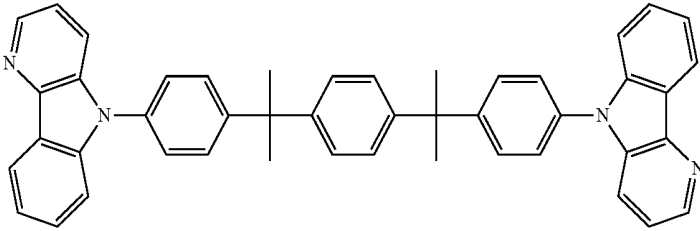
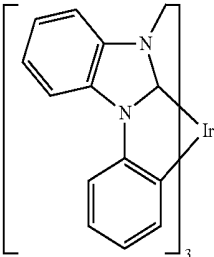
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Silicon/ Germanium aryl compounds		EP2034538A
Aryl benzoyl ester		WO2006100298
Carbazole linked by non- conjugated groups		US20040115476
Aza- carbazoles		US20060121308
High triplet metal organo- metallic complex		U.S. Pat. No. 7,154,114

TABLE 1-continued

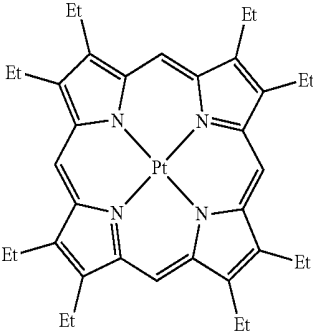
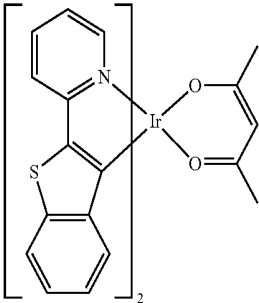
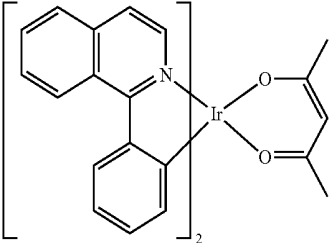
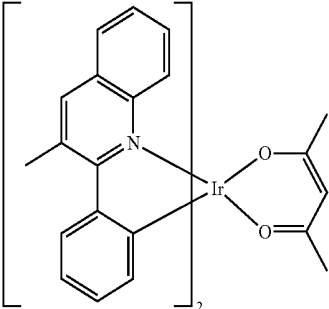
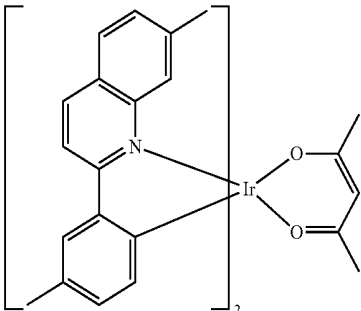
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	Phosphorescent dopants Red dopants	
Heavy metal porphyrins (e.g., PtOEP)		Nature 395, 151 (1998)
Iridium(III) organo-metallic complexes		Appl. Phys. Lett. 78, 1622 (2001)
		US20030072964
		US20030072964
		US20060202194

TABLE 1-continued

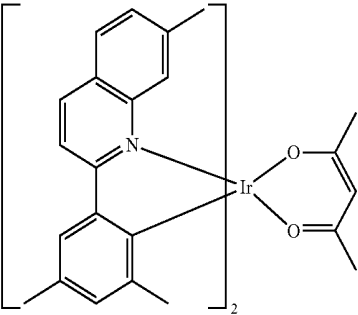
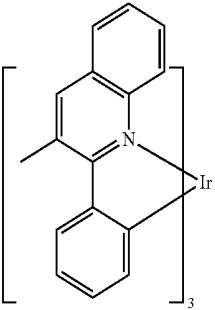
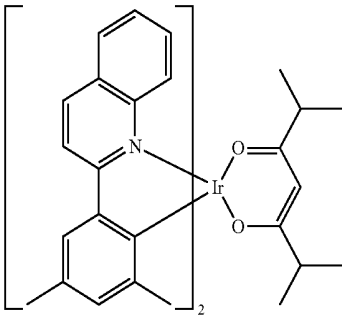
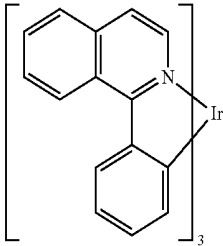
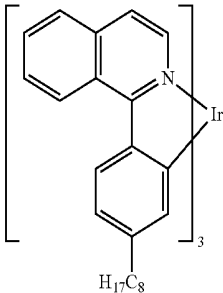
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TABLE 1-continued

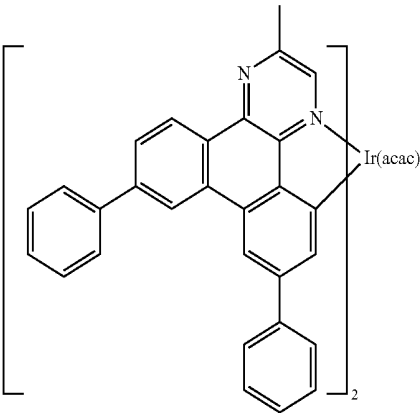
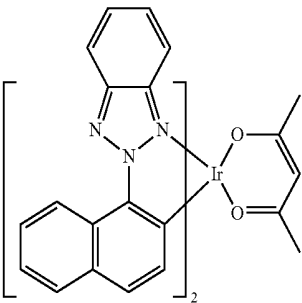
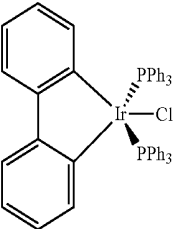
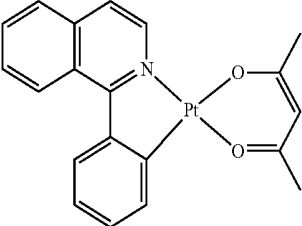
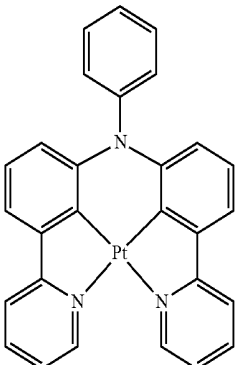
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		WO2008101842
		U.S. Pat. No. 7,232,618
Platinum(II) organo- metallic complexes		WO2003040257
		US20070103060

TABLE 1-continued

US20020034656

TABLE 1-continued

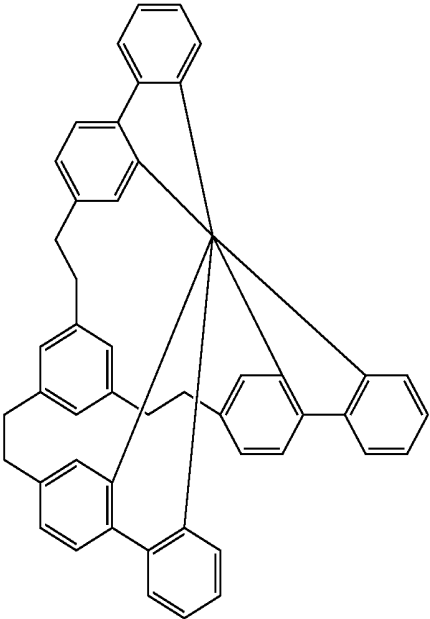
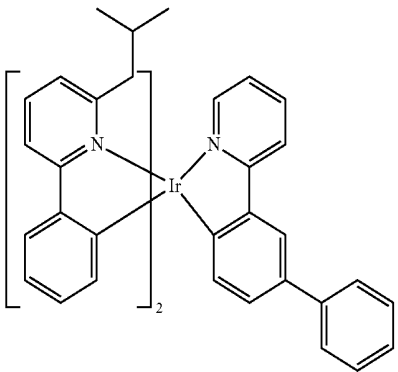
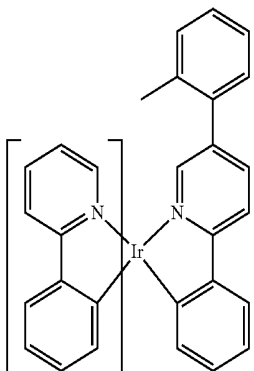
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		US20090108737
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TABLE 1-continued

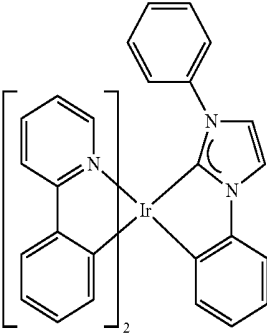
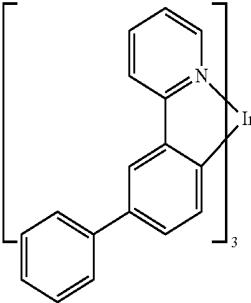
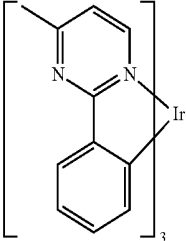
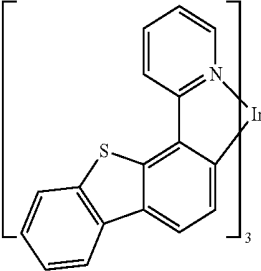
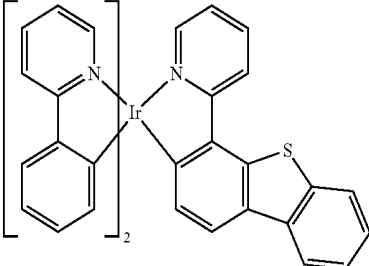
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		U.S. Pat. No. 6,921,915
		US20100244004

TABLE 1-continued

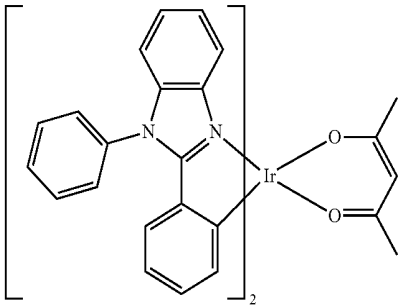
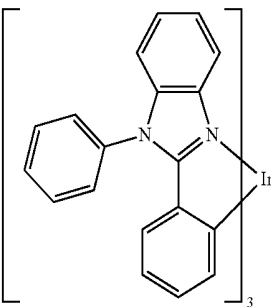
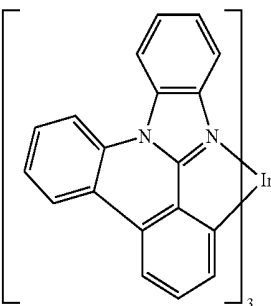
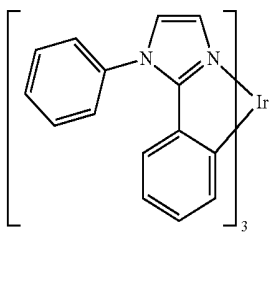
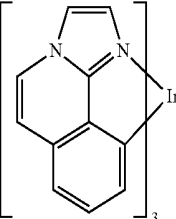
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
		U.S. Pat. No. 6,687,266
		Chem. Mater. 16, 2480 (2004)
		US20070190359
		US 20060008670 JP2007123392
		WO2010086089, WO2011044988

TABLE 1-continued

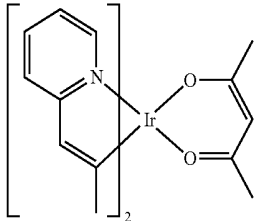
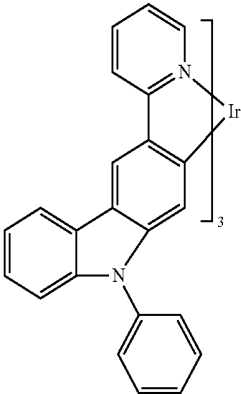
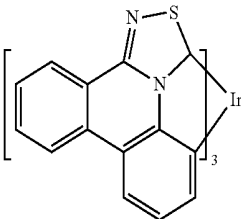
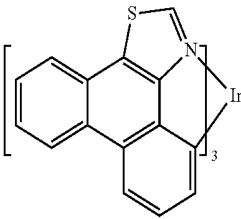
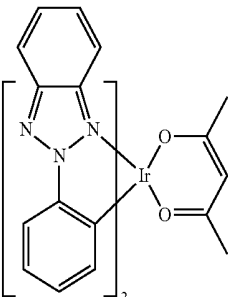
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
		Adv. Mater. 16, 2003 (2004)
		Angew. Chem. Int. Ed. 2006, 45, 7800
		WO2009050290
		US20090165846
		US20080015355

TABLE 1-continued

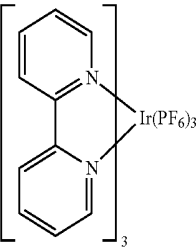
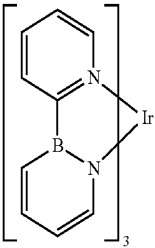
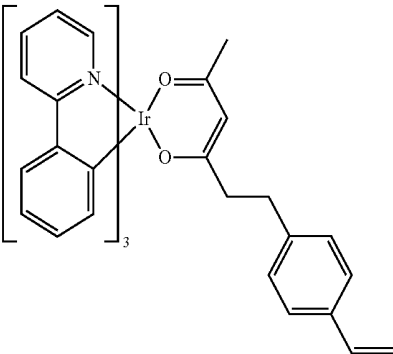
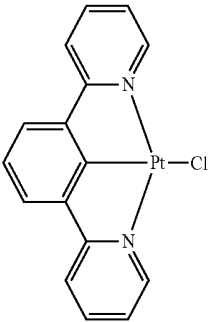
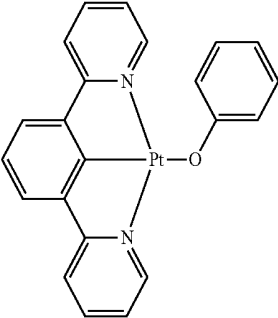
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
		US20010015432
		US20100295032
Monomer for polymeric metal organo-metallic compounds		U. S. Pat. No. 7,250,226, U.S. Pat. No. 7,396,598
Pt(II) organo-metallic complexes, including poly-dentated ligands		Appl. Phys. Lett. 86, 153505 (2005)
		Appl. Phys. Lett. 86, 153505 (2005)

TABLE 1-continued

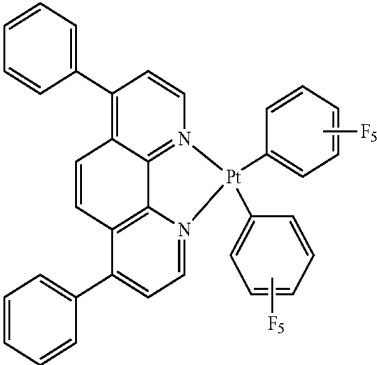
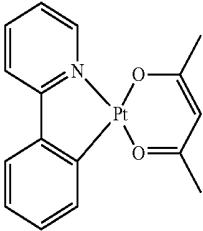
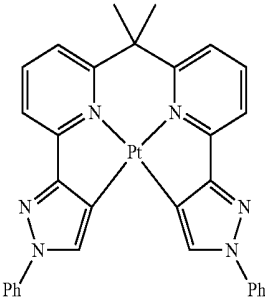
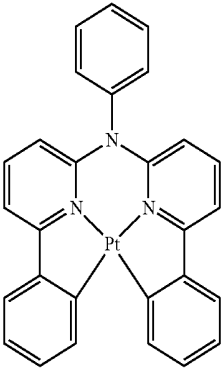
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
		Chem. Lett. 34, 592 (2005)
		WO2002015645
		US20060263635
		US20060182992 US20070103060

TABLE 1-continued

MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Cu complexes		WO2009000673
		US20070111026
Gold complexes		Chem. Commun. 2906 (2005)
Rhenium (III) complexes		Inorg. Chem. 42, 1248 (2003)

TABLE 1-continued

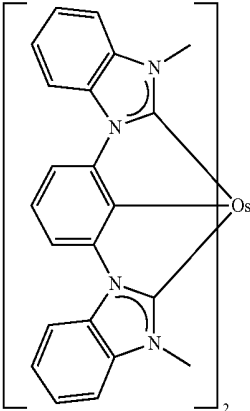
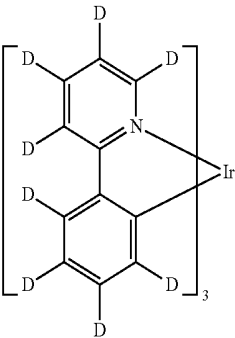
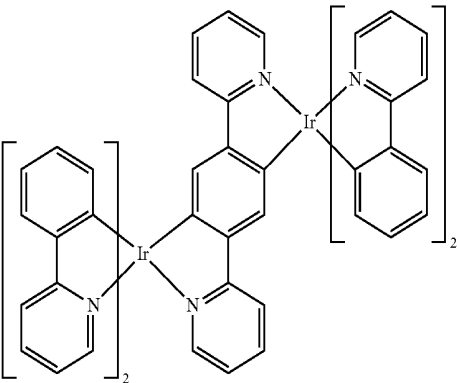
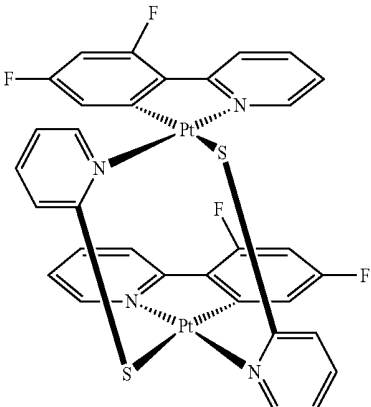
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Osmium (II) complexes		U.S. Pat. No. 7,279,704
Deuterated organo- metallic complexes		US20030138657
Organo- metallic complexes with two or more metal centers		US20030152802
		U.S. Pat. No. 7,090,928

TABLE 1-continued

MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Blue dopants		
Iridium(III) organo- metallic complexes		WO2002002714
		WO2006009024
		US20060251923 US20110057559 US20110204333
		U.S. Pat. No. 7,393,599, WO2006056418, US20050260441, WO2005019373
		U.S. Pat. No. 7,534,505

TABLE 1-continued

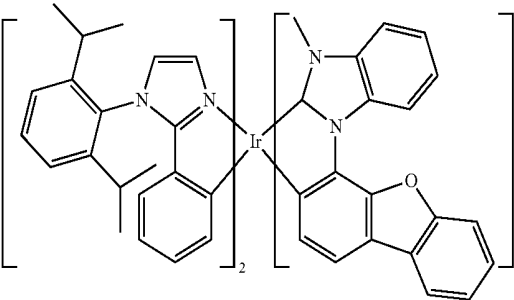
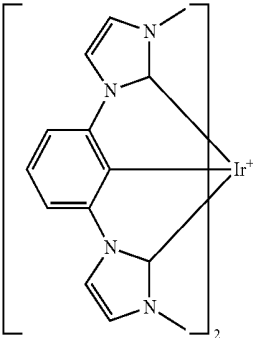
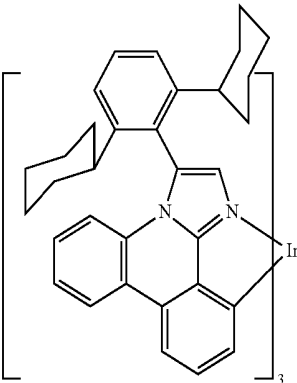
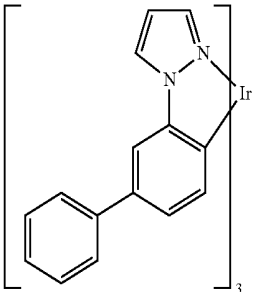
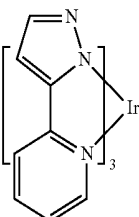
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
		WO2011051404
		U.S. Pat. No. 7,445,855
		US20070190359, US20080297033 US20100148663
		U.S. Pat. No. 7,338,722
		US20020134984

TABLE 1-continued

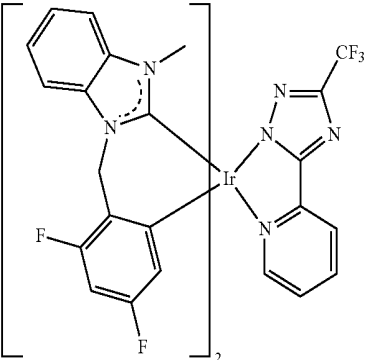
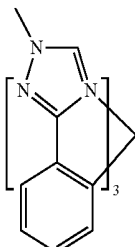
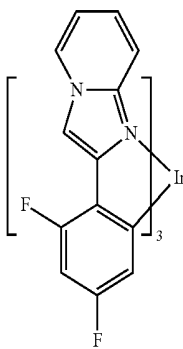
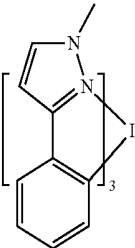
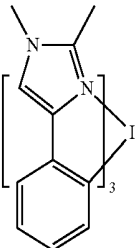
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
		Angew. Chem. Int. Ed. 47, 4542 (2008)
		Chem. Mater. 18, 5119 (2006)
		Inorg. Chem. 46, 4308 (2007)
		WO2005123873
		WO2005123873

TABLE 1-continued

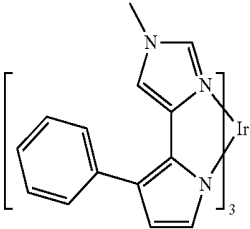
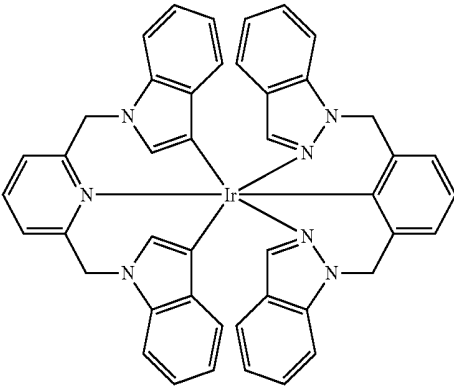
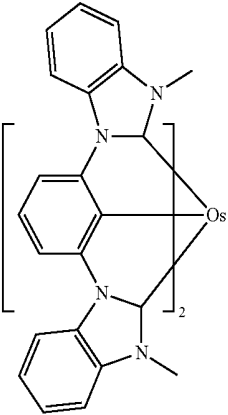
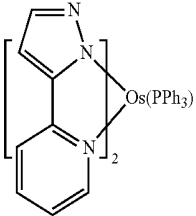
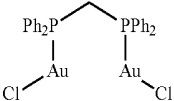
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
		WO2007004380
		WO2006082742
Osmium (II) complexes		U.S. Pat. No. 7,279,704
		Organometallics 23, 3745 (2004)
Gold complexes		Appl. Phys. Lett. 74, 1361 (1999)

TABLE 1-continued

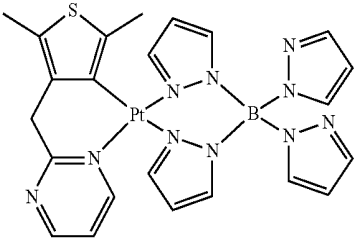
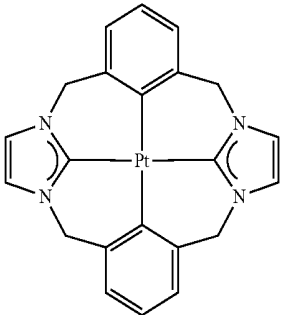
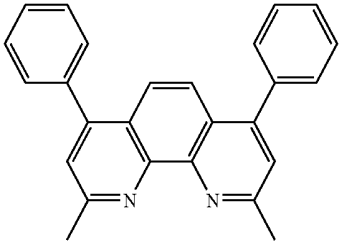
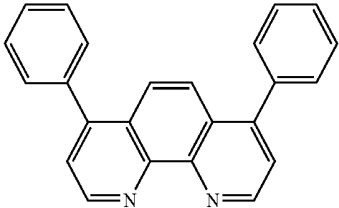
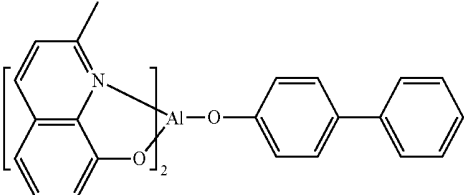
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Platinum (II) complexes		WO2006098120, WO2006103874
Pt tetradentate complexes with at least one metal-carbene bond		U.S. Pat. No. 7,655,323
Exciton/hole blocking layer materials		
Bathocuprine compounds (e.g., BCP, BPhen)		Appl. Phys. Lett. 75, 4 (1999)
		Appl. Phys. Lett. 79, 449 (2001)
Metal 8-hydroxy-quinolates (e.g., BALq)		Appl. Phys. Lett. 81, 162 (2002)

TABLE 1-continued

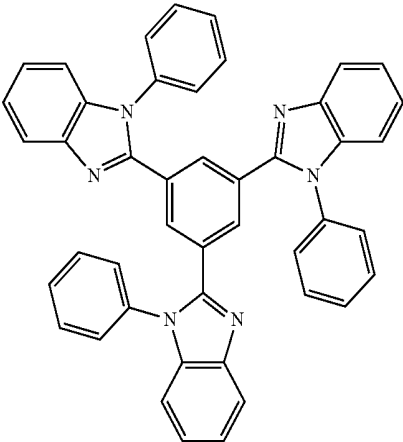
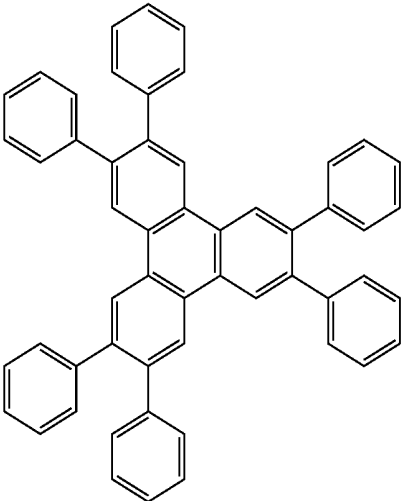
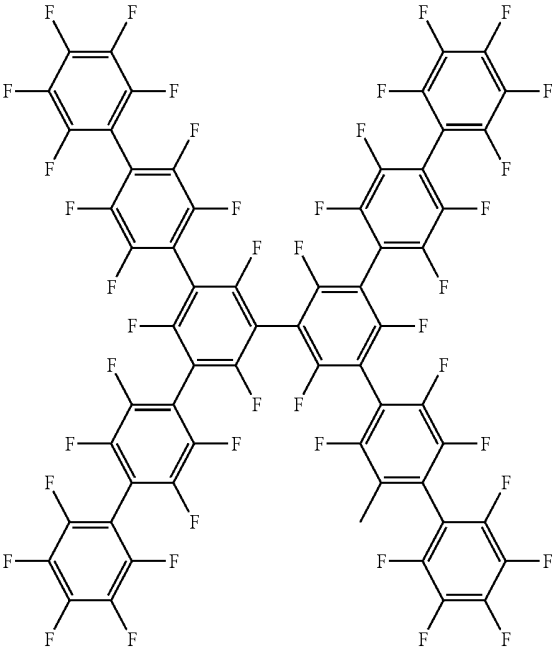
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
5-member ring electron deficient heterocycles such as triazole, oxadiazole, imidazole, benzo- imidazole		Appl. Phys. Lett. 81, 162 (200)
Tri- phenylene compounds		US20050025993
Fluorinated aromatic compounds		Appl. Phys. Lett. 79, 156 (2001)

TABLE 1-continued

MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Pheno- thiazine- S-oxide		WO2008132085
Silylated five- membered nitrogen, oxygen, sulfur or phosphorus dibenzo- heterocycles		WO2010079051
Aza- carbazole		US20060121308
Electron transporting materials		
Anthracene- benzo- imidazole compounds		WO2003060956

TABLE 1-continued

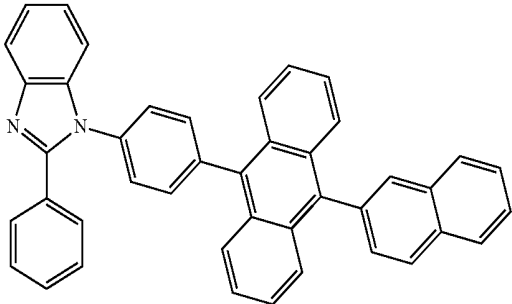
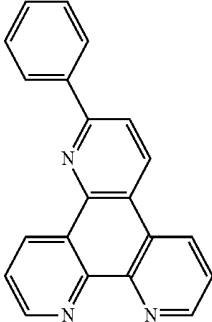
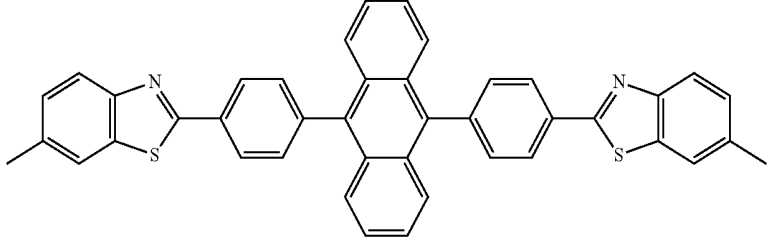
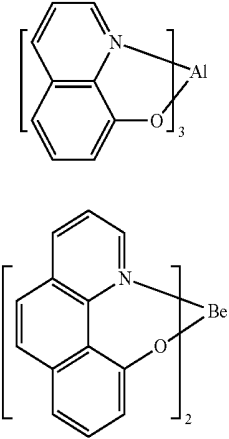
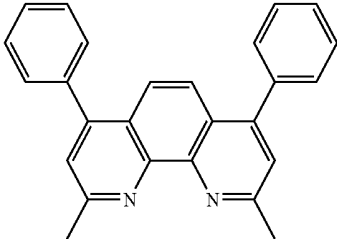
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Aza tri-phenylene derivatives		US20090179554
Anthracene-benzothiazole compounds		US20090115316
Metal 8-hydroxy-quinolates (e.g., Alq ₃ , Zr _q ₄)		Appl. Phys. Lett. 89, 063504 (2006)
Metal hydroxy-benzo-quinolates		Appl. Phys. Lett. 51, 913 (1987) U.S. Pat. No. 7,230,107
Bathocuprine compounds such as BCP, BPhen, etc		Appl. Phys. Lett. 91, 263503 (2007)

TABLE 1-continued

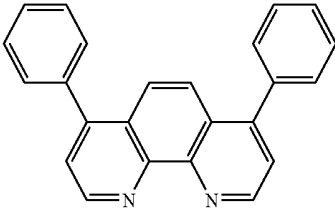
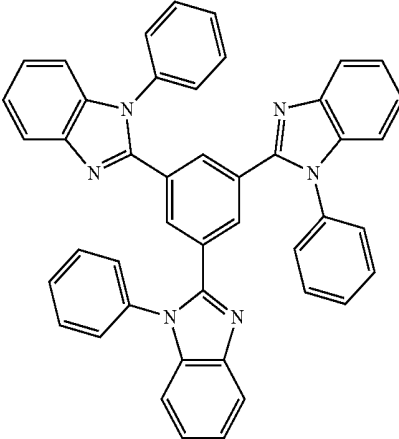
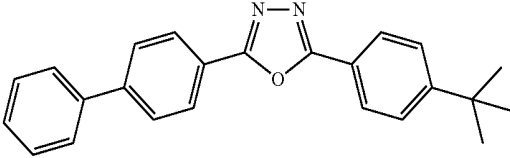
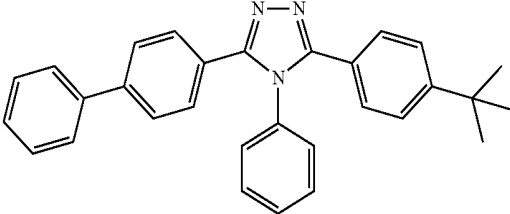
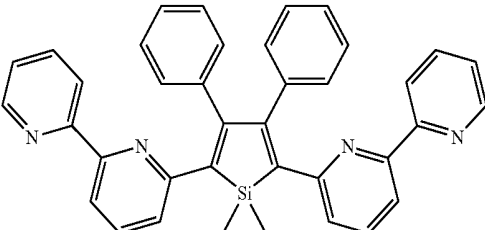
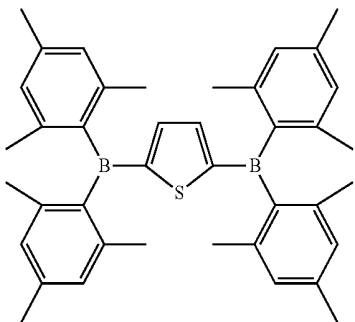
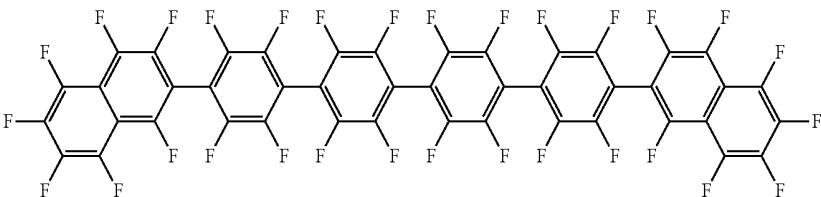
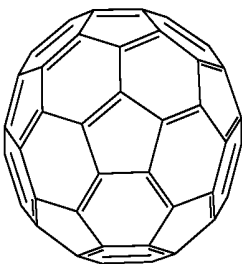
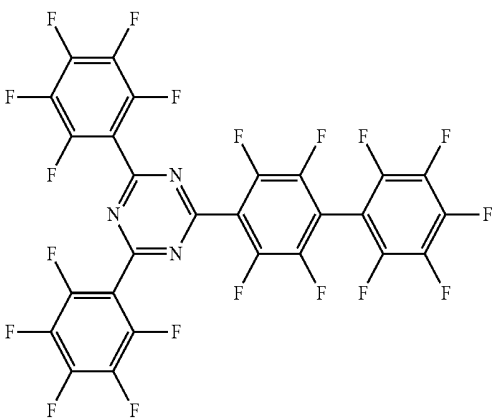
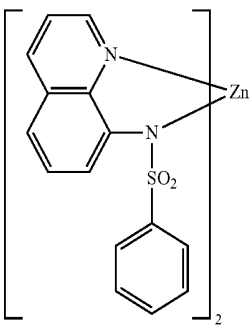
MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
5-member ring electron deficient heterocycles (e.g., triazole, oxadiazole, imidazole, benzo- imidazole)		Appl. Phys. Lett. 79, 449 (2001)
		Appl. Phys. Lett. 74, 865 (1999)
		Appl. Phys. Lett. 55, 1489 (1989)
Silole compounds		Jpn. J. Appl. Phys. 32, L917 (1993)
		Org. Electron. 4, 113 (2003)

TABLE 1-continued

MATERIAL	EXAMPLES OF MATERIAL	PUBLICATIONS
Arylborane compounds		J. Am. Chem. Soc. 120, 9714 (1998)
Fluorinated aromatic compounds		J. Am. Chem. Soc. 122, 1832 (2000)
Fullerene (e.g., C ₆₀)		US20090101870
Triazine complexes		US20040036077
Zn (N ^{''} N) complexes		U.S. Pat. No. 6,528,187

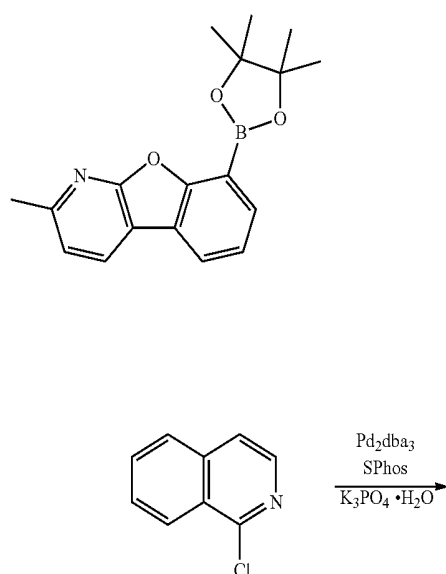
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EXPERIMENTAL

Synthetic Examples

All reactions were carried out under nitrogen protections unless specified otherwise. All solvents for reactions are anhydrous and used as received from commercial sources.

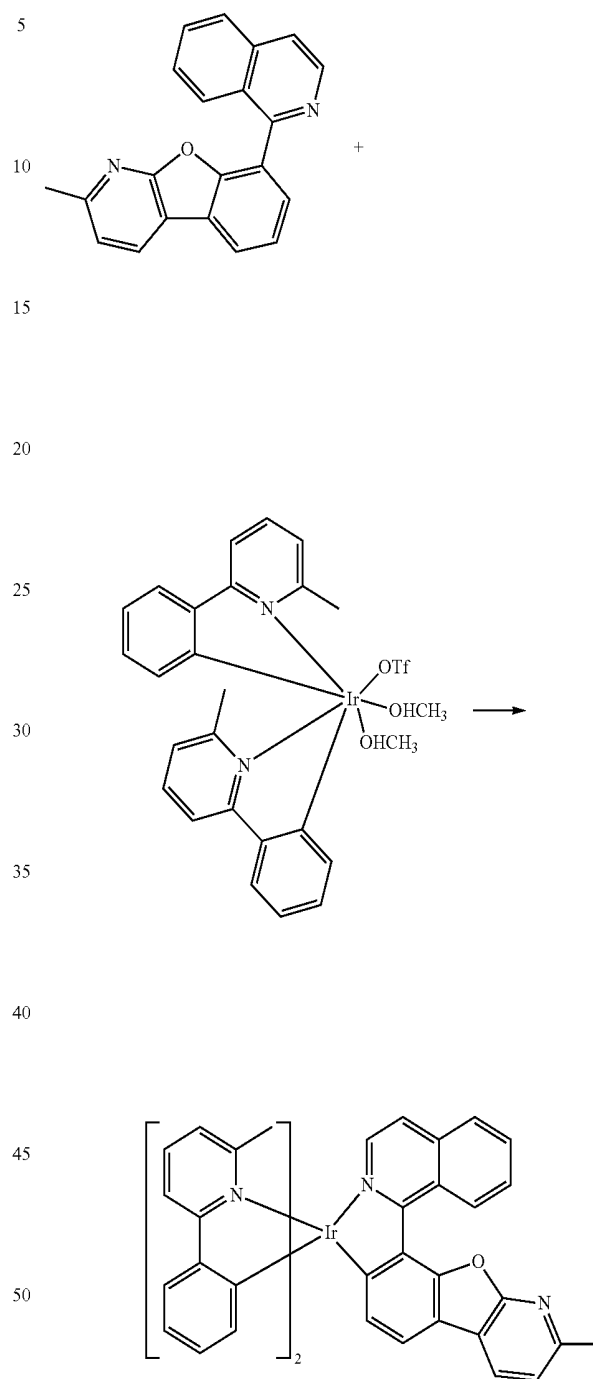
Synthesis of 8-(isoquinolin-1-yl)-2-methylbenzofuro[2,3-b]pyridine



2-methyl-8-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl) benzofuro[2,3-b]pyridine (4.73 g, 15.3 mmol), 1-chloroisoquinoline (2.75 g, 16.8 mmol), Pd_2dba_3 (0.28 g, 0.31 mmol), SPhos (0.50 g, 1.22 mmol), and $\text{K}_3\text{PO}_4 \cdot \text{H}_2\text{O}$ (10.6 g, 45.9 mmol) were dissolved in toluene (170 mL) and Water (20 mL), degassed by bubbling nitrogen, and heated to 100°C overnight. Upon completion of the reaction, the reaction mixture was cooled to room temperature and extracted with toluene. The crude material was purified via column chromatography using 20% ethyl acetate in 80% heptanes. It was noticed that a lot of deborylated compound was collected. After most of the impurity had come out, the mobile phase was gradually increased to 40% ethyl acetate in heptanes. The material was recrystallized from methanol to obtain the pure product, 8-(isoquinolin-1-yl)-2-methylbenzofuro[2,3-b]pyridine (0.60 g, 13% yield).

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Synthesis of Compound 10

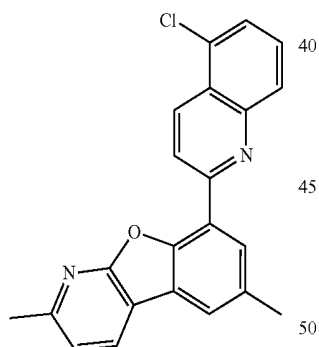
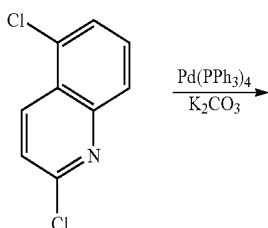
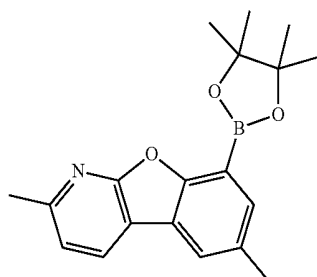


The Ir(III) intermediate shown above, left, (0.510 g, 0.687 mmol) and 8-(isoquinolin-1-yl)-2-methylbenzofuro[2,3-b]pyridine (0.640 g, 2.062 mmol) were mixed in 7 mL of ethanol and heated to reflux for 36 hours. The reaction was stopped when there was no Ir timer left as shown by HPLC. The mixture was cooled to room temperature and filtered through a pad of Celite. The solid was collected by washing the Celite pad with dichloromethane (DCM). The crude material was purified by column chromatography starting with 50% DCM in heptanes and gradually increasing to 80% DCM in heptanes. The red solid product, compound 10, was collected (0.40 g, 70% yield).

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Synthesis of Compound 24

Synthesis of 8-(5-chloroquinolin-2-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine



2,6-dimethyl-8-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzofuro[2,3-b]pyridine (7.0 g, 21.7 mmol), 2,5-dichloroquinoline (4.50 g, 22.7 mmol), and K_2CO_3 (5.99 g, 43.3 mmol) were dissolved in toluene (180 mL) and water (36 mL). The mixture was degassed by bubbling with nitrogen for 15 minutes, then $Pd(PPh_3)_4$ (1.25 g, 1.08 mmol) was added and the mixture was heated to reflux overnight. Upon completion, the mixture was cooled to room temperature, extracted using ethyl acetate, and the organic layer was washed with brine and water. The crude mixture was filtered through a plug of silica using a dichloromethane and ethyl acetate mixture. After evaporation of the solvent, the product was triturated from heptanes to yield pure 8-(5-chloroquinolin-2-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (6.0 g, 77% yield).

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Synthesis of 8-(5-isobutylquinolin-2-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine

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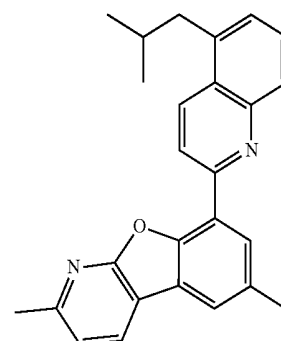
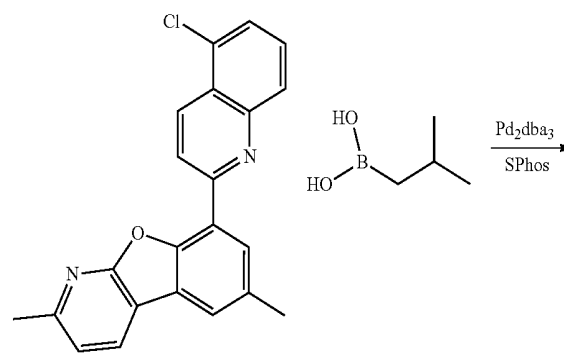
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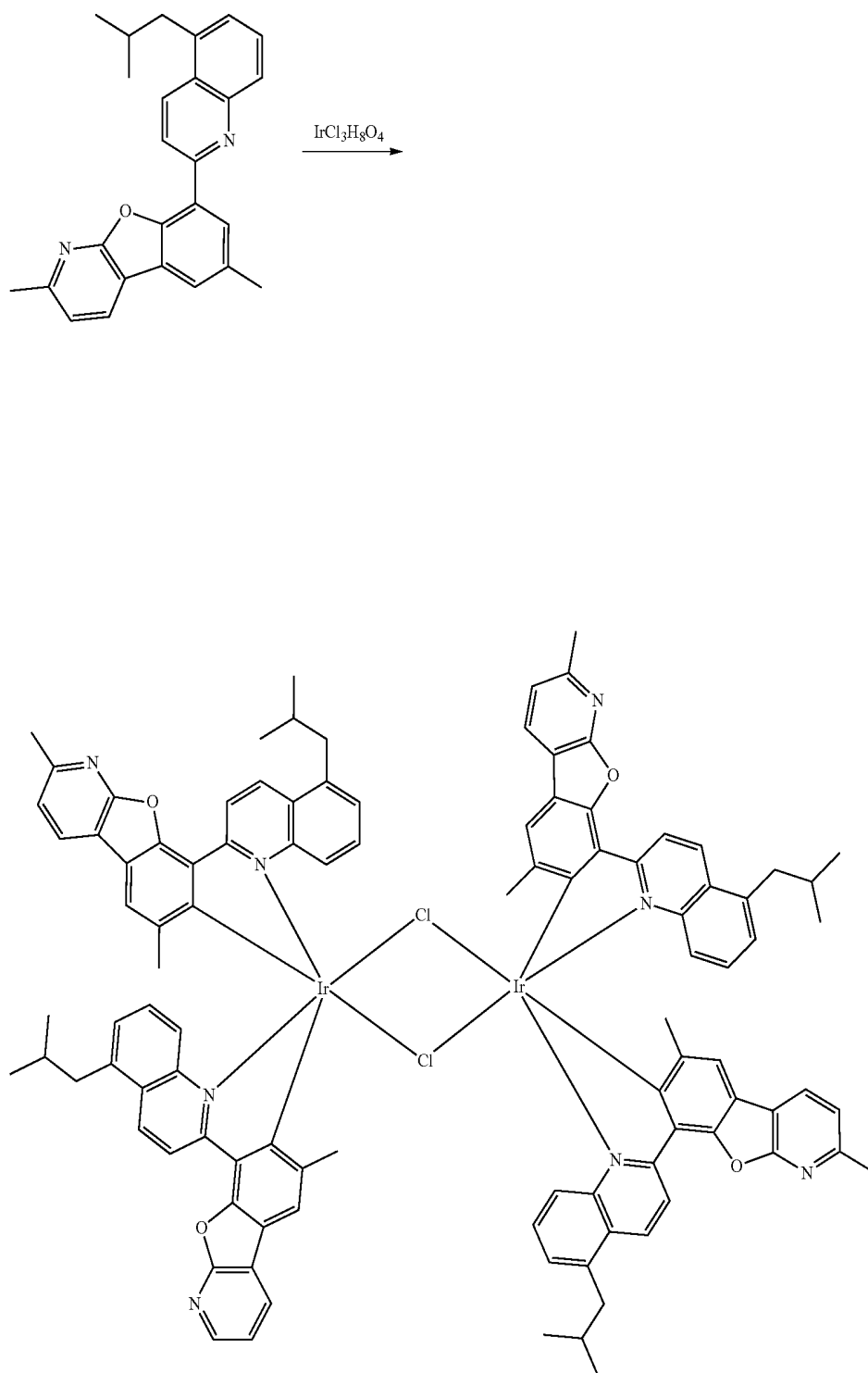


8-(5-chloroquinolin-2-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (4.75 g, 13.2 mmol), isobutylboronic acid (2.70 g, 26.5 mmol), Pd_2dba_3 (0.24 g, 0.27 mmol), dicyclohexyl(2',6'-dimethoxy-[1,1'-biphenyl]-2-yl)phosphine (SPhos) (0.44 g, 1.06 mmol), and K_3PO_4 (5.62 g, 26.5 mmol) were dissolved in toluene (150 mL) and water (15 mL). The solution was degassed by bubbling nitrogen for 15 minutes, then refluxed overnight. Upon completion, the mixture was cooled to room temperature, extracted using ethyl acetate, and washed with water. The crude product was purified by column chromatography using 25% ethyl acetate in heptanes. The product was further purified by recrystallization from heptanes to yield 8-(5-isobutylquinolin-2-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (4.5 g, 89% yield).

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Synthesis of Ir(III) Dimer

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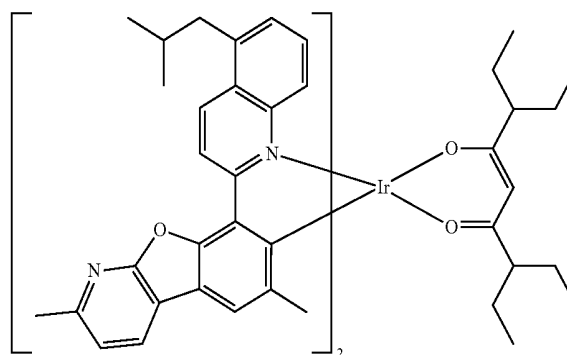
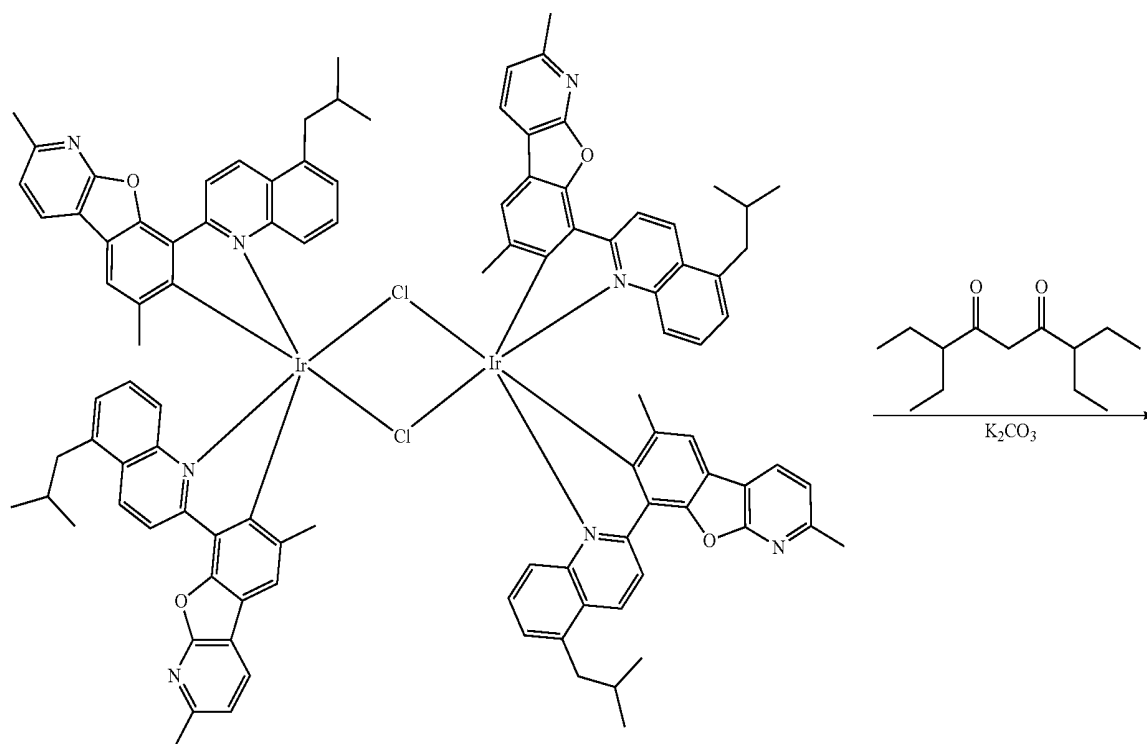


8-(5-isobutylquinolin-2-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (3.00 g, 7.88 mmol) was solubilized in ethoxy-ethanol (25 mL) and water (8 mL), then degassed by bubbling nitrogen for 30 minutes. Iridium chloride (0.97 g, 2.63 mmol) was then added to the solution and the reaction was refluxed under nitrogen for 24 h. After cooling to room temperature, the solid was filtered, washed with methanol, and dried to give the Ir(III) Dimer (1.95 g, 0.99 mmol, 75% yield) as a light orange powder.

155

Synthesis of Compound 24

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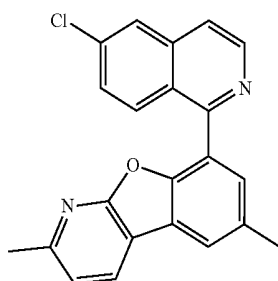
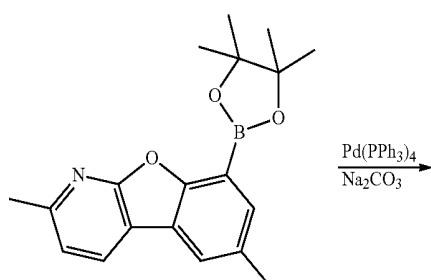
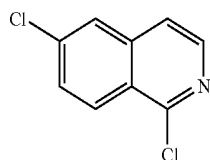
Ir(III) dimer (0.39 g, 0.20 mmol) and 3,7-diethylnonane-4,6-dione (0.42 g, 1.98 mmol) were added to a flask. The mixture was diluted in ethoxyethanol (6.6 mL) and degassed by bubbling nitrogen for 15 minutes. K_2CO_3 (0.27 g, 1.98 mmol) was then added to the mixture, which was then stirred at room temperature overnight. Upon completion of the reaction, the mixture was diluted in dichloromethane

60 (DCM), filtered through a pad of Celite, and washed with more DCM. The solvents were evaporated and the crude material was purified by column chromatography using triethylamine (TEA) pre-treated silica gel. The mobile phase used was 10% DCM in heptanes. The resulting product—
65 Compound 24—was purified by recrystallization from a DCM and methanol mixture to afford 0.2 g (44% yield).

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Synthesis of Compound 44

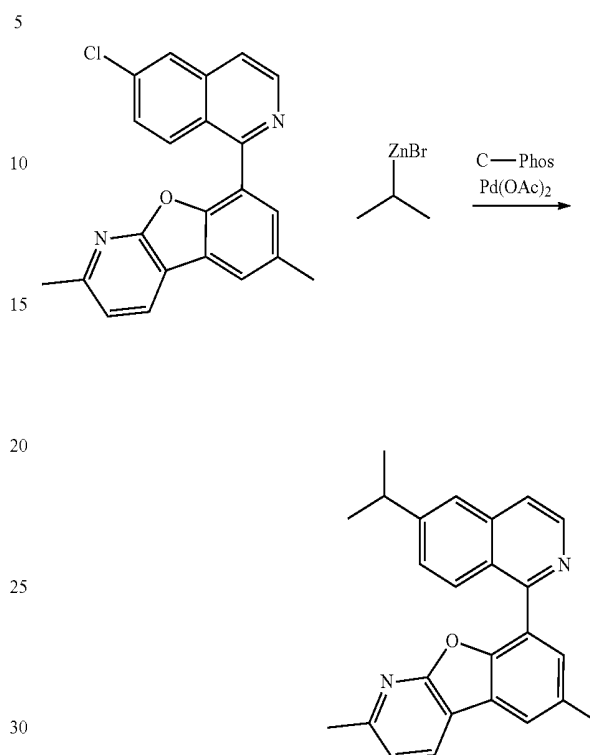
Synthesis of 8-(6-chloroisoquinolin-1-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine



1,6-dichloroisoquinoline (4.80 g, 24.2 mmol), 2,6-dimethyl-8-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzofuro[2,3-b]pyridine (8.22 g, 25.4 mmol), sodium carbonate (6.42 g, 60.6 mmol), palladium tetrakis (0.84 g, 0.73 mmol), 160 mL dimethoxyethane (DME) and 40 mL of water were combined in a round bottom flask. A condenser was attached and then the system was evacuated and purged with nitrogen three times. The reaction mixture was heated to a vigorous reflux overnight. The reaction mixture was diluted with ethyl acetate and water, the suspension was then filtered through Celite and washed with ethyl acetate. The aqueous portion was partitioned off and the organic was washed once with brine, dried with sodium sulfate, filtered, and concentrated down to beige solid. The Celite was further washed with 50/50 DCM/THF and the filtrate was concentrated and combined with the other crude sample. The combined crude sample was dissolved in DCM and purified with silica gel using DCM to 85/15 DCM/ethyl acetate solvent system to get a pale beige solid. The pale beige solid was triturated in 90/10 heptane/ethyl acetate, then filtered to get a white precipitate of 8-(6-chloroisoquinolin-1-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (7.8 g, 91% yield).

158

Synthesis of 8-(6-isopropylisoquinolin-1-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine

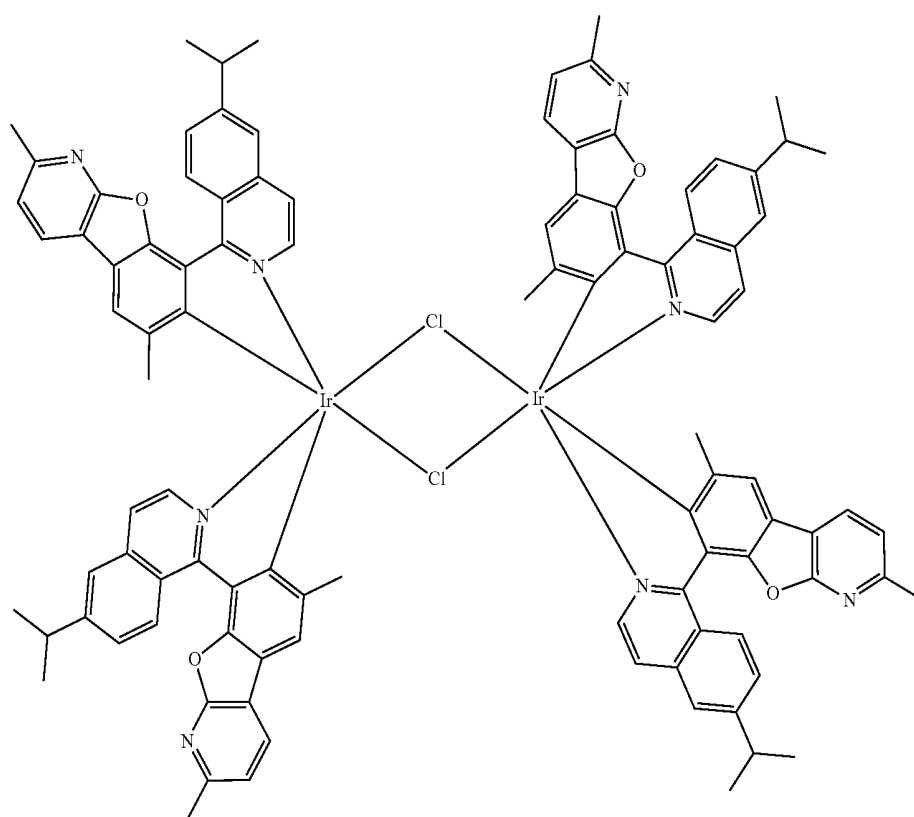
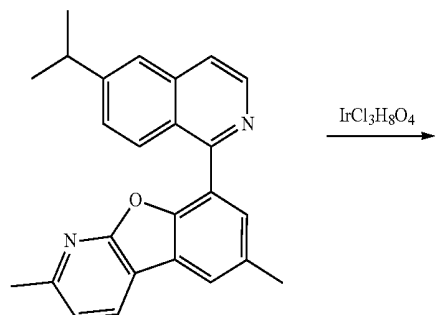


8-(6-chloroisoquinolin-1-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (4.0 g, 11.2 mmol), 2'-(dicyclohexylphosphino)-N2,N2,N6,N6-tetramethyl-[1,1'-biphenyl]-2,6-diamine (0.39 g, 0.89 mmol), diacetoxypalladium (0.10 g, 0.45 mmol) and 200 mL anhydrous THF were combined in an oven dried three neck round bottom flask. A condenser was attached then the system was evacuated and purged with nitrogen three times. The reaction was heated to 60° for 15 min to dissolve the reactant and form the catalyst to get a pale brown solution. The reaction was then cooled to 0° C., then isopropylzinc(II) bromide (33 mL, 16.7 mmol) was added rapidly with a syringe through a septum. The reaction mixture was allowed to stir in the ice bath for 30 minutes then removed to let it warm to room temperature. Upon completion of the reaction, it was quenched with ammonium chloride solution then filtered through a Celite plug. The Celite was washed well with ethyl acetate. The aqueous portion was partitioned off and the organic portion was washed once with brine, dried with sodium sulfate, filtered, and then concentrated down to yield 5.5 g of a brown solid. The brown solid was dissolved in DCM and purified with a silica gel cartridge using a DCM to 85/15 DCM/EtOAc solvent system to get 3.8 g of an off-white sticky solid. The sample was dissolved in acetonitrile and purified with C¹⁸ cartridges using a 50/50 to 85/15 acetonitrile/water solvent system. This produced 1.3 g of pure white solid. The crude fraction were re-purified using the same technique to produce 2.2 g (54% yield) of 8-(6-isopropylisoquinolin-1-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine, the pure target compound.

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Synthesis of Ir(III) Dimer

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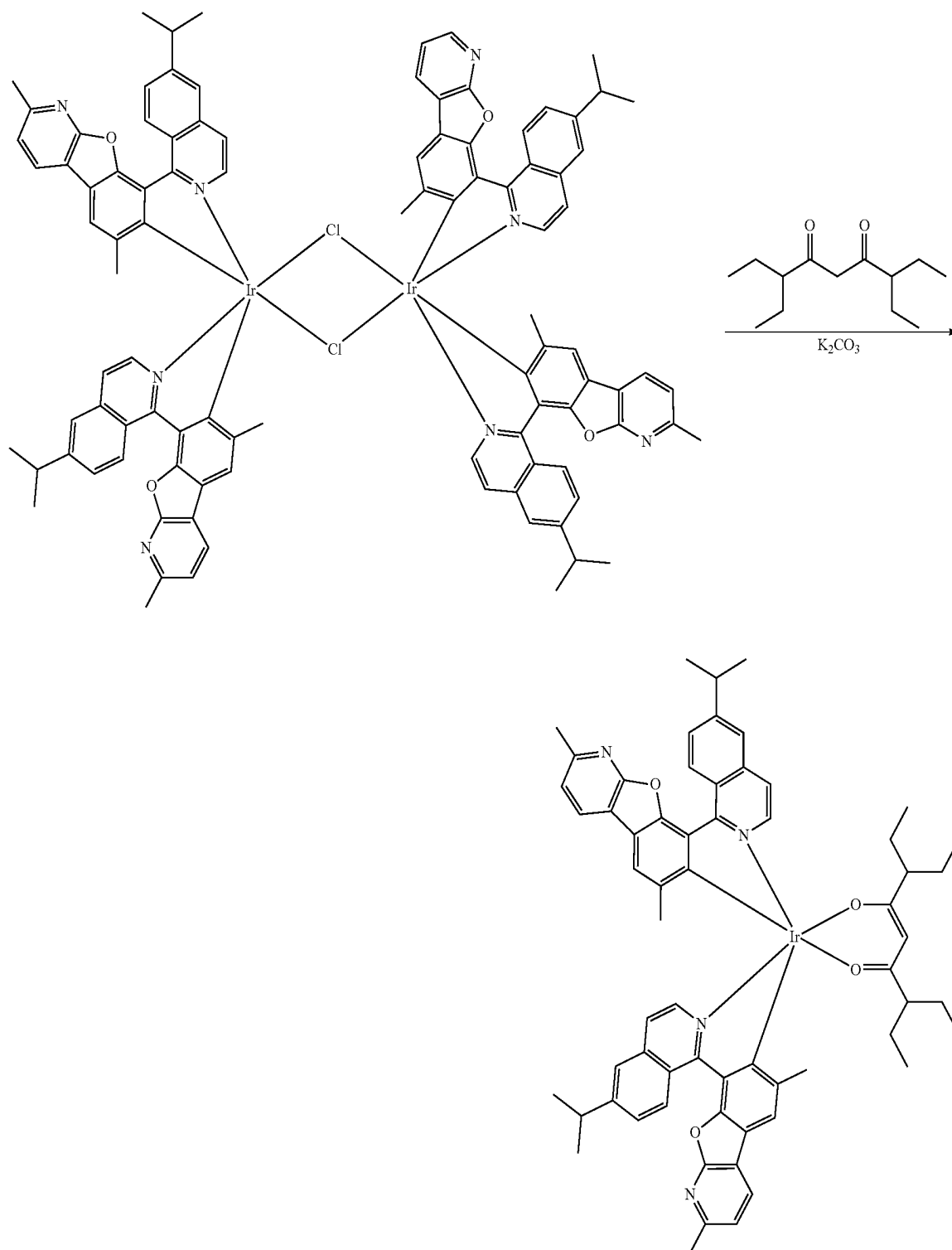
8-(6-isopropylisoquinolin-1-yl)-2,6-dimethylbenzofuro
[2,3-b]pyridine (2.5 g, 6.82 mmol) was solubilized in
ethoxyethanol (19 mL) and water (6 mL), then degassed
with nitrogen for 30 minutes. Iridium chloride (0.56 g, 1.52
mmol) was then added to the solution and the reaction
mixture was refluxed under nitrogen for 24 hours. After

cooling to room temperature, the solid was filtered, washed
with methanol, and dried to give Ir(III) Dimer (1.9 g, 0.99
mmol, 131% yield) as a brown powder. The yield was higher
than 100% because of the ligand remaining within the solid.
The solid was used as is.

161

Synthesis of Compound 44

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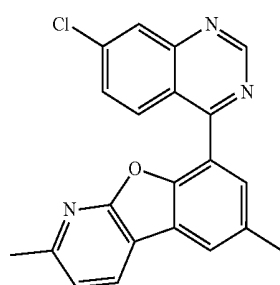
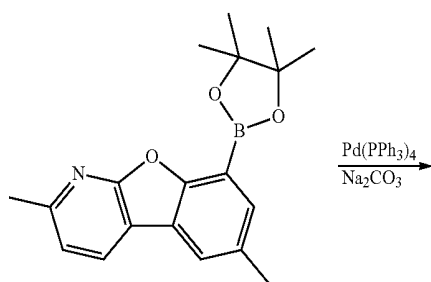
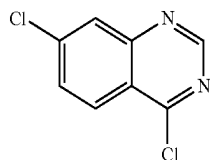
The Ir(II) Dimer (1.22 g, 0.78 mmol) and 3,7-diethylnonane-4,6-dione (1.66 g, 7.84 mmol) were solubilized in 2-ethoxyethanol (26 mL) and degassed by bubbling nitrogen for 15 minutes. Potassium carbonate (1.08 g, 7.84 mmol) was then added and the mixture was stirred at room temperature overnight. The dimer was not completely consumed, so the mixture was then heated to 50° C. for 4 hours. Upon completion, the mixture was diluted in DCM and

60 filtered through a pad of Celite, then washed with DCM. The solvents were evaporated and the crude material was purified by column chromatography (pre-treated with triethylamine) starting from 10% DCM in Heptanes to 40% DCM in Heptanes. The dark red solid was recrystallized from a mixture of DCM and methanol to yield the pure product, Compound 44 (1.4 g, 63% yield).

163

Synthesis of Compound 56

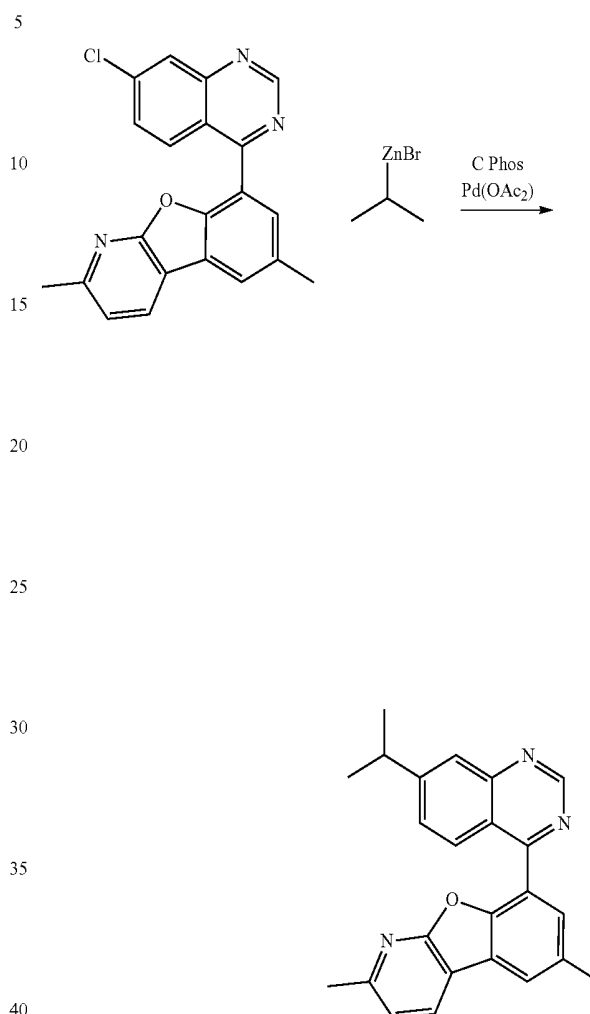
Synthesis of 8-(7-chloroquinazolin-4-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine



4,7-dichloroquinazoline (3.00 g, 15.1 mmol) and 2,6-dimethyl-8-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)benzofuro[2,3-b]pyridine (5.11 g, 15.8 mmol), and K_2CO_3 (4.17 g, 30.1 mmol) were dissolved in DME (150 mL) and Water (40 mL). The solution was degassed by bubbling nitrogen gas, $Pd(PPh_3)_4$ (0.70 g, 0.60 mmol) was added and the reaction was heated to reflux overnight. Upon completion of the reaction, the mixture was extracted with three times with ethyl acetate and washed with water. The crude material was purified by column chromatography using Heptanes/EA (90/10 to 80/20) solvent system. The solvent of the combined was removed under vacuum to afford 8-(7-chloroquinazolin-4-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (5.0 g, 92% yield) as a white solid.

164

Synthesis of 8-(7-isopropylquinazolin-4-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine

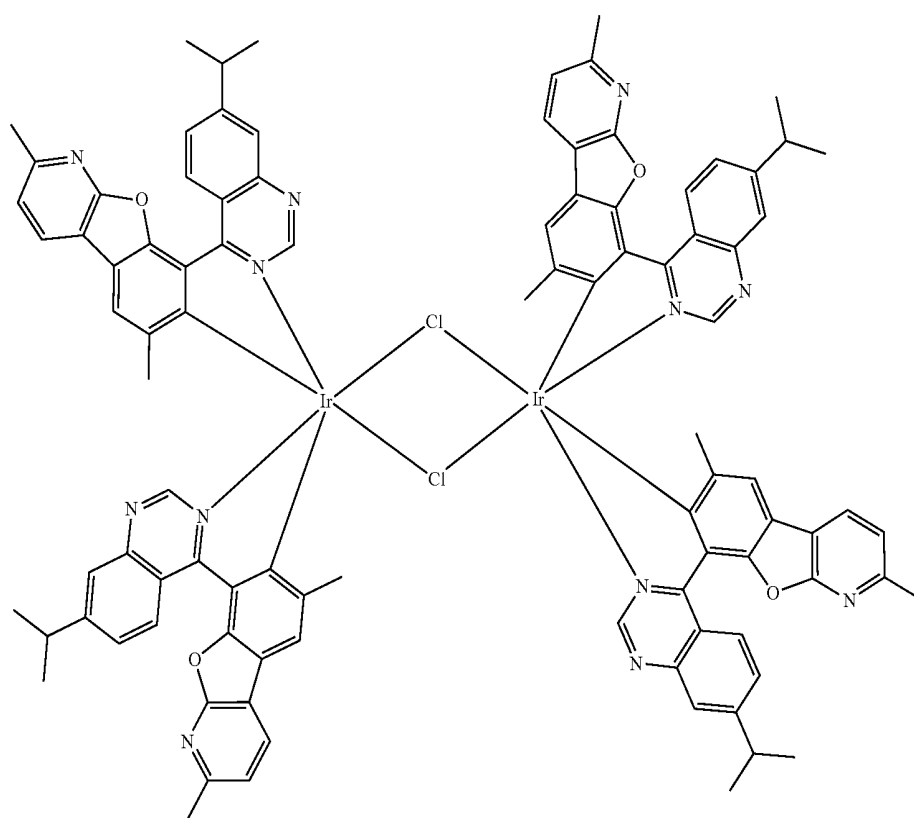
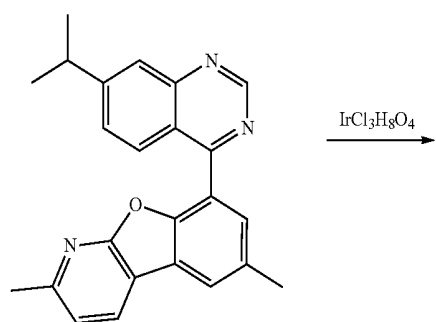


8-(7-chloroquinazolin-4-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (3.33 g, 9.25 mmol), 2'-(dicyclohexylphosphino)-N2,N2,N6,N6-tetramethyl-[1,1'-biphenyl]-2,6-diamine (CPhos) (0.32 g, 0.74 mmol) and diacetoxypalladium (0.08 g, 0.37 mmol) were diluted in dry THF (185 mL). The solution was cooled down to 0° C. and a solution of isopropylzinc(II) bromide (28 mL, 13.9 mmol) was added dropwise. The reaction was stirred for 30 minutes at this temperature and then stirred overnight at room temperature. Upon completion, the reaction was quenched with a solution of ammonium chloride, extracted with ethyl acetate and washed with Brine and water. The crude material was purified by column chromatography using Heptanes/EA/DCM (60/30/10 to 45/10/45) solvent system. The resulting solid still contained around 1% of n-propyl isomer. In order to remove that impurity, the product was purified by reverse phase column chromatography using Acetonitrile/Water (80/20). The removal of the n-propyl was successful but there was still some starting material left. The product was further purified two times by column chromatography using the same solvent system as described before. The title compound 8-(7-isopropylquinazolin-4-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (1.6 g, 47% yield) was afforded as a white powder.

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Synthesis of Ir(III) Dimer

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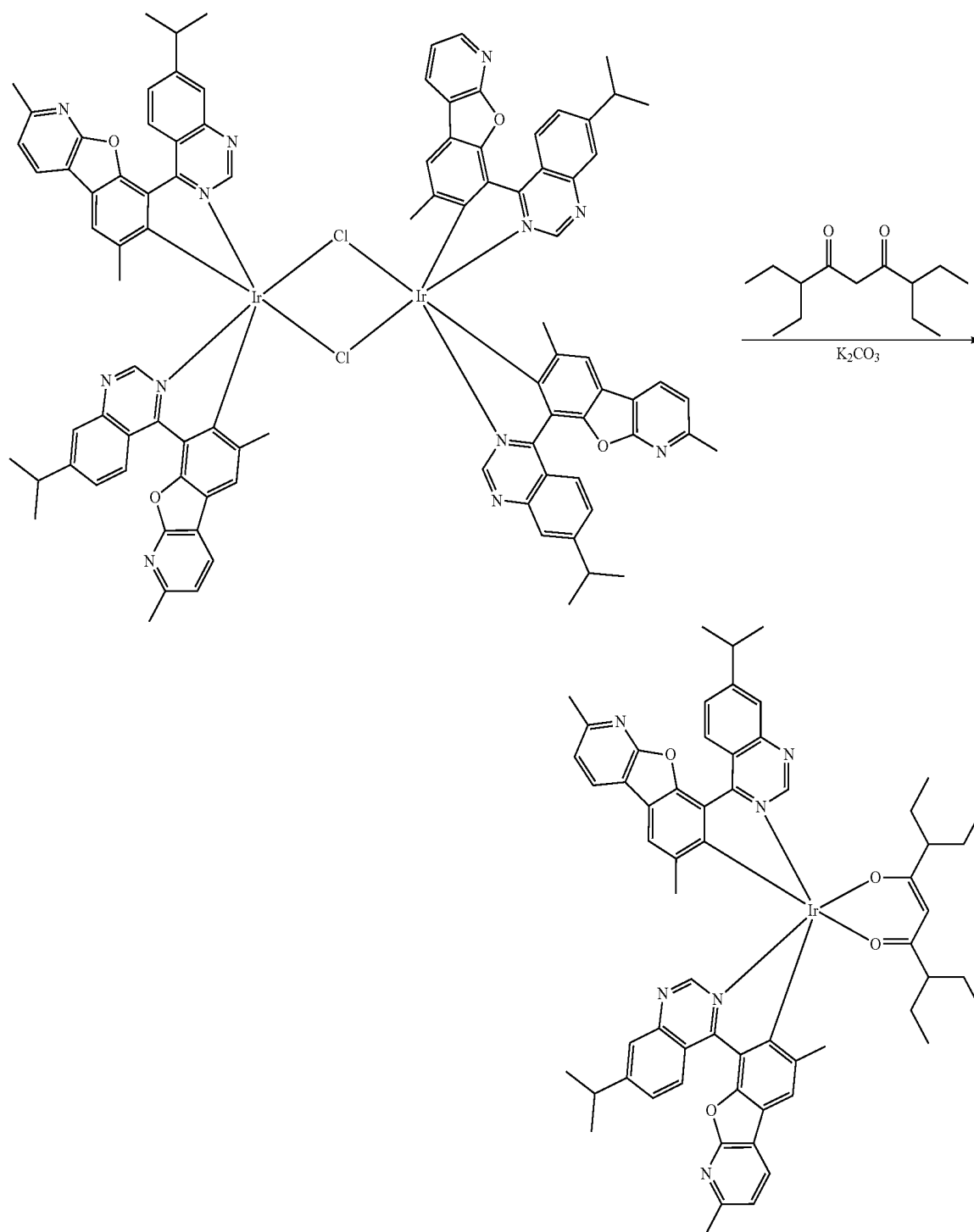


8-(7-isopropylquinazolin-4-yl)-2,6-dimethylbenzofuro[2,3-b]pyridine (1.6 g, 4.35 mmol) was solubilized in ethoxyethanol (13 mL) and Water (4 mL) and degassed by bubbling nitrogen gas for 30 minutes. Iridium chloride (0.38 g, 1.03 mmol) was then added to the solution and the reaction was

refluxed under nitrogen for 24 hours. After cooling down to room temperature, the solid was filtered, washed with methanol and dried to give Ir(III) Dimer (1.0 g, 100% yield) as an orange powder. There is still ligand left but will use without further purification.

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Synthesis of Compound 56

Ir(III) Dimer (1.0 g, 0.52 mmol) and 3,7-diethylnonane-4,6-dione (1.11 g, 5.21 mmol) were diluted in ethoxyethanol (20 mL) and the mixture was degassed by bubbling nitrogen gas. K_2CO_3 (0.72 g, 5.21 mmol) was then added and the reaction was stirred at room temperature overnight. The mixture was diluted with DCM, filtered through a pad of Celite, and washed with DCM. The crude material was purified by column chromatography (silica pre-treated with TEA) using Heptanes/DCM 90/10 solvent system. The

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product was triturated in methanol and the title compound was afforded as a red powder (0.16 g, 14% yield).

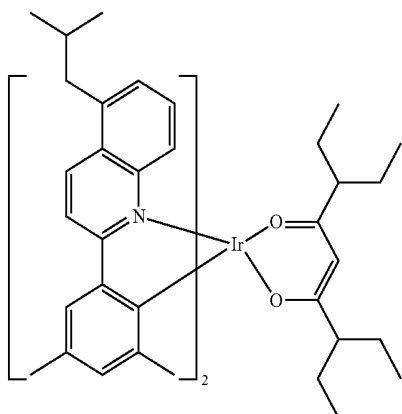
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Device Examples

The inventors have verified the benefits of the inventive compounds disclosed herein by fabricating experimental OLED devices. Device examples were made using Compound 24, Compound 56, and Compound 10 as an emitter material in the emissive layer. A Comparative Device was made using Comparative Compound 1 shown below:

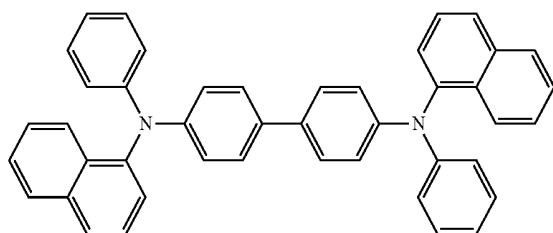
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Comparative Compound 1



All example devices were fabricated by high vacuum ($<10^{-7}$ Torr) thermal evaporation. The anode electrode is 1200 Å of indium tin oxide (ITO). The cathode consisted of 10 Å of LiF followed by 1,000 Å of Al. All devices are encapsulated with a glass lid sealed with an epoxy resin in a nitrogen glove box (<1 ppm of H_2O and O_2) immediately after fabrication, and a moisture getter was incorporated inside the package.

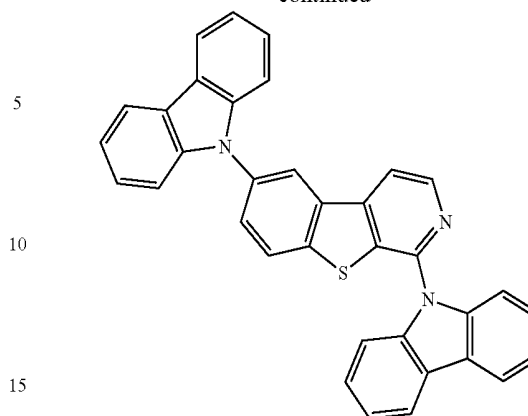
The organic stack of the device examples consisted of sequentially, from the ITO surface, 100 Å of LG101 (purchased from LG chem) as the hole injection layer (HIL); 400 Å of 4,4'-bis[N-(1-naphthyl)-N-phenylamino]biphenyl (NPD) as the hole transporting layer (HTL); 300 Å of an emissive layer (EML) containing Compound H as a host (79%), a stability dopant (SD) (18%), and Compound 24, Compound 56, or Compound 10 as an emitter 100 Å of Compound H as a blocking layer; and 450 Å of Alq_3 (tris-8-hydroxyquinoline aluminum) as the ETL. The emitter was selected to provide the desired color and the stability dopant (SD) was mixed with the electron-transporting host and the emitter to help transport positive charge in the emissive layer. The Comparative Example was fabricated similarly to the device examples except that Comparative Compound 1 was used as the emitter in the EML. Table 2 shows the composition of the EML in the device, while the device results and data are summarized in Table 3. As used herein, NPD, compound H, SD, and Alq_3 have the following structures:



NPD

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Compound H

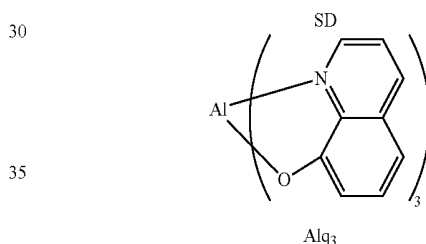
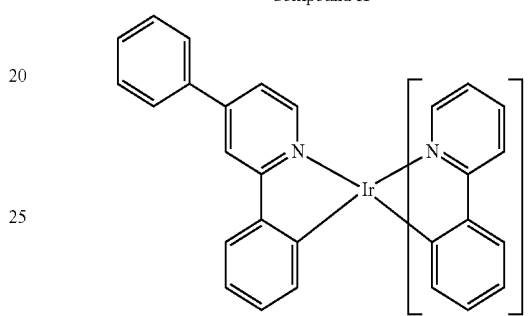
 Alq_3

TABLE 2

Compounds of EML in the devices			
Example	Host	Stability dopant	Emitter
Device Example 1	Compound H	SD	Compound 24
Device Example 2			Compound 56
Device Example 3			Compound 10
Comparative example			Comparative compound 1

TABLE 3

Device results					
	1931 CIE		λ max	FWHM	At 80 mA/cm ² Relative
	x	y	[nm]	[nm]	LT _{95%} [h]
Device Example 1	0.63	0.37	606	42	3.1
Device Example 2	0.68	0.32	648	54	6.3
Device Example 3	0.60	0.39	614	88	8

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TABLE 3-continued

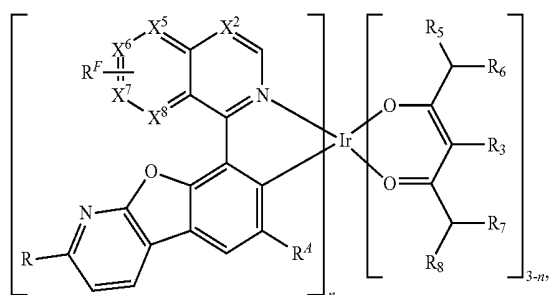
	Device results				
	1931 CIE		λ max	FWHM	At 80 mA/cm ²
	x	y	[nm]	[nm]	Relative LT _{95%} [h]
Comparative example	0.64	0.36	612	52	1

Table 3 summarizes the performance of the devices. The 1931 CIE values were measured at 10 mA/cm². The device operation lifetime measurements were performed at a constant dc current of 80 mA/cm² at room temperature with light output monitored as a function of time. The operational lifetimes defined at 95% of the initial luminance (LT_{95%}). The lifetime of the Comparative Example was set to 1 and the lifetimes of device examples are indicated as relative values compared to the Comparative Example (i.e., a value of 2 indicates a LT_{95%} that is twice that of the Comparative Example). Device Example 1 has a full width at half maximum (FWHM) that is 10 nm narrower than the Comparative Example. Device Example 1 also exhibited a LT_{95%} at 80 mA/cm² more than three times longer than the Comparative Device. Device Example 2 exhibits a 42 nm red shift of the peak wavelength compared to Device Example 1 and had a LT_{95%} at 80 mA/cm² double that of Device Example 1. Device Example 3 exhibits a FWHM 36 nm wider than the Comparative Examiner, but also exhibits a LT_{95%} at 80 mA/cm² that is 8 times the LT_{95%} of the Comparative Example.

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.

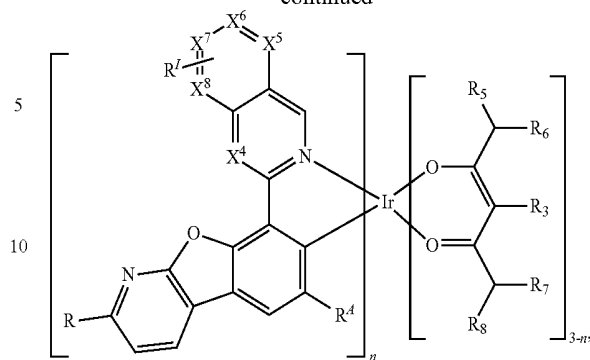
We claim:

1. A compound having a formula $M(L_A)_n(L_B)_{3-n}$ selected from the group consisting of:

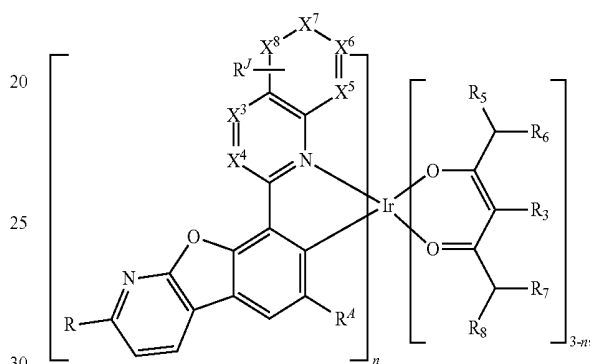


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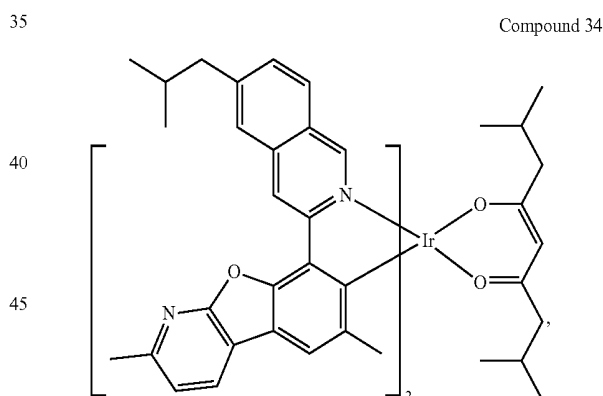
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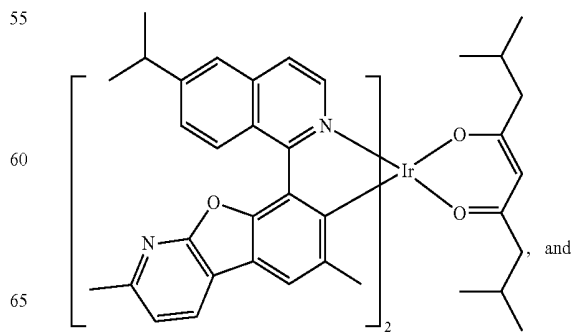
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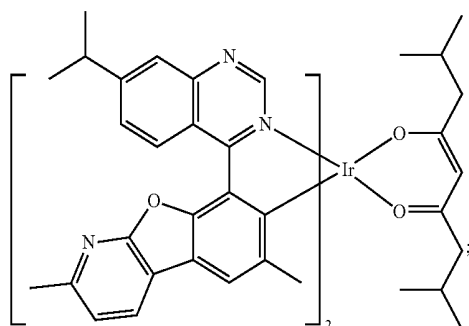
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Compound 58



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wherein n is 1 or 2;

wherein X^2 , X^3 , X^4 are independently CH or N;wherein X^5 , X^6 , X^7 , and X^8 are C or N;

20

wherein R^F , R^I , and R^J each independently represent mono, di, tri, or tetra-substitution, or no substitution;

wherein R is selected from the group consisting of alkyl, partially or fully deuterated alkyl, cycloalkyl, partially or fully deuterated cycloalkyl, and combinations thereof;

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wherein R^5 , R^6 , R^7 , and R^8 are independently selected from group consisting of alkyl, cycloalkyl, aryl, and heteroaryl;

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wherein at least one of R^5 , R^6 , R^7 , and R^8 has at least two C atoms;wherein each of R^4 , R^F , R^I , R^J , R^1 , R^2 , and R^3 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.

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2. The compound of claim 1, wherein X^2 , X^3 , and X^4 are CH; and wherein X^5 , X^6 , X^7 , and X^8 are C.

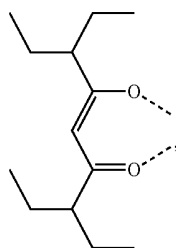
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3. The compound of claim 1, wherein (a) at least one of X^2 , X^3 , and X^4 is N in the compound, (b) wherein at least one of X^5 , X^6 , X^7 , and X^8 is N, or (c) both.

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4. The compound of claim 1, wherein L_B is selected from the group consisting of:

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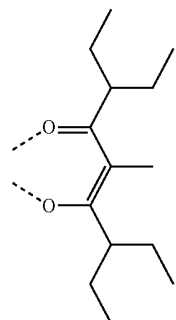
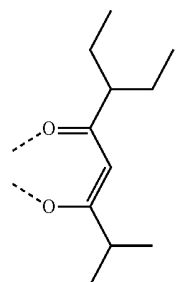
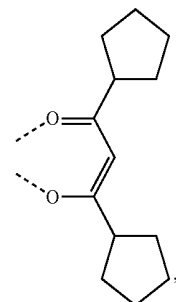
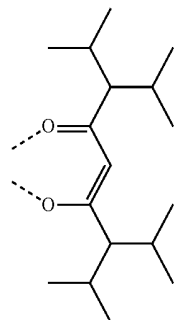
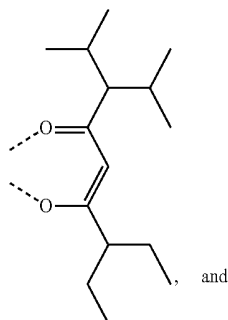
 L_{B43}

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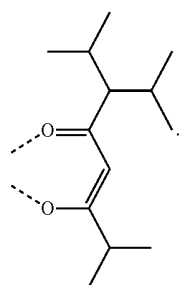
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 L_{B44}  L_{B45}  L_{B50}  L_{B52}  L_{B53} 

and

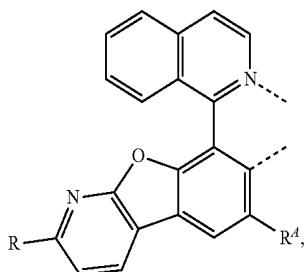
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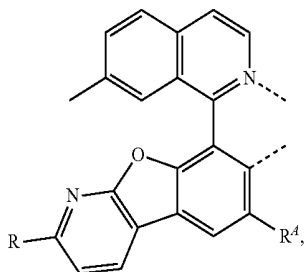
5. The compound of claim 1, wherein L_A is selected from the group consisting of:

L_{A44} through L_{A113} , each represented by the formula



wherein in L_{A44} , $R = \text{CH}_3$, and $R^A = \text{H}$,
 in L_{A45} , $R = \text{CD}_3$, and $R^A = \text{H}$,
 in L_{A46} , $R = \text{CH}_3$, and $R^A = \text{CH}_3$,
 in L_{A47} , $R = \text{CD}_3$, and $R^A = \text{CD}_3$,
 in L_{A48} , $R = \text{Ethyl}$, and $R^A = \text{H}$,
 in L_{A49} , $R = \text{Ethyl}$, and $R^A = \text{CH}_3$,
 in L_{A10} , $R = \text{Ethyl-d5}$, and $R^A = \text{CD}_3$,
 in L_{A11} , $R = \text{isopropyl}$, and $R^A = \text{H}$,
 in L_{A12} , $R = \text{isopropyl}$, and $R^A = \text{CH}_3$,
 in L_{A13} , $R = \text{isopropyl-d7}$, and $R^A = \text{CD}_3$

L_{A17} through L_{A26} , each represented by the formula



wherein in L_{A17} , $R = \text{CH}_3$, and $R^A = \text{H}$,
 in L_{A18} , $R = \text{CD}_3$, and $R^A = \text{H}$,
 in L_{A19} , $R = \text{CH}_3$, and $R^A = \text{CH}_3$,
 in L_{A20} , $R = \text{CD}_3$, and $R^A = \text{CD}_3$,
 in L_{A21} , $R = \text{Ethyl}$, and $R^A = \text{H}$,
 in L_{A22} , $R = \text{Ethyl}$, and $R^A = \text{CH}_3$,
 in L_{A23} , $R = \text{Ethyl-d5}$, and $R^A = \text{CD}_3$,
 in L_{A24} , $R = \text{isopropyl}$, and $R^A = \text{H}$,
 in L_{A25} , $R = \text{isopropyl}$, and $R^A = \text{CH}_3$,
 in L_{A26} , $R = \text{isopropyl-d7}$, and $R^A = \text{CD}_3$

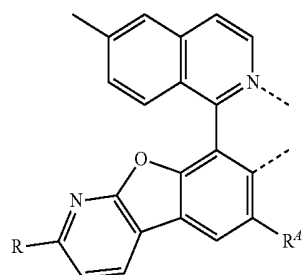
176

 L_{B54}

L_{A30} through L_{A39} , each represented by the formula

5

10



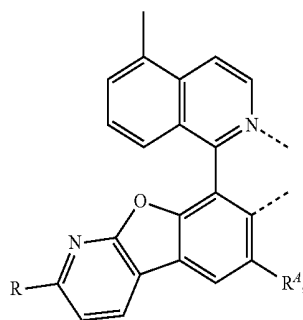
wherein in L_{A30} , $R = \text{CH}_3$, and $R^A = \text{H}$,
 15 in L_{A31} , $R = \text{CD}_3$, and $R^A = \text{H}$,
 in L_{A32} , $R = \text{CH}_3$, and $R^A = \text{CH}_3$,
 in L_{A33} , $R = \text{CD}_3$, and $R^A = \text{CD}_3$,
 in L_{A34} , $R = \text{Ethyl}$, and $R^A = \text{H}$,
 in L_{A35} , $R = \text{Ethyl}$, and $R^A = \text{CH}_3$,
 20 in L_{A36} , $R = \text{Ethyl-d5}$, and $R^A = \text{CD}_3$,
 in L_{A37} , $R = \text{isopropyl}$, and $R^A = \text{H}$,
 in L_{A38} , $R = \text{isopropyl}$, and $R^A = \text{CH}_3$,
 in L_{A39} , $R = \text{isopropyl-d7}$, and $R^A = \text{CD}_3$

25

L_{A43} through L_{A52} , each represented by the formula

30

35



40

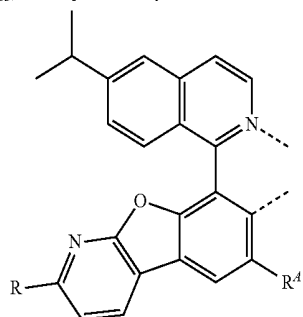
wherein in L_{A43} , $R = \text{CH}_3$, and $R^A = \text{H}$,
 in L_{A44} , $R = \text{CD}_3$, and $R^A = \text{H}$,
 in L_{A45} , $R = \text{CH}_3$, and $R^A = \text{CH}_3$,
 in L_{A46} , $R = \text{CD}_3$, and $R^A = \text{CD}_3$,
 45 in L_{A47} , $R = \text{Ethyl}$, and $R^A = \text{H}$,
 in L_{A48} , $R = \text{Ethyl}$, and $R^A = \text{CH}_3$,
 in L_{A49} , $R = \text{Ethyl-d5}$, and $R^A = \text{CD}_3$,
 in L_{A50} , $R = \text{isopropyl}$, and $R^A = \text{H}$,
 in L_{A51} , $R = \text{isopropyl}$, and $R^A = \text{CH}_3$,
 50 in L_{A52} , $R = \text{isopropyl-d7}$, and $R^A = \text{CD}_3$

55

L_{A56} through L_{A65} , each represented by the formula

60

65

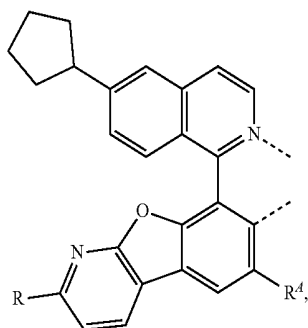


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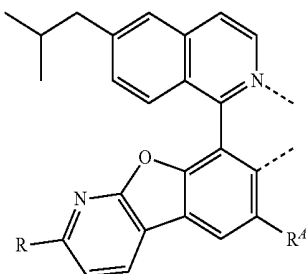
wherein in L_{A56} , $R = CH_3$, and $R^A = H$,
 in L_{A57} , $R = CD_3$, and $R^A = H$,
 in L_{A58} , $R = CH_3$, and $R^A = CH_3$,
 in L_{A59} , $R = CD_3$, and $R^A = CD_3$,
 in L_{A60} , $R = Ethyl$, and $R^A = H$,
 in L_{A61} , $R = Ethyl$, and $R^A = CH_3$,
 in L_{A62} , $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A63} , $R = isopropyl$, and $R^A = H$,
 in L_{A64} , $R = isopropyl$, and $R^A = CH_3$,
 in L_{A65} , $R = isopropyl-d7$, and $R^A = CD_3$

L_{A69} through L_{A78} , each represented by the formula



wherein in L_{A69} , $R = CH_3$, and $R^A = H$,
 in L_{A70} , $R = CD_3$, and $R^A = H$,
 in L_{A71} , $R = CH_3$, and $R^A = CH_3$,
 in L_{A72} , $R = CD_3$, and $R^A = CD_3$,
 in L_{A73} , $R = Ethyl$, and $R^A = H$,
 in L_{A74} , $R = Ethyl$, and $R^A = CH_3$,
 in L_{A75} , $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A76} , $R = isopropyl$, and $R^A = H$,
 in L_{A77} , $R = isopropyl$, and $R^A = CH_3$,
 in L_{A78} , $R = isopropyl-d7$, and $R^A = CD_3$

L_{A82} through L_{A91} , each represented by the formula

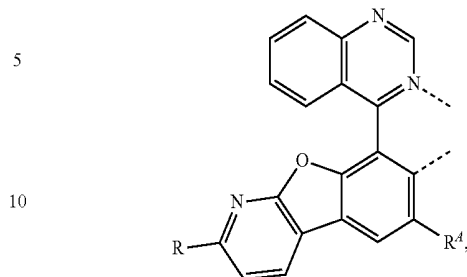


wherein in L_{A82} , $R = CH_3$, and $R^A = H$,
 in L_{A83} , $R = CD_3$, and $R^A = H$,
 in L_{A84} , $R = CH_3$, and $R^A = CH_3$,
 in L_{A85} , $R = CD_3$, and $R^A = CD_3$,
 in L_{A86} , $R = Ethyl$, and $R^A = H$,
 in L_{A87} , $R = Ethyl$, and $R^A = CH_3$,
 in L_{A88} , $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A89} , $R = isopropyl$, and $R^A = H$,
 in L_{A90} , $R = isopropyl$, and $R^A = CH_3$,
 in L_{A91} , $R = isopropyl-d7$, and $R^A = CD_3$

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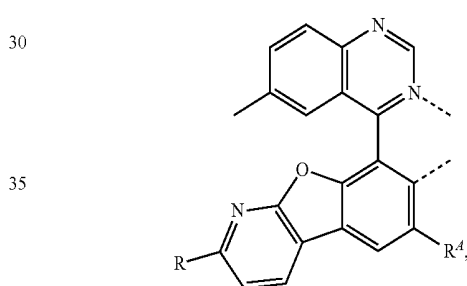
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L_{A95} through L_{A104} , each represented by the formula



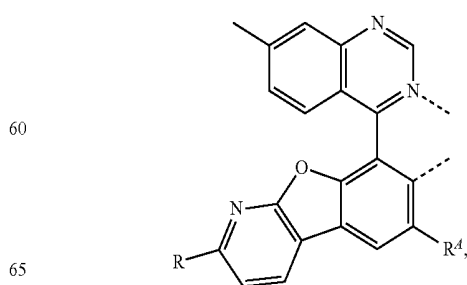
wherein in L_{A95} , $R = CH_3$, and $R^A = H$,
 in L_{A96} , $R = CD_3$, and $R^A = H$,
 in L_{A97} , $R = CH_3$, and $R^A = CH_3$,
 in L_{A98} , $R = CD_3$, and $R^A = CD_3$,
 in L_{A99} , $R = Ethyl$, and $R^A = H$,
 in L_{A100} , $R = Ethyl$, and $R^A = CH_3$,
 in L_{A101} , $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A102} , $R = isopropyl$, and $R^A = H$,
 in L_{A103} , $R = isopropyl$, and $R^A = CH_3$,
 in L_{A104} , $R = isopropyl-d7$, and $R^A = CD_3$

L_{A108} through L_{A117} , each represented by the formula



wherein in L_{A108} , $R = CH_3$, and $R^A = H$,
 in L_{A109} , $R = CD_3$, and $R^A = H$,
 in L_{A110} , $R = CH_3$, and $R^A = CH_3$,
 in L_{A111} , $R = CD_3$, and $R^A = CD_3$,
 in L_{A112} , $R = Ethyl$, and $R^A = H$,
 in L_{A113} , $R = Ethyl$, and $R^A = CH_3$,
 in L_{A114} , $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A115} , $R = isopropyl$, and $R^A = H$,
 in L_{A116} , $R = isopropyl$, and $R^A = CH_3$,
 in L_{A117} , $R = isopropyl-d7$, and $R^A = CD_3$

L_{A121} through L_{A130} , each represented by the formula

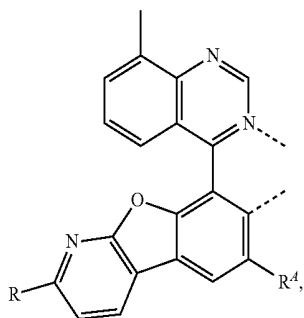


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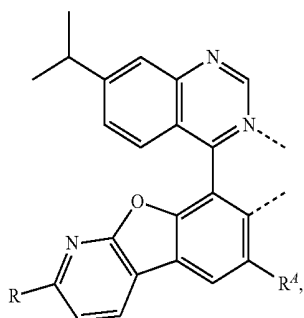
wherein in L_{A121} : $R = CH_3$, and $R^A = H$,
 in L_{A122} : $R = CD_3$, and $R^A = H$,
 in L_{A123} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A124} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A125} : $R = Ethyl$, and $R^A = H$,
 in L_{A126} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A127} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A128} : $R = isopropyl$, and $R^A = H$,
 in L_{A129} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A130} : $R = isopropyl-d7$, and $R^A = CD_3$

L_{A134} through L_{A143} , each represented by the formula



wherein in L_{A134} : $R = CH_3$, and $R^A = H$,
 in L_{A135} : $R = CD_3$, and $R^A = H$,
 in L_{A136} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A137} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A138} : $R = Ethyl$, and $R^A = H$,
 in L_{A139} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A140} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A141} : $R = isopropyl$, and $R^A = H$,
 in L_{A142} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A143} : $R = isopropyl-d7$, and $R^A = CD_3$

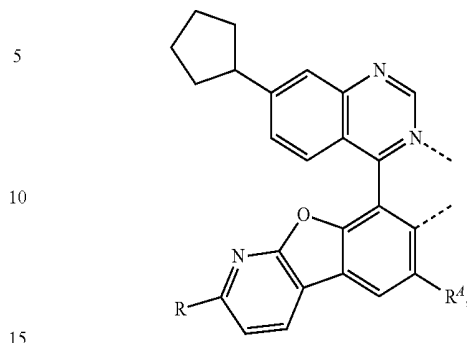
L_{A147} through L_{A156} , each represented by the formula



wherein in L_{A147} : $R = CH_3$, and $R^A = H$,
 in L_{A148} : $R = CD_3$, and $R^A = H$,
 in L_{A149} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A150} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A151} : $R = Ethyl$, and $R^A = H$,
 in L_{A152} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A153} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A154} : $R = isopropyl$, and $R^A = H$,
 in L_{A155} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A156} : $R = isopropyl-d7$, and $R^A = CD_3$

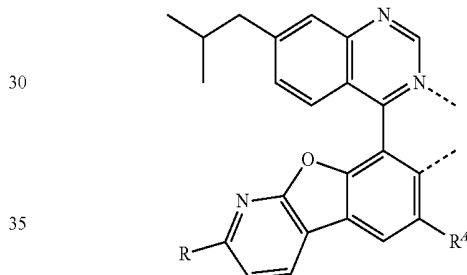
180

L_{A160} through L_{A169} , each represented by the formula



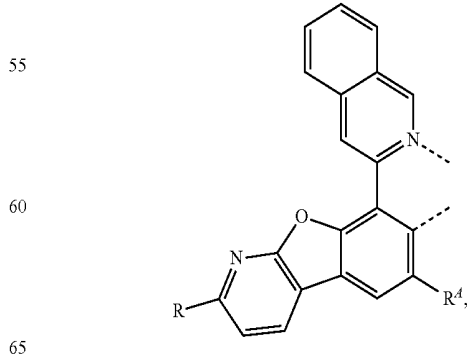
wherein in L_{A160} : $R = CH_3$, and $R^A = H$,
 in L_{A161} : $R = CD_3$, and $R^A = H$,
 in L_{A162} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A163} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A164} : $R = Ethyl$, and $R^A = H$,
 in L_{A165} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A166} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A167} : $R = isopropyl$, and $R^A = H$,
 in L_{A168} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A169} : $R = isopropyl-d7$, and $R^A = CD_3$

L_{A173} through L_{A182} , each represented by the formula



wherein in L_{A173} : $R = CH_3$, and $R^A = H$,
 in L_{A174} : $R = CD_3$, and $R^A = H$,
 in L_{A175} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A176} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A177} : $R = Ethyl$, and $R^A = H$,
 in L_{A178} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A179} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A180} : $R = isopropyl$, and $R^A = H$,
 in L_{A181} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A182} : $R = isopropyl-d7$, and $R^A = CD_3$

L_{A186} through L_{A195} , each represented by the formula

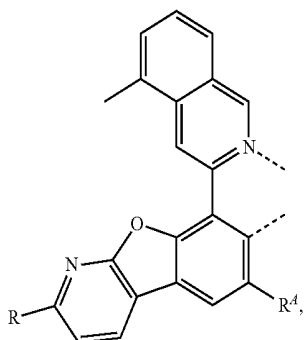


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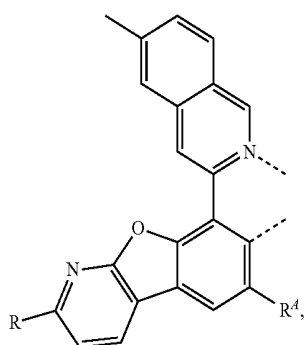
wherein in L_{A186} : $R = CH_3$, and $R^A = H$,
 in L_{A187} : $R = CD_3$, and $R^A = H$,
 in L_{A188} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A189} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A190} : $R = Ethyl$, and $R^A = H$,
 in L_{A191} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A192} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A193} : $R = isopropyl$, and $R^A = H$,
 in L_{A194} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A195} : $R = isopropyl-d7$, and $R^A = CD_3$

L_{A199} through L_{A208} , each represented by the formula



wherein in L_{A199} : $R = CH_3$, and $R^A = H$,
 in L_{A200} : $R = CD_3$, and $R^A = H$,
 in L_{A201} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A202} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A203} : $R = Ethyl$, and $R^A = H$,
 in L_{A204} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A205} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A206} : $R = isopropyl$, and $R^A = H$,
 in L_{A207} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A208} : $R = isopropyl-d7$, and $R^A = CD_3$

L_{A212} through L_{A221} , each represented by the formula

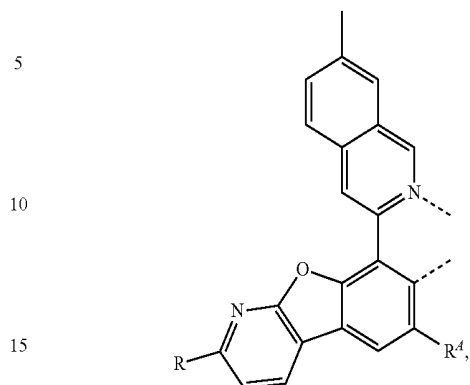


wherein in L_{A212} : $R = CH_3$, and $R^A = H$,
 in L_{A213} : $R = CD_3$, and $R^A = H$,
 in L_{A214} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A215} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A216} : $R = Ethyl$, and $R^A = H$,
 in L_{A217} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A218} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A219} : $R = isopropyl$, and $R^A = H$,
 in L_{A220} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A221} : $R = isopropyl-d7$, and $R^A = CD_3$

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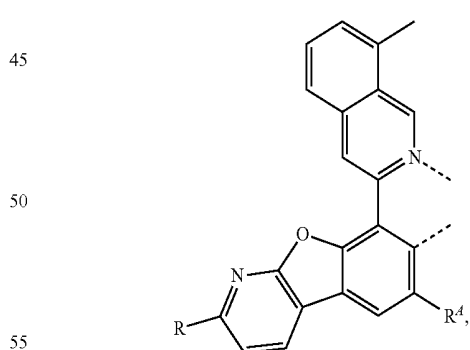
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L_{A225} through L_{A234} , each represented by the formula



wherein in L_{A225} : $R = CH_3$, and $R^A = H$,
 in L_{A226} : $R = CD_3$, and $R^A = H$,
 in L_{A227} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A228} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A229} : $R = Ethyl$, and $R^A = H$,
 in L_{A230} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A231} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A232} : $R = isopropyl$, and $R^A = H$,
 in L_{A233} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A234} : $R = isopropyl-d7$, and $R^A = CD_3$

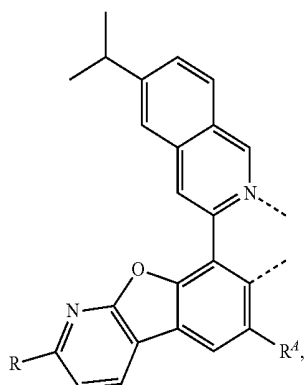
L_{A238} through L_{A247} , each represented by the formula



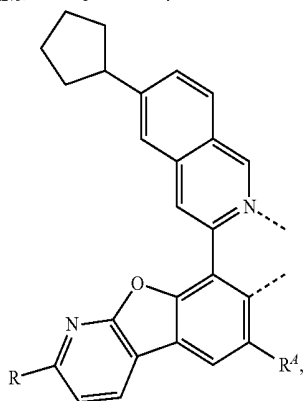
wherein in L_{A238} : $R = CH_3$, and $R^A = H$,
 in L_{A239} : $R = CD_3$, and $R^A = H$,
 in L_{A240} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A241} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A242} : $R = Ethyl$, and $R^A = H$,
 in L_{A243} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A244} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A245} : $R = isopropyl$, and $R^A = H$,
 in L_{A246} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A247} : $R = isopropyl-d7$, and $R^A = CD_3$

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L_{A251} through L_{A260}, each represented by the formula

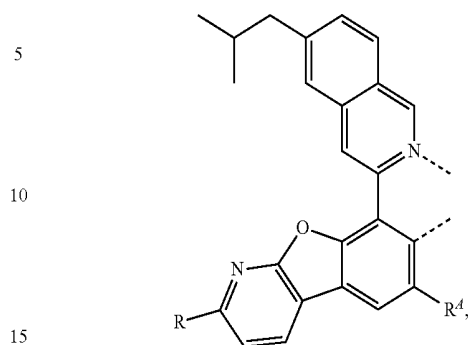
wherein in L_{A251}: R = CH₃, and R^A = H,
 in L_{A252}: R = CD₃, and R^A = H,
 in L_{A253}: R = CH₃, and R^A = CH₃,
 in L_{A254}: R = CD₃, and R^A = CD₃,
 in L_{A255}: R = Ethyl, and R^A = H,
 in L_{A256}: R = Ethyl, and R^A = CH₃,
 in L_{A257}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A258}: R = isopropyl, and R^A = H,
 in L_{A259}: R = isopropyl, and R^A = CH₃,
 in L_{A260}: R = isopropyl-d7, and R^A = CD₃

L_{A264} through L_{A273}, each represented by the formula

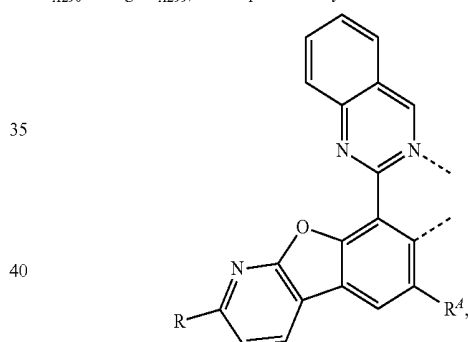
wherein in L_{A264}: R = CH₃, and R^A = H,
 in L_{A265}: R = CD₃, and R^A = H,
 in L_{A266}: R = CH₃, and R^A = CH₃,
 in L_{A267}: R = CD₃, and R^A = CD₃,
 in L_{A268}: R = Ethyl, and R^A = H,
 in L_{A269}: R = Ethyl, and R^A = CH₃,
 in L_{A270}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A271}: R = isopropyl, and R^A = H,
 in L_{A272}: R = isopropyl, and R^A = CH₃,
 in L_{A273}: R = isopropyl-d7, and R^A = CD₃

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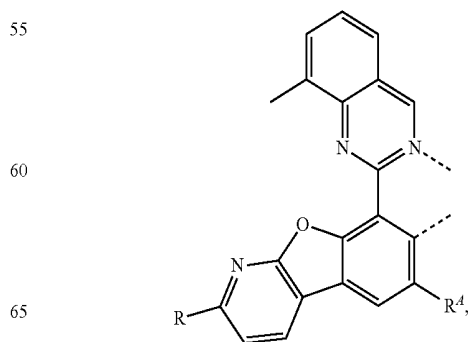
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L_{A277} through L_{A286}, each represented by the formula

wherein in L_{A277}: R = CH₃, and R^A = H,
 in L_{A278}: R = CD₃, and R^A = H,
 in L_{A279}: R = CH₃, and R^A = CH₃,
 in L_{A280}: R = CD₃, and R^A = CD₃,
 in L_{A281}: R = Ethyl, and R^A = H,
 in L_{A282}: R = Ethyl, and R^A = CH₃,
 in L_{A283}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A284}: R = isopropyl, and R^A = H,
 in L_{A285}: R = isopropyl, and R^A = CH₃,
 in L_{A286}: R = isopropyl-d7, and R^A = CD₃

L_{A290} through L_{A299}, each represented by the formula

wherein in L_{A290}: R = CH₃, and R^A = H,
 in L_{A291}: R = CD₃, and R^A = H,
 in L_{A292}: R = CH₃, and R^A = CH₃,
 in L_{A293}: R = CD₃, and R^A = CD₃,
 in L_{A294}: R = Ethyl, and R^A = H,
 in L_{A295}: R = Ethyl, and R^A = CH₃,
 in L_{A296}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A297}: R = isopropyl, and R^A = H,
 in L_{A298}: R = isopropyl, and R^A = CH₃,
 in L_{A299}: R = isopropyl-d7, and R^A = CD₃

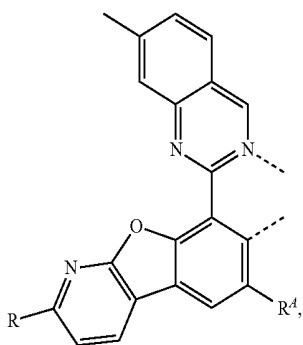
L_{A303} through L_{A312}, each represented by the formula

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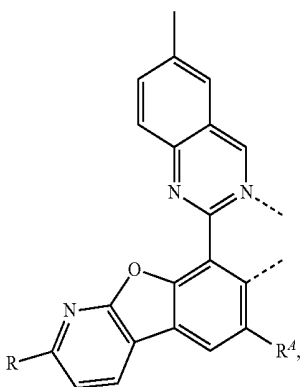
wherein in L_{A303} : $R = CH_3$, and $R^A = H$,
 in L_{A304} : $R = CD_3$, and $R^A = H$,
 in L_{A305} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A306} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A307} : $R = Ethyl$, and $R^A = H$,
 in L_{A308} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A309} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A310} : $R = isopropyl$, and $R^A = H$,
 in L_{A311} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A312} : $R = isopropyl-d7$, and $R^A = CD_3$

L_{A316} through L_{A326} , each represented by the formula



wherein in L_{A316} : $R = CH_3$, and $R^A = H$,
 in L_{A317} : $R = CD_3$, and $R^A = H$,
 in L_{A318} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A319} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A320} : $R = Ethyl$, and $R^A = H$,
 in L_{A321} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A322} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A323} : $R = isopropyl$, and $R^A = H$,
 in L_{A324} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A325} : $R = isopropyl-d7$, and $R^A = CD_3$

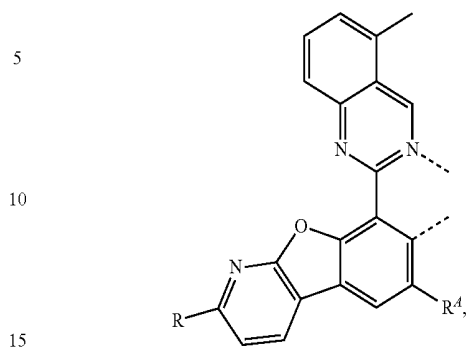
L_{A329} through L_{A338} , each represented by the formula



wherein in L_{A329} : $R = CH_3$, and $R^A = H$,
 in L_{A330} : $R = CD_3$, and $R^A = H$,
 in L_{A331} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A332} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A333} : $R = Ethyl$, and $R^A = H$,
 in L_{A334} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A335} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A336} : $R = isopropyl$, and $R^A = H$,
 in L_{A337} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A338} : $R = isopropyl-d7$, and $R^A = CD_3$

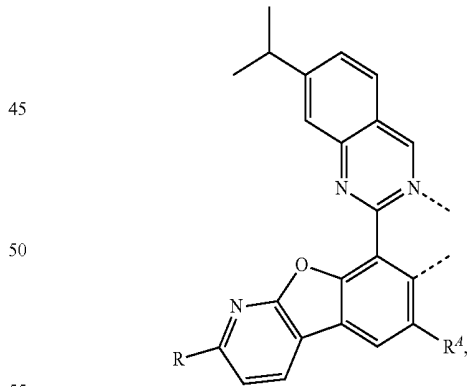
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L_{A342} through L_{A351} , each represented by the formula



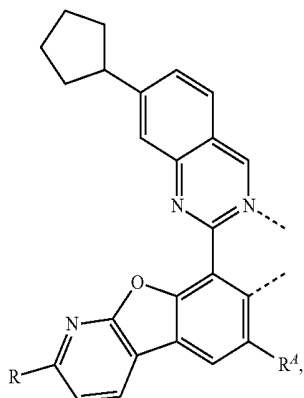
wherein in L_{A342} : $R = CH_3$, and $R^A = H$,
 in L_{A343} : $R = CD_3$, and $R^A = H$,
 in L_{A344} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A345} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A346} : $R = Ethyl$, and $R^A = H$,
 in L_{A347} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A348} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A349} : $R = isopropyl$, and $R^A = H$,
 in L_{A350} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A351} : $R = isopropyl-d7$, and $R^A = CD_3$

L_{A355} through L_{A364} , each represented by the formula

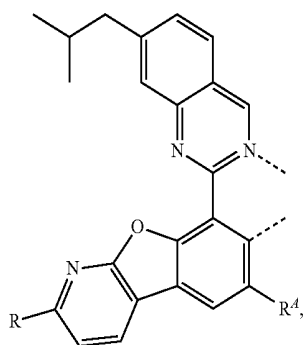


wherein in L_{A355} : $R = CH_3$, and $R^A = H$,
 in L_{A356} : $R = CD_3$, and $R^A = H$,
 in L_{A357} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A358} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A359} : $R = Ethyl$, and $R^A = H$,
 in L_{A360} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A361} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A362} : $R = isopropyl$, and $R^A = H$,
 in L_{A363} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A364} : $R = isopropyl-d7$, and $R^A = CD_3$

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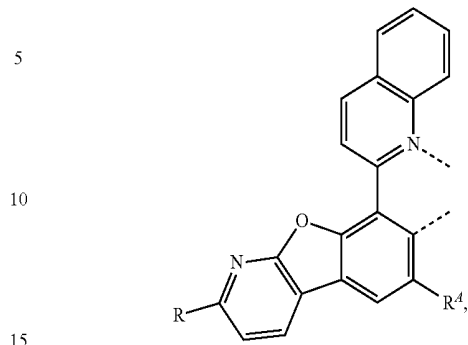
L_{A368} through L_{A377}, each represented by the formula

wherein in L_{A368}: R = CH₃, and R^A = H,
 in L_{A369}: R = CD₃, and R^A = H,
 in L_{A370}: R = CH₃, and R^A = CH₃,
 in L_{A371}: R = CD₃, and R^A = CD₃,
 in L_{A372}: R = Ethyl, and R^A = H,
 in L_{A373}: R = Ethyl, and R^A = CH₃,
 in L_{A374}: R = Ethyl-d₅, and R^A = CD₃,
 in L_{A375}: R = isopropyl, and R^A = H,
 in L_{A376}: R = isopropyl, and R^A = CH₃,
 in L_{A377}: R = isopropyl-d₇, and R^A = CD₃

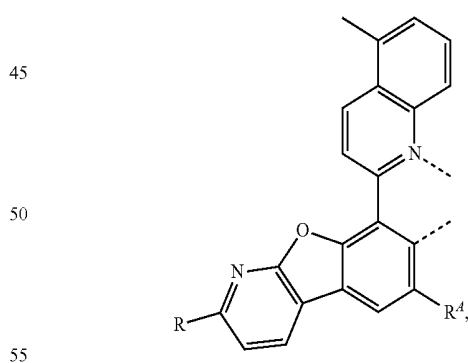
L_{A381} through L_{A390}, each represented by the formula

wherein in L_{A381}: R = CH₃, and R^A = H,
 in L_{A382}: R = CD₃, and R^A = H,
 in L_{A383}: R = CH₃, and R^A = CH₃,
 in L_{A384}: R = CD₃, and R^A = CD₃,
 in L_{A385}: R = Ethyl, and R^A = H,
 in L_{A386}: R = Ethyl, and R^A = CH₃,
 in L_{A387}: R = Ethyl-d₅, and R^A = CD₃,
 in L_{A388}: R = isopropyl, and R^A = H,
 in L_{A389}: R = isopropyl, and R^A = CH₃,
 in L_{A390}: R = isopropyl-d₇, and R^A = CD₃

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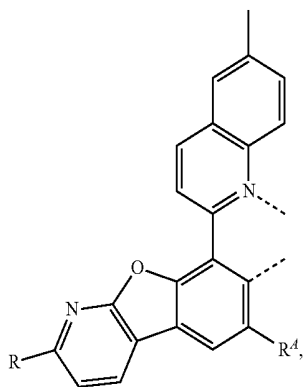
L_{A394} through L_{A406}, each represented by the formula

wherein in L_{A394}: R = CH₃, and R^A = H,
 in L_{A395}: R = CD₃, and R^A = H,
 in L_{A396}: R = CH₃, and R^A = CH₃,
 in L_{A397}: R = CD₃, and R^A = CD₃,
 in L_{A398}: R = Ethyl, and R^A = H,
 in L_{A399}: R = Ethyl, and R^A = CH₃,
 in L_{A400}: R = Ethyl-d₅, and R^A = CD₃,
 in L_{A401}: R = isopropyl, and R^A = H,
 in L_{A402}: R = isopropyl, and R^A = CH₃,
 in L_{A403}: R = isopropyl-d₇, and R^A = CD₃

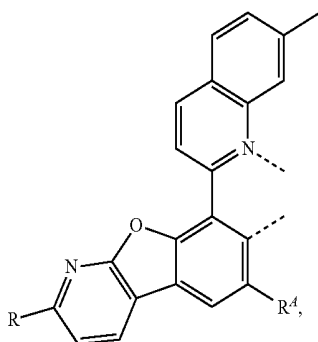
L_{A407} through L_{A416}, each represented by the formula

wherein in L_{A407}: R = CH₃, and R^A = H,
 in L_{A408}: R = CD₃, and R^A = H,
 in L_{A409}: R = CH₃, and R^A = CH₃,
 in L_{A410}: R = CD₃, and R^A = CD₃,
 in L_{A411}: R = Ethyl, and R^A = H,
 in L_{A412}: R = Ethyl, and R^A = CH₃,
 in L_{A413}: R = Ethyl-d₅, and R^A = CD₃,
 in L_{A414}: R = isopropyl, and R^A = H,
 in L_{A415}: R = isopropyl, and R^A = CH₃,
 in L_{A416}: R = isopropyl-d₇, and R^A = CD₃

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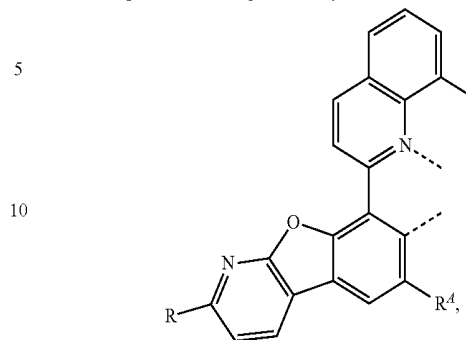
L_{A420} through L_{A429}, each represented by the formula

wherein in L_{A420}: R = CH₃, and R^A = H,
 in L_{A421}: R = CD₃, and R^A = H,
 in L_{A422}: R = CH₃, and R^A = CH₃,
 in L_{A423}: R = CD₃, and R^A = CD₃,
 in L_{A424}: R = Ethyl, and R^A = H,
 in L_{A425}: R = Ethyl, and R^A = CH₃,
 in L_{A426}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A427}: R = isopropyl, and R^A = H,
 in L_{A428}: R = isopropyl, and R^A = CH₃,
 in L_{A429}: R = isopropyl-d7, and R^A = CD₃

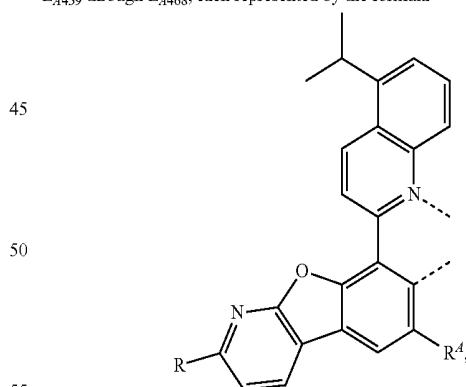
L_{A433} through L_{A442}, each represented by the formula

wherein in L_{A433}: R = CH₃, and R^A = H,
 in L_{A434}: R = CD₃, and R^A = H,
 in L_{A435}: R = CH₃, and R^A = CH₃,
 in L_{A436}: R = CD₃, and R^A = CD₃,
 in L_{A437}: R = Ethyl, and R^A = H,
 in L_{A438}: R = Ethyl, and R^A = CH₃,
 in L_{A439}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A440}: R = isopropyl, and R^A = H,
 in L_{A441}: R = isopropyl, and R^A = CH₃,
 in L_{A442}: R = isopropyl-d7, and R^A = CD₃

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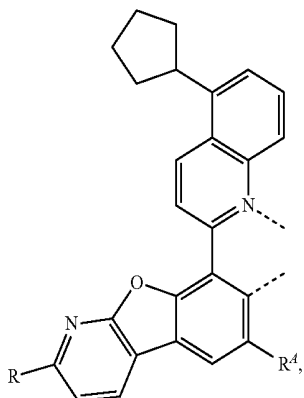
L_{A446} through L_{A455}, each represented by the formula

wherein in L_{A446}: R = CH₃, and R^A = H,
 in L_{A447}: R = CD₃, and R^A = H,
 in L_{A448}: R = CH₃, and R^A = CH₃,
 in L_{A449}: R = CD₃, and R^A = CD₃,
 in L_{A450}: R = Ethyl, and R^A = H,
 in L_{A451}: R = Ethyl, and R^A = CH₃,
 in L_{A452}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A453}: R = isopropyl, and R^A = H,
 in L_{A454}: R = isopropyl, and R^A = CH₃,
 in L_{A455}: R = isopropyl-d7, and R^A = CD₃

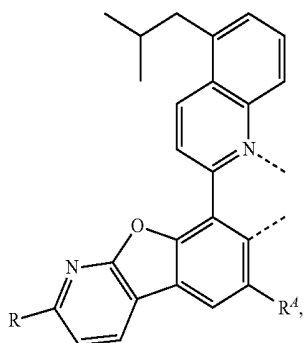
L_{A459} through L_{A468}, each represented by the formula

wherein in L_{A459}: R = CH₃, and R^A = H,
 in L_{A460}: R = CD₃, and R^A = H,
 in L_{A461}: R = CH₃, and R^A = CH₃,
 in L_{A462}: R = CD₃, and R^A = CD₃,
 in L_{A463}: R = Ethyl, and R^A = H,
 in L_{A464}: R = Ethyl, and R^A = CH₃,
 in L_{A465}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A466}: R = isopropyl, and R^A = H,
 in L_{A467}: R = isopropyl, and R^A = CH₃,
 in L_{A468}: R = isopropyl-d7, and R^A = CD₃

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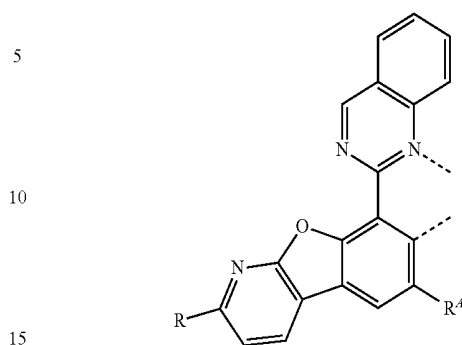
L_{A472} through L_{A481}, each represented by the formula

wherein in L_{A472}: R = CH₃, and R^A = H,
 in L_{A473}: R = CD₃, and R^A = H,
 in L_{A474}: R = CH₃, and R^A = CH₃,
 in L_{A475}: R = CD₃, and R^A = CD₃,
 in L_{A476}: R = Ethyl, and R^A = H,
 in L_{A477}: R = Ethyl, and R^A = CH₃,
 in L_{A478}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A479}: R = isopropyl, and R^A = H,
 in L_{A480}: R = isopropyl, and R^A = CH₃,
 in L_{A481}: R = isopropyl-d7, and R^A = CD₃

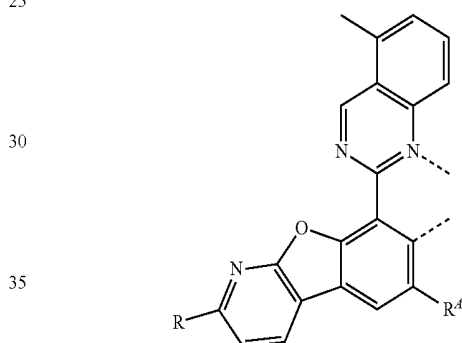
L_{A485} through L_{A494}, each represented by the formula

wherein in L_{A485}: R = CH₃, and R^A = H,
 in L_{A486}: R = CD₃, and R^A = H,
 in L_{A487}: R = CH₃, and R^A = CH₃,
 in L_{A488}: R = CD₃, and R^A = CD₃,
 in L_{A489}: R = Ethyl, and R^A = H,
 in L_{A490}: R = Ethyl, and R^A = CH₃,
 in L_{A491}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A492}: R = isopropyl, and R^A = H,
 in L_{A493}: R = isopropyl, and R^A = CH₃,
 in L_{A494}: R = isopropyl-d7, and R^A = CD₃

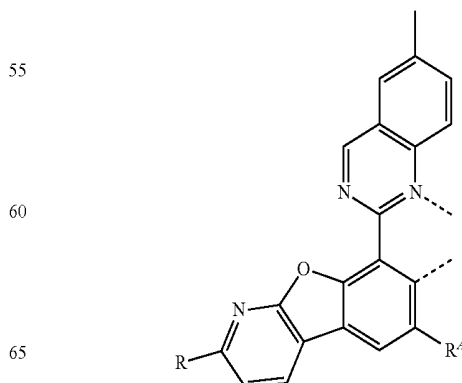
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L_{A498} through L_{A507}, each represented by the formula

wherein in L_{A498}: R = CH₃, and R^A = H,
 in L_{A499}: R = CD₃, and R^A = H,
 in L_{A500}: R = CH₃, and R^A = CH₃,
 in L_{A501}: R = CD₃, and R^A = CD₃,
 in L_{A502}: R = Ethyl, and R^A = H,
 in L_{A503}: R = Ethyl, and R^A = CH₃,
 in L_{A504}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A505}: R = isopropyl, and R^A = H,
 in L_{A506}: R = isopropyl, and R^A = CH₃,
 in L_{A507}: R = isopropyl-d7, and R^A = CD₃,

L_{A511} through L_{A520}, each represented by the formula

wherein in L_{A511}: R = CH₃, and R^A = H,
 in L_{A512}: R = CD₃, and R^A = H,
 in L_{A513}: R = CH₃, and R^A = CH₃,
 in L_{A514}: R = CD₃, and R^A = CD₃,
 in L_{A515}: R = Ethyl, and R^A = H,
 in L_{A516}: R = Ethyl, and R^A = CH₃,
 in L_{A517}: R = Ethyl-d5, and R^A = CD₃,
 in L_{A518}: R = isopropyl, and R^A = H,
 in L_{A519}: R = isopropyl, and R^A = CH₃,
 in L_{A520}: R = isopropyl-d7, and R^A = CD₃,

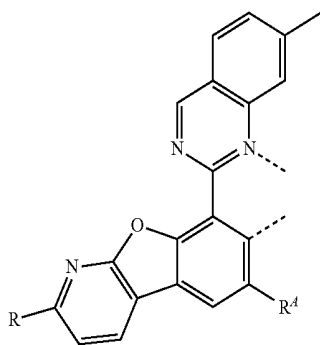
L_{A524} through L_{A533}, each represented by the formula

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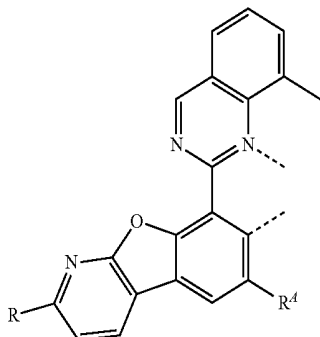
wherein in L_{A524} : $R = CH_3$, and $R^A = H$,
 in L_{A525} : $R = CD_3$, and $R^A = H$,
 in L_{A526} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A527} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A528} : $R = Ethyl$, and $R^A = H$,
 in L_{A529} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A530} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A531} : $R = isopropyl$, and $R^A = H$,
 in L_{A532} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A533} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A537} through L_{A546} , each represented by the formula



wherein in L_{A637} : $R = CH_3$, and $R^A = H$,
 in L_{A538} : $R = CD_3$, and $R^A = H$,
 in L_{A539} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A540} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A541} : $R = Ethyl$, and $R^A = H$,
 in L_{A542} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A543} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A544} : $R = isopropyl$, and $R^A = H$,
 in L_{A545} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A546} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A550} through L_{A559} , each represented by the formula

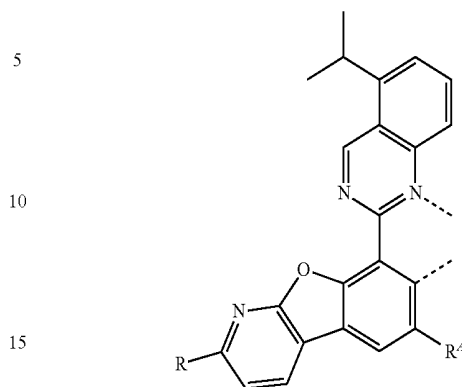


wherein in L_{A550} : $R = CH_3$, and $R^A = H$,
 in L_{A551} : $R = CD_3$, and $R^A = H$,
 in L_{A552} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A553} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A554} : $R = Ethyl$, and $R^A = H$,
 in L_{A555} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A556} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A557} : $R = isopropyl$, and $R^A = H$,
 in L_{A558} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A559} : $R = isopropyl-d7$, and $R^A = CD_3$,

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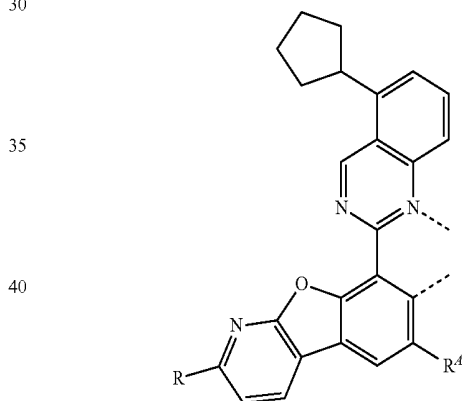
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L_{A563} through L_{A572} , each represented by the formula



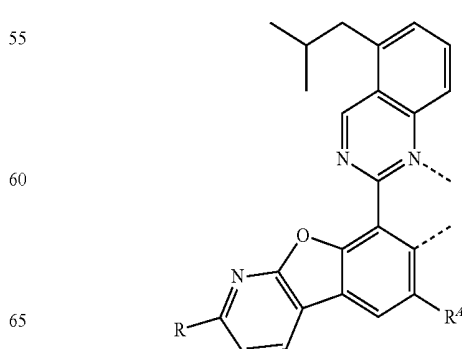
wherein in L_{A563} : $R = CH_3$, and $R^A = H$,
 in L_{A564} : $R = CD_3$, and $R^A = H$,
 in L_{A565} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A566} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A567} : $R = Ethyl$, and $R^A = H$,
 in L_{A568} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A569} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A570} : $R = isopropyl$, and $R^A = H$,
 in L_{A571} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A572} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A576} through L_{A585} , each represented by the formula



wherein in L_{A576} : $R = CH_3$, and $R^A = H$,
 in L_{A577} : $R = CD_3$, and $R^A = H$,
 in L_{A578} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A579} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A580} : $R = Ethyl$, and $R^A = H$,
 in L_{A581} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A582} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A583} : $R = isopropyl$, and $R^A = H$,
 in L_{A584} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A585} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A589} through L_{A598} , each represented by the formula

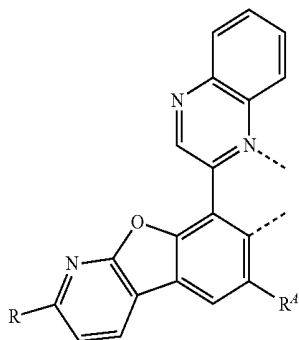


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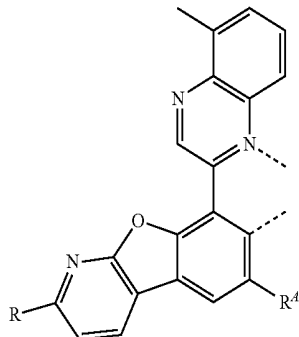
wherein in L_{A589} : $R = CH_3$, and $R^A = H$,
 in L_{A590} : $R = CD_3$, and $R^A = H$,
 in L_{A591} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A592} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A593} : $R = Ethyl$, and $R^A = H$,
 in L_{A594} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A595} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A596} : $R = isopropyl$, and $R^A = H$,
 in L_{A597} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A598} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A602} through L_{A611} , each represented by the formula



wherein in L_{A602} : $R = CH_3$, and $R^A = H$,
 in L_{A603} : $R = CD_3$, and $R^A = H$,
 in L_{A604} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A605} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A606} : $R = Ethyl$, and $R^A = H$,
 in L_{A607} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A608} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A609} : $R = isopropyl$, and $R^A = H$,
 in L_{A610} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A611} : $R = isopropyl-d7$, and $R^A = CD_3$,

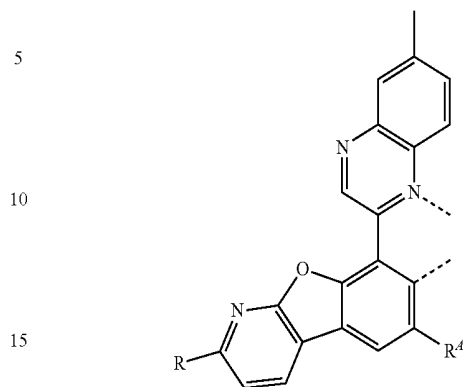
L_{A615} through L_{A624} , each represented by the formula



wherein in L_{A615} : $R = CH_3$, and $R^A = H$,
 in L_{A616} : $R = CD_3$, and $R^A = H$,
 in L_{A617} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A618} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A619} : $R = Ethyl$, and $R^A = H$,
 in L_{A620} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A621} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A622} : $R = isopropyl$, and $R^A = H$,
 in L_{A623} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A624} : $R = isopropyl-d7$, and $R^A = CD_3$,

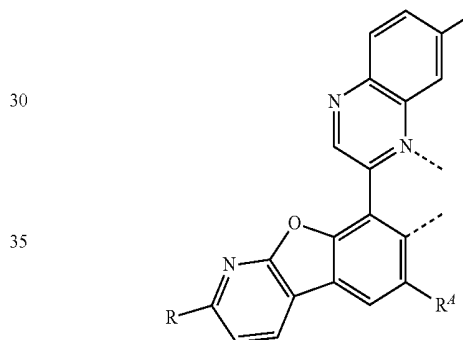
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L_{A628} through L_{A637} , each represented by the formula



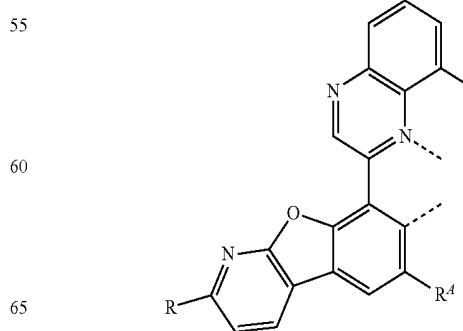
wherein in L_{A628} : $R = CH_3$, and $R^A = H$,
 in L_{A629} : $R = CD_3$, and $R^A = H$,
 in L_{A630} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A631} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A632} : $R = Ethyl$, and $R^A = H$,
 in L_{A633} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A634} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A635} : $R = isopropyl$, and $R^A = H$,
 in L_{A636} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A637} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A641} through L_{A650} , each represented by the formula



wherein in L_{A641} : $R = CH_3$, and $R^A = H$,
 in L_{A642} : $R = CD_3$, and $R^A = H$,
 in L_{A643} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A644} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A645} : $R = Ethyl$, and $R^A = H$,
 in L_{A646} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A647} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A648} : $R = isopropyl$, and $R^A = H$,
 in L_{A649} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A650} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A654} through L_{A663} , each represented by the formula

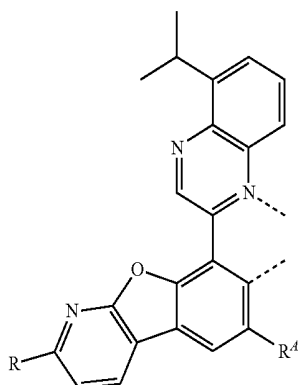


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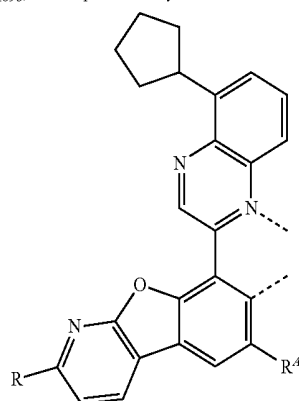
wherein in L_{A654} : $R = CH_3$, and $R^A = H$,
 in L_{A655} : $R = CD_3$, and $R^A = H$,
 in L_{A656} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A657} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A658} : $R = Ethyl$, and $R^A = H$,
 in L_{A659} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A660} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A661} : $R = isopropyl$, and $R^A = H$,
 in L_{A662} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A663} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A667} through L_{A676} , each represented by the formula



wherein in L_{A667} : $R = CH_3$, and $R^A = H$,
 in L_{A668} : $R = CD_3$, and $R^A = H$,
 in L_{A669} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A670} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A671} : $R = Ethyl$, and $R^A = H$,
 in L_{A672} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A673} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A674} : $R = isopropyl$, and $R^A = H$,
 in L_{A675} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A676} : $R = isopropyl-d7$, and $R^A = CD_3$,

L_{A807} through L_{A698} , each represented by the formula

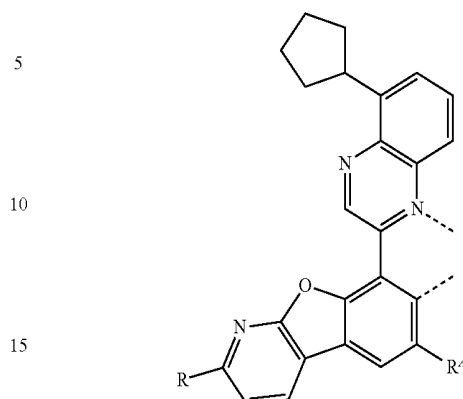


wherein in L_{A680} : $R = CH_3$, and $R^A = H$,
 in L_{A681} : $R = CD_3$, and $R^A = H$,
 in L_{A682} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A683} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A684} : $R = Ethyl$, and $R^A = H$,
 in L_{A685} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A686} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A687} : $R = isopropyl$, and $R^A = H$,
 in L_{A688} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A689} : $R = isopropyl-d7$, and $R^A = CD_3$,

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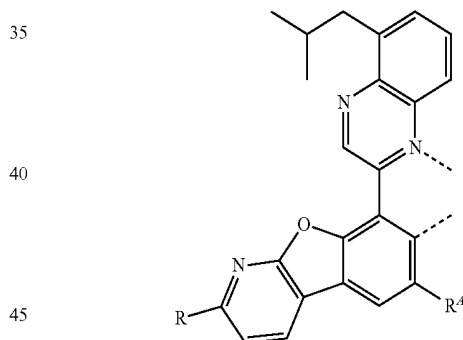
L_{A693} through L_{A702} , each represented by the formula



wherein in L_{A693} : $R = CH_3$, and $R^A = H$,
 in L_{A694} : $R = CD_3$, and $R^A = H$,
 in L_{A695} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A696} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A697} : $R = Ethyl$, and $R^A = H$,
 in L_{A698} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A699} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A700} : $R = isopropyl$, and $R^A = H$,
 in L_{A701} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A702} : $R = isopropyl-d7$, and $R^A = CD_3$,

30 and

L_{A706} through L_{A715} , each represented by the formula



wherein in L_{A703} : $R = H$, and $R^A = H$,
 in L_{A704} : $R = H$, and $R^A = CH_3$,
 in L_{A705} : $R = H$, and $R^A = CD_3$,
 in L_{A706} : $R = CH_3$, and $R^A = H$,
 in L_{A707} : $R = CD_3$, and $R^A = H$,
 in L_{A708} : $R = CH_3$, and $R^A = CH_3$,
 in L_{A709} : $R = CD_3$, and $R^A = CD_3$,
 in L_{A710} : $R = Ethyl$, and $R^A = H$,
 in L_{A711} : $R = Ethyl$, and $R^A = CH_3$,
 in L_{A712} : $R = Ethyl-d5$, and $R^A = CD_3$,
 in L_{A713} : $R = isopropyl$, and $R^A = H$,
 in L_{A714} : $R = isopropyl$, and $R^A = CH_3$,
 in L_{A715} : $R = isopropyl-d7$, and $R^A = CD_3$.

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6. The compound of claim 1, wherein at least one R^F , R^I ,
 or R^J present in the compound is selected from the group
 consisting of alkyl, cycloalkyl, heteroalkyl, arylalkyl, partially and fully deuterated variants thereof, and combinations thereof.

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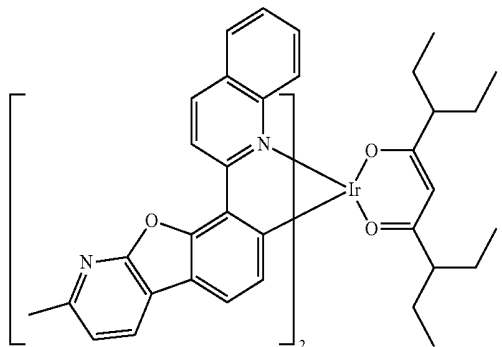
7. The compound of claim 1, selected from the group consisting of

200

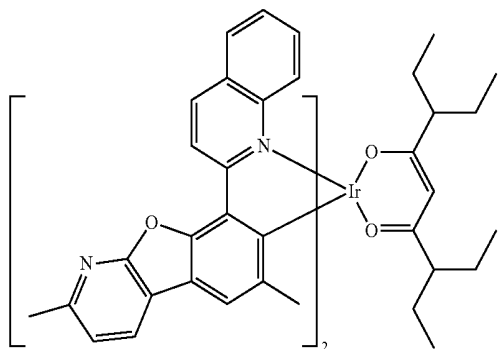
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Compound 26

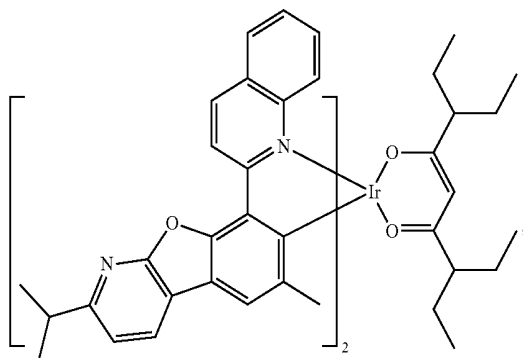
Compound 18 5



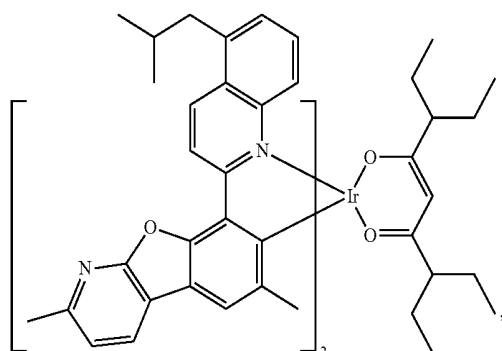
Compound 20 10



Compound 22 15



Compound 24 20



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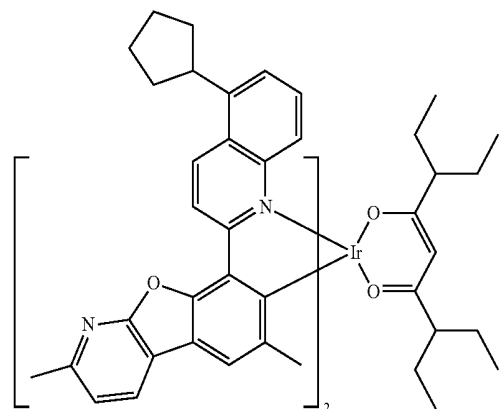
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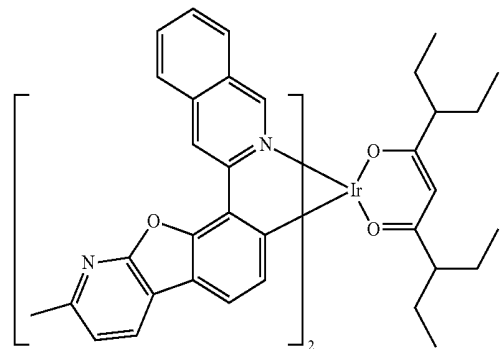
55

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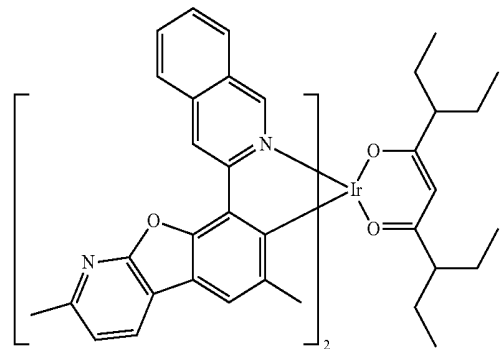
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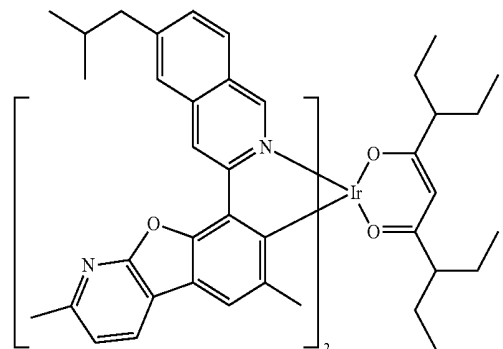
Compound 28



Compound 30



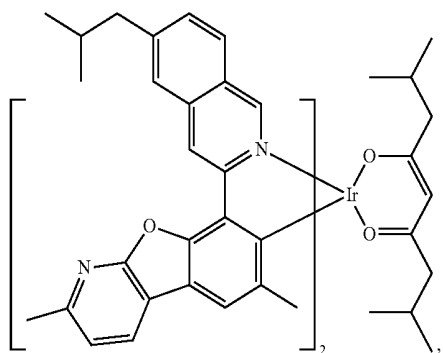
Compound 32



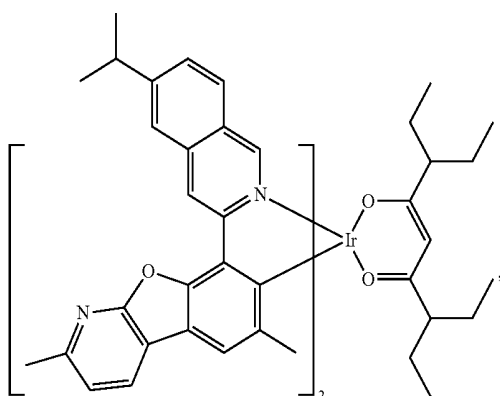
201

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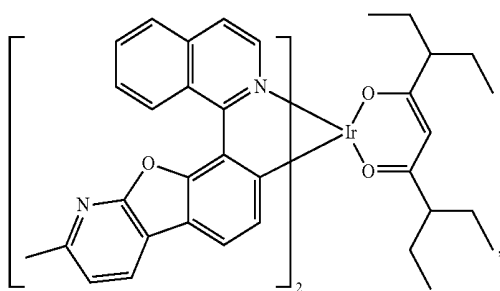
Compound 34



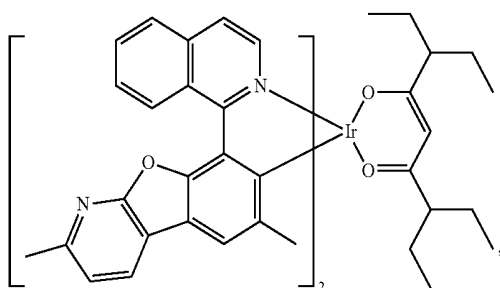
Compound 36



Compound 38

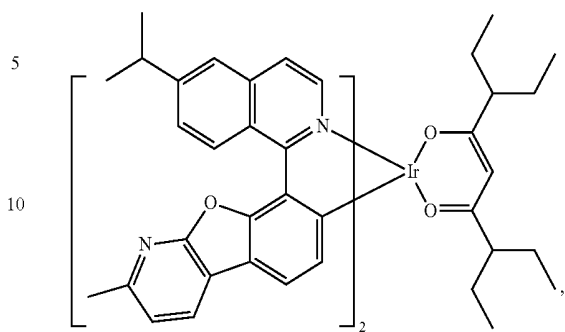


Compound 40

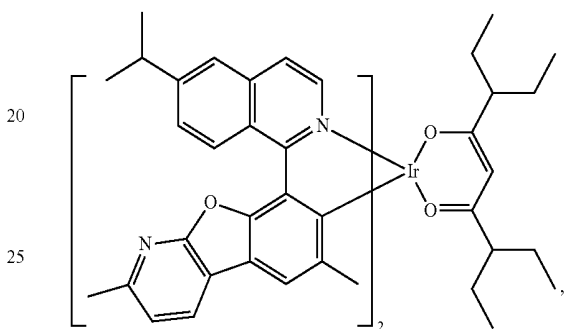
**202**

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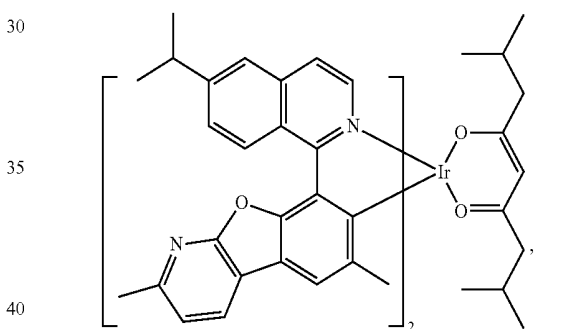
Compound 42



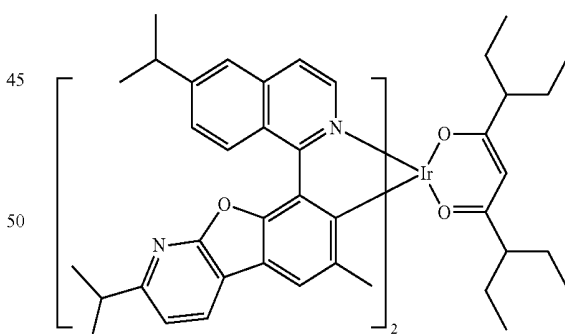
Compound 44



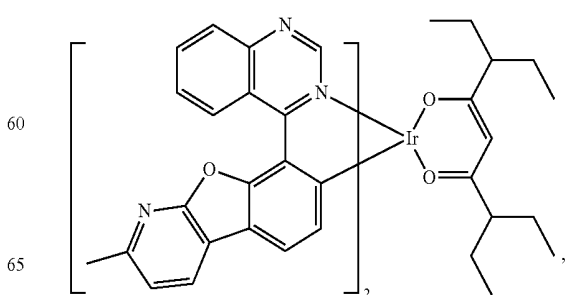
Compound 46



Compound 48



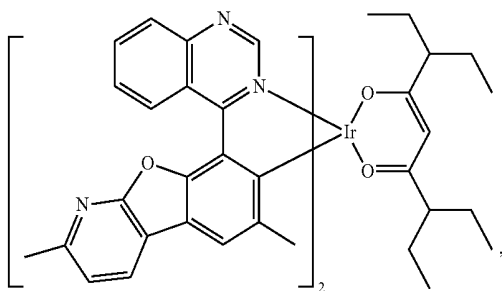
Compound 50



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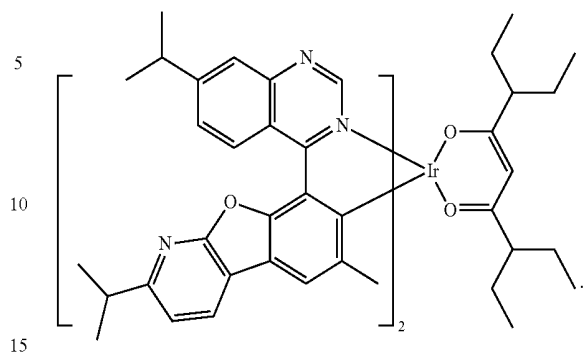
Compound 52



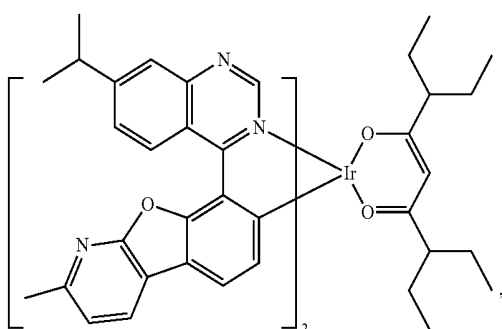
204

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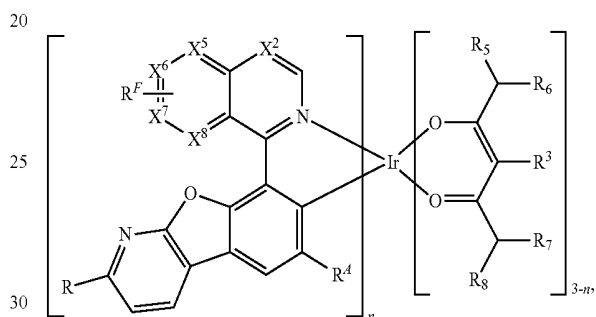
Compound 60



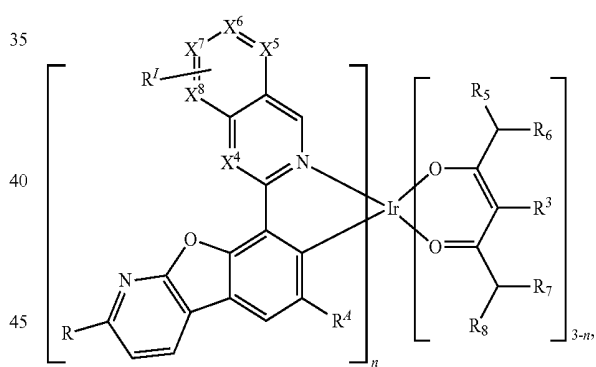
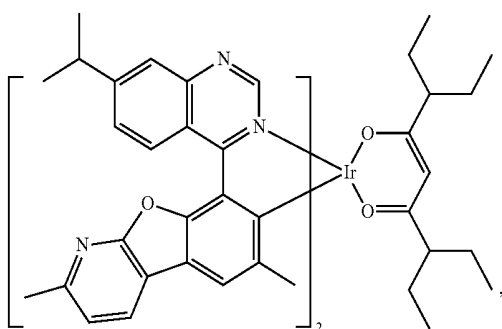
Compound 54



8. The compound of claim 1, wherein the compound is selected from the group consisting of:



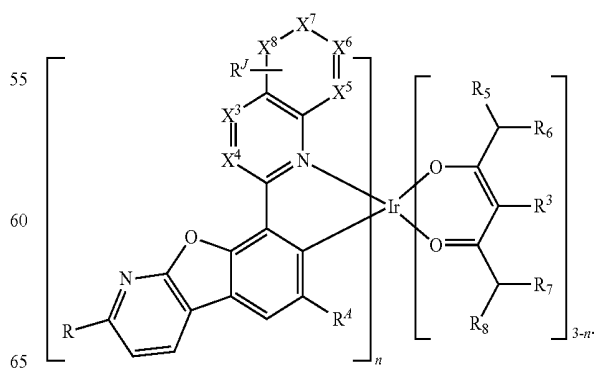
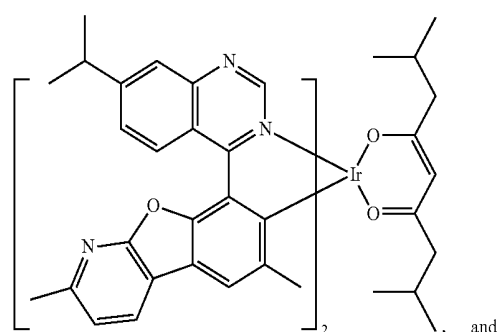
Compound 56



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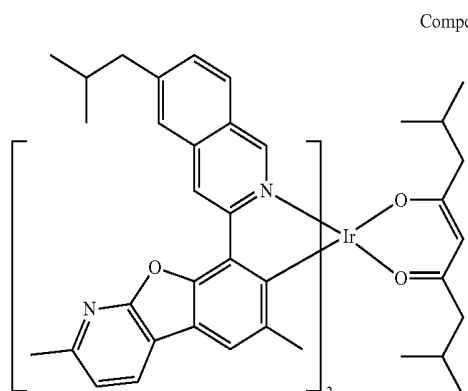
and

Compound 58

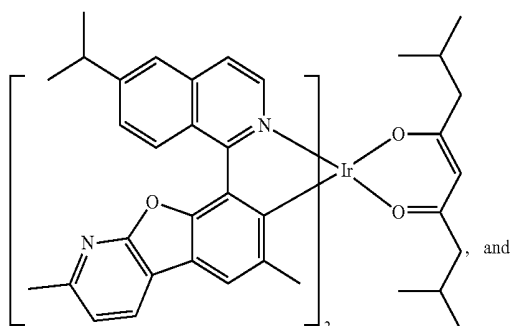


205

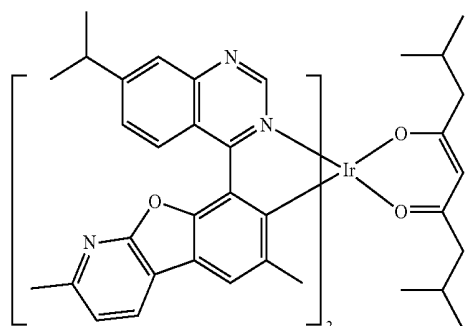
9. The compound of claim 1, wherein the compound is selected from the group consisting of:



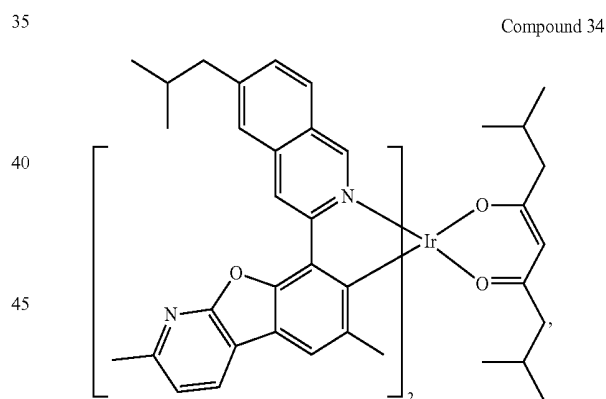
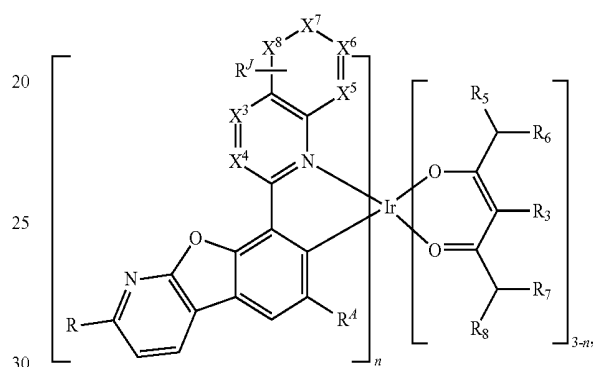
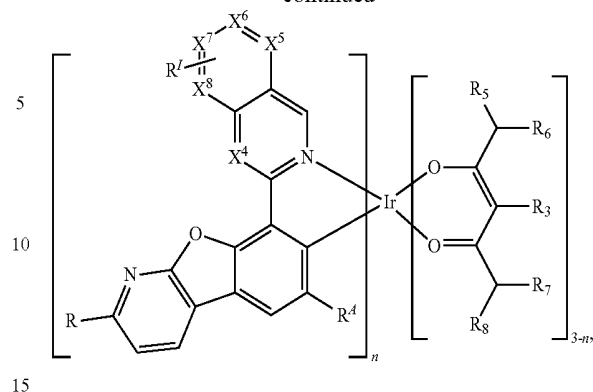
Compound 48



Compound 58

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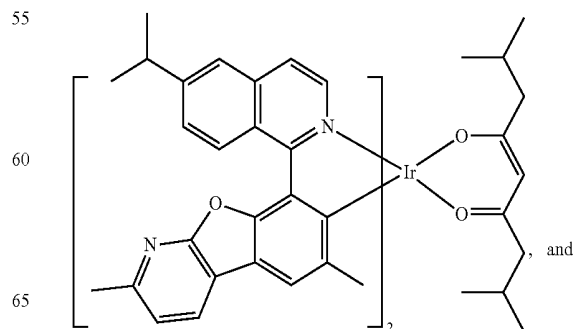
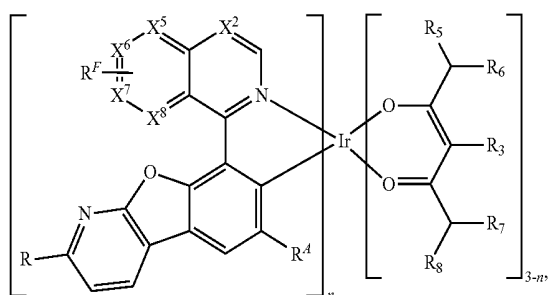


10. A first device comprising a first organic light emitting device, the first organic light emitting device comprising:

an anode;

a cathode; and

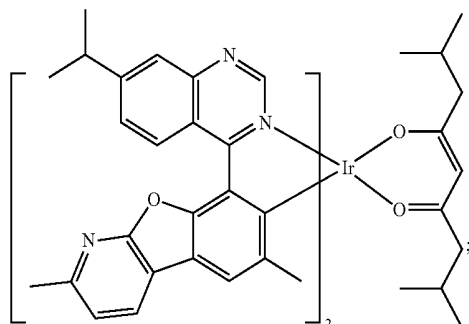
an organic layer, disposed between the anode and the cathode, comprising a compound $M(L_A)_n(L_B)_{3-n}$ selected from the group consisting of:



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-continued

Compound 58



wherein n is 1 or 2;

wherein X^2 , X^3 , X^4 are independently CH or N;

wherein X^5 , X^6 , X^7 , and X^8 are C or N;

wherein R^F , R^I , and R^J each independently represent

mono, di, tri, or tetra-substitution, or no substitution;
wherein R is selected from the group consisting of alkyl,
partially or fully deuterated alkyl, cycloalkyl, partially
or fully deuterated cycloalkyl, and combinations
thereof;

wherein R^5 , R^6 , R^7 , and R^8 are independently selected
from group consisting of alkyl, cycloalkyl, aryl, and
heteroaryl;

wherein at least one of R^5 , R^6 , R^7 , and R^8 has at least two
C atoms;

wherein each of R^4 , R^F , R^I , R^J , R^1 , R^2 , and R^3 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.

11. The first device of claim 10, wherein the first device
is selected from a consumer product, an organic light
emitting device, and a light panel.

12. The first device of claim 10, wherein the organic layer
is an emissive layer and the compound is an emissive
dopant.

13. The first device of claim 10, wherein the organic layer
is an emissive layer and the compound is a non-emissive
dopant.

14. The first device of claim 10, wherein the organic layer
further comprises a host material.

15. The first device of claim 14, wherein the host material
comprises a triphenylene containing benzo-fused thiophene
or benzo-fused furan;

wherein any substituent in the host material is an unfused
substituent independently selected from the group con-
sisting 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 , $C_nH_{2n}-Ar_1$;

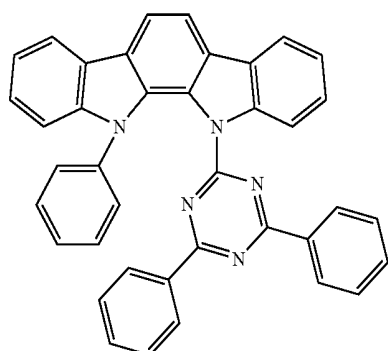
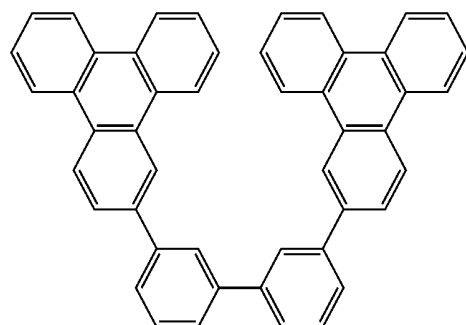
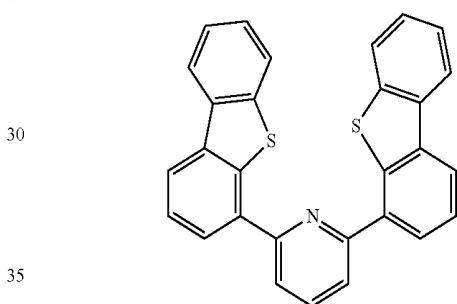
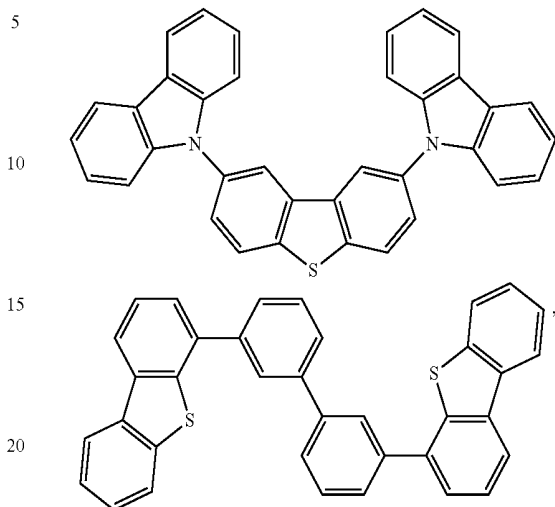
wherein n is from 1 to 10; and

wherein Ar_1 and Ar_2 are independently selected from the
group consisting of benzene, biphenyl, naphthalene,
triphenylene, carbazole, and heteroaromatic analogs
thereof.

16. The first device of claim 14, wherein the host material
comprises at least one chemical group selected from the
group consisting of carbazole, dibenzothiophene, dibenzofuran, dibenzoselenophene, azacarbazole, aza-dibenzothiophene, aza-dibenzofuran, and aza-dibenzoselenophene.

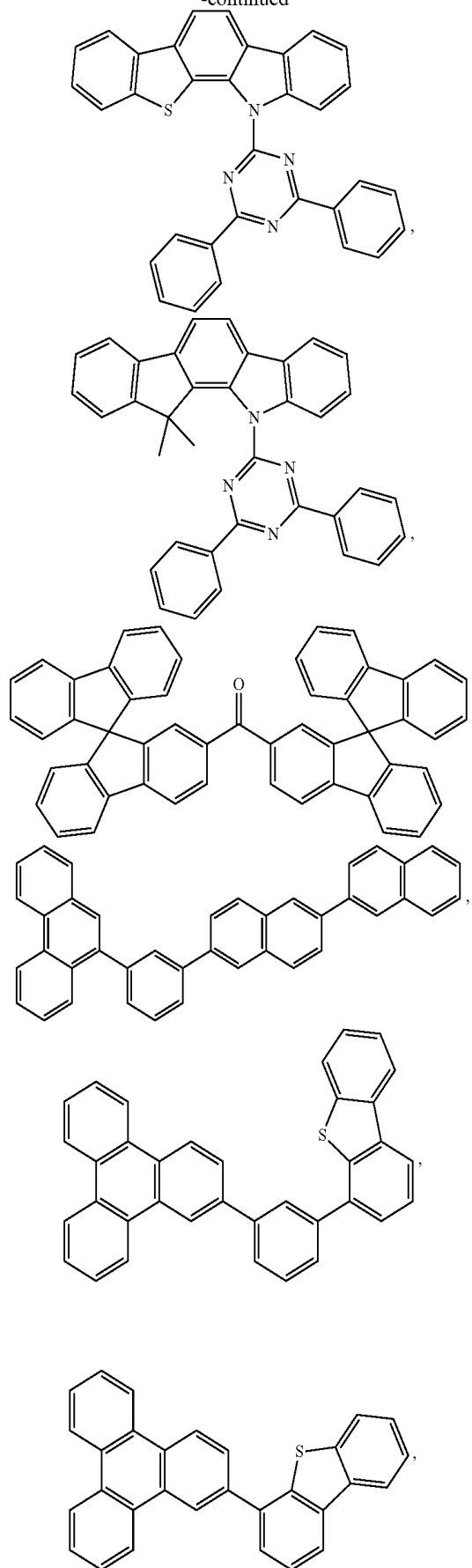
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17. The first device of claim 14, wherein the host material
is selected from the group consisting of:



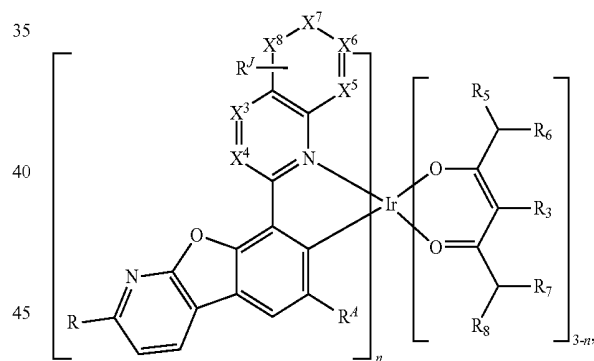
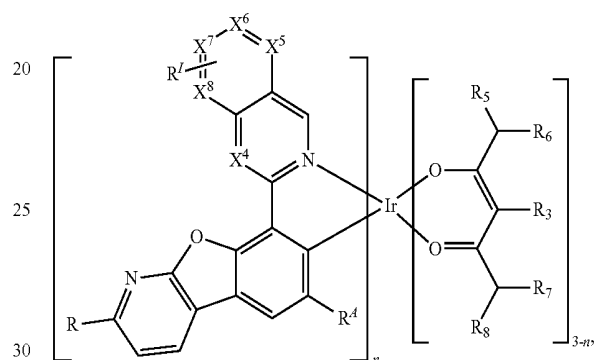
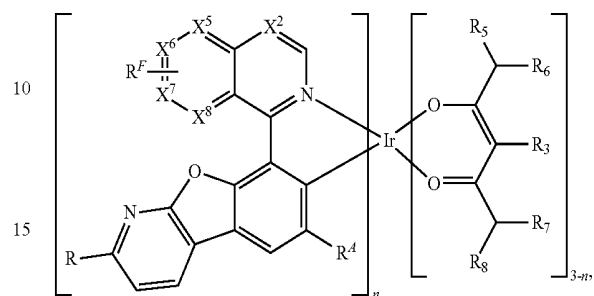
209

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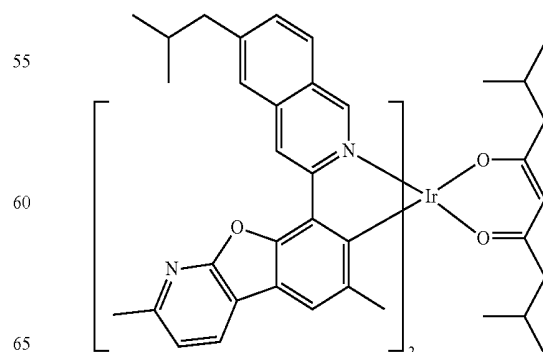
**210**

18. The first device of claim **14**, wherein the host material comprises a metal complex.

19. A formulation comprising a compound $M(L_A)_n(L_B)_{3-n}$ selected from the group consisting of:



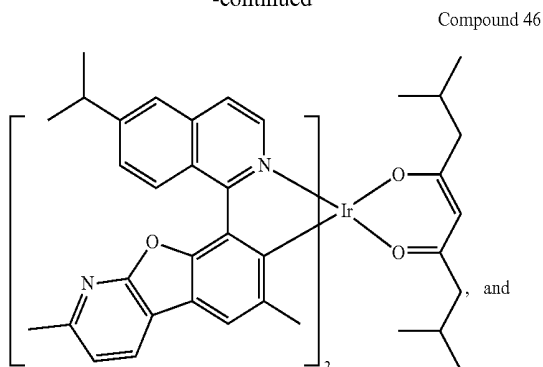
Compound 34



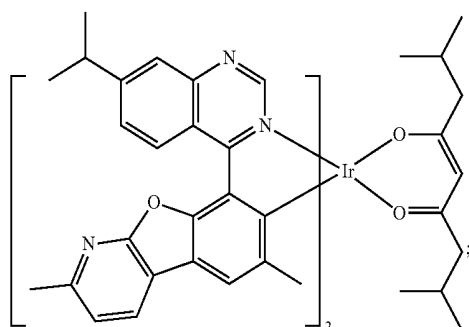
and combinations thereof.

211

-continued



Compound 58



212

wherein n is 1 or 2;

wherein X^2 , X^3 , X^4 are independently CH or N;wherein X^5 , X^6 , X^7 , and X^8 are C or N;

5 wherein R^F , R^I , and R^J each independently represent mono, di, tri, or tetra-substitution, or no substitution;

10 wherein R is selected from the group consisting of alkyl, partially or fully deuterated alkyl, cycloalkyl, partially or fully deuterated cycloalkyl, and combinations thereof;

wherein R^5 , R^6 , R^7 , and R^8 are independently selected from group consisting of alkyl, cycloalkyl, aryl, and heteroaryl;

15 wherein at least one of R^5 , R^6 , R^7 , and R^8 has at least two C atoms;

20 wherein each of R^4 , R^F , R^I , R^J , R^1 , R^2 , and R^3 is independently selected from the group consisting of hydrogen, deuterium, halide, alkyl, cycloalkyl, heteroalkyl, arylalkyl, alkoxy, aryloxy, amino, silyl, alk-enyl, cycloalkenyl, heteroalkenyl, alkynyl, aryl, heteroaryl, acyl, carbonyl, carboxylic acids, ester, nitrile, isonitrile, sulfanyl, sulfinyl, sulfonyl, phosphino, and combinations thereof.

* * * * *

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当前申请(专利权)人(译)	通用显示器公司		
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摘要(译)

具有根据式M(LA)_x(LB)_y(LC)_z：其中的配体LA是配体LB是和配体LC是公开了含有这些化合物的装置和制剂。在公式M(LA)_x(LB)_y(LC)_z：x是1或2；x+y+z是金属M的氧化态；X¹-X⁴和A¹-A⁸是C或N；A中的至少一个A¹-A⁸是N；X是O，S或Se；两个相邻的RB形成一个与环B稠合的六元芳香环E；其中环E可以被RE；每个RA-RE和R¹-R⁴独立地选自氢，氘，卤化物，烷基，环烷基，杂烷基，芳基烷基，烷氧基，芳氧基，氨基，甲硅烷基，烯基，环烯基，杂烯基，炔基，芳基，杂芳基，酰基，羰基，羧酸，酯，腈，异腈，硫烷基，亚磺酰基，磺酰基，膦基及其组合。

